Draft

Phase II Remedial Investigation Report and Feasibility Study for Soil, Sediment, and Surface Water at RVAAP-42 Load Line 9

Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

Contract No. W912QR-15-C-0046

Prepared for:

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U.S. Army Corps of Engineers
Louisville District

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14. ABSTRACT

This Phase II Remedial Investigation Report and Feasibility Study Report for Load Line 9 presents physical characteristics, geology, and hydrogeology of Load Line 9; compiles historical and newly acquired environmental data; summarizes nature and extent of contamination in soil, sediment, and surface water; evaluates contaminant fate and transport; provides human health and ecological risk assessments; identifies response actions, screening of remedial technologies and process options; develops remedial alternatives to address chemicals of concern (COCs) presenting unacceptable risk; and presents a recommended alternative to meet the remedial action objective at this AOC. To achieve an Unrestricted (Residential) Land Use for soil, sediment, and surface water, this report recommends implementing “Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097– Attain Unrestricted (Residential) Land Use" to conduct soil removal at LL9ss-011 and to treat surface soil at sample locations LL9ss-096/097.

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Cleanup goals, remedial action objective, risk assessment, weight of evidence, nature and extent, fate and transport, remedial alternative

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CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Leidos has completed the Phase II Remedial Investigation Report and Feasibility Study for Soil, Sediment, and Surface Water at RVAAP-42 Load Line 9 at the Former Ravenna Army Ammunition Plant, Portage and Trumbull Counties, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures, and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing United States Army Corps of Engineers (USACE) policy.

02/10/2016

Jed Thomas, P.E.
Study/Design Team Leader, Main Author

Date

02/10/2016

Selvam Arunachalam, P.E.
Independent Technical Review Team Leader

Date

Significant concerns and the explanation of the resolution are as follows:

Internal Leidos Independent Technical Review comments are recorded on a Document Review Record per Leidos standard operating procedure ESE A3.1 Document Review. This Document Review Record is maintained in the project file. Changes to the report addressing the comments have been verified by the Study/Design Team Leader. As noted above, all concerns resulting from independent technical review of the project have been considered.

02/10/2016

Lisa Jones-Bateman
Senior Program Manager

Date

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ARNG = Army National Guard.
CO = Central Office.
DERR = Division of Environmental Response and Revitalization.
ILE = Installation, Logistics, and Environment.
OHARNG = Ohio Army National Guard.
Ohio EPA = Ohio Environmental Protection Agency.
NEDO = Northeast Ohio District Office.
REIMS = Ravenna Environmental Information Management System.
USACE = United States Army Corps of Engineers.

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ACRONYMS AND ABBREVIATIONS

ACM	Asbestos-containing Material
amsl	Above Mean Sea Level
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirements
AT123D	Analytical Transient 1-, 2-, 3-Dimensional
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
Camp Ravenna	Camp Ravenna Joint Military Training Center
CAMU	Corrective Action Management Unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMCOC	Contaminant Migration Chemical of Concern
CMCOPC	Contaminant Migration Chemical of Potential Concern
COC	Chemical of Concern
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSM	Conceptual Site Model
CUG	Cleanup Goal
DAF	Dilution Attenuation Factor
DERR	Division of Environmental Response and Revitalization
DFFO	Director’s Final Findings and Orders
DNT	Dinitrotoluene
DQO	Data Quality Objective
DWA	Dry Well Area
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ESV	Ecological Screening Value
EU	Exposure Unit
FA	Functional Area
FCR	Field Change Request
f_{oc}	mass fraction of the organic carbon soil content
FPA	Former Production Area
FS	Feasibility Study
FWCUG	Facility-wide Cleanup Goal
FWERWP	Facility-wide Ecological Risk Work Plan
FWGWMP	Facility-wide Groundwater Monitoring Program
FWHHRAM	Facility-wide Human Health Risk Assessor Manual
FWSAP	Facility-wide Sampling and Analysis Plan
gpm	Gallons Per Minute
GRA	General Response Action
GSSL	Generic Soil Screening Level

ACRONYMS AND ABBREVIATIONS (continued)

HELP	Hydrologic Evaluation of Landfill Performance
HHRA	Human Health Risk Assessment
HLC	Henry's Law Constant
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HQ	Hazard Quotient
ILCR	Incremental Lifetime Cancer Risk
INRMP	Integrated Natural Resources Management Plan
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
ISM	Incremental Sampling Methodology
K_d	soil/water partitioning coefficient
K_ds	distribution coefficients
K_{oc}	water/organic carbon partition coefficient
K_{ow}	octanol-water partition coefficient
LDR	Land Disposal Restriction
LES	Lakeshore Engineering Services, Inc.
LUC	Land Use Control
MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
MDL	Method Detection Limit
MTR	Minimum Technical Requirement
NCP	National Contingency Plan
NPA	Non-Production Area
O&M	Operation and Maintenance
OAC	Ohio Administrative Code
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
OMZA	Outside Mixing Zone Average
OMZM	Outside Mixing Zone Maximum
PAH	Polycyclic Aromatic Hydrocarbon
PBA08 RI	Performance-Based Acquisition 2008 Remedial Investigation
PBA08 SAP	Performance Based Acquisition 2008 Supplemental Investigation Sampling and Analysis Plan Addendum No. 1
PBR	Permit-by-Rule
PBT	Persistent, Bioaccumulative, and Toxic
PCB	Polychlorinated Biphenyl
PETN	Pentaerythritol Tetranitrate
PP	Proposed Plan
PPE	Personal Protective Equipment
ppm	Parts Per Million
PRG	Preliminary Remediation Goal

ACRONYMS AND ABBREVIATIONS (continued)

QA	Quality Assurance
QC	Quality Control
R	Retardation Factor
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDA	Recommended Daily Allowance
RDI	Recommended Daily Intake
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
REIMS	Ravenna Environmental Information Management System
RfD	Reference dose
RI	Remedial Investigation
ROD	Record of Decision
RRSE	Relative Risk Site Evaluation
RSL	Regional Screening Level
RVAAP	Ravenna Army Ammunition Plant
SERA	Screening Ecological Risk Assessment
SESOIL	Seasonal Soil Compartment Model
SL	Screening Level
SOR	Sum-of-Ratios
SRC	Site-related Contaminant
SRV	Sediment Reference Value
SSL	Soil Screening Level
SSSL	Site-Specific Soil Screening Level
SVOC	Semi-volatile Organic Compound
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TestAmerica	TestAmerica Laboratories, Inc.
TNT	2,4,6-Trinitrotoluene
TR	Target Risk
UCL	Upper Confidence Limit
URF	Unit Risk Factor
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAEHA	U.S. Army Environmental Hygiene Agency
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USEPA	U.S. Environmental Protection Agency
USP&FO	U.S. Property and Fiscal Officer
UTS	Universal Treatment Standard
VOC	Volatile Organic Compound
WOE	Weight-of-Evidence

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EXECUTIVE SUMMARY

ES.1 INTRODUCTION AND SCOPE

This document has been revised by Leidos under the U.S. Army Corps of Engineers (USACE), Louisville District Contract No. W912QR-15-C-0046. This report replaces the *Draft Phase II Remedial Investigation Report and Feasibility Study for Soil, Sediment, and Surface Water at RVAAP-42 Load Line 9*, dated December 30, 2011, originally submitted to Ohio Environmental Protection Agency (Ohio EPA). This Remedial Investigation/Feasibility Study (RI/FS) Report addresses soil, sediment, and surface water at Load Line 9 within the former Ravenna Army Ammunition Plant (RVAAP) [now known as Camp Ravenna Joint Military Training Center (Camp Ravenna)] in Portage and Trumbull counties, Ohio.

This report has been prepared in accordance with the requirements of the Ohio EPA *Director's Final Findings and Orders* (DFFO) for RVAAP, dated June 10, 2004 (Ohio EPA 2004). The DFFO requires conformance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and National Contingency Plan (NCP) to implement an RI to characterize the area of concern (AOC); develop an FS Report (if remediation is necessary); and evaluate remedial alternatives to address contamination presenting unacceptable risk to human health and the environment, present a preferred alternative in a proposed plan (PP), and document stakeholder selection and acceptance of the preferred final remedy in a record of decision (ROD). The following sections present the site history, scope of this report, and an explanation of the evaluation of future use.

ES.1.1 Site History

Load Line 9 is designated as AOC RVAAP-42 within the former RVAAP. Load Line 9, formerly known as the detonator line, is a 69-acre, fenced AOC located north of Fuze and Booster Road, west of George Road, and northeast of Load Line 10 in the south-central portion of Camp Ravenna. The only existing structure at Load Line 9 is an elevated water tank (WW-32) in the western part of the AOC. Gravel perimeter roads are inside the AOC, as well as two dirt mounds north of former Buildings DT-2 and DT-5.

From 1941–1945, Load Line 9 operated at full capacity to produce fuze component parts for artillery projectiles. Load Line 9 was deactivated at the end of World War II, and the process equipment was removed. Load Line 9 has not been used since 1945, and no historical information exists to indicate Load Line 9 was used for any other processes, other than what is presented above.

ES.1.2 Scope

The scope of this RI/FS Report is to perform a CERCLA evaluation of soil, sediment, and surface water at Load Line 9. The media of concern associated with Load Line 9 are surface soil [0–1 ft below ground surface (bgs)], subsurface soil (1–13 ft bgs), sediment, and surface water. This report does not include a full evaluation of groundwater or facility-wide sewers, as those will be evaluated as individual AOCs for the entire facility. However, the potential for soil contaminants to leach to and migrate in groundwater is evaluated in this RI/FS Report to determine whether soil remedial actions to protect groundwater may be necessary.

ES.1.3 Evaluation of Future Use

In February 2014, the U.S. Department of the Army (Army) and Ohio EPA amended the risk assessment process to address changes in the RVAAP restoration program. The *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the RVAAP Installation Restoration Program* (ARNG 2014) (herein referred to as the Technical Memorandum) identified three Categorical Land Uses and Representative Receptors to be considered during the RI phase of the CERCLA process. These three Land Uses and Representative Receptors are presented below.

1. Unrestricted (Residential) Land Use – Resident Receptor (Adult and Child) (formerly called Resident Farmer).
2. Military Training Land Use – National Guard Trainee.
3. Commercial/Industrial Land Use – Industrial Receptor [U.S. Environmental Protection Agency's (USEPA) Composite Worker].

Unrestricted (Residential) Land Use is considered protective for all three Land Uses at Camp Ravenna. Therefore, if an AOC meets the requirements for Unrestricted (Residential) Land Use, then the AOC is also considered to have met the requirements of the other Land Uses (i.e., Industrial and Military Training), and those other Land Uses do not require evaluation.

As stated in Paragraph 6.d of the Technical Memorandum, if an AOC fails to meet Unrestricted (Residential) Land Use, then an FS will be completed that evaluates cleanup options for all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use]. Remedial alternatives for meeting each Land Use are to be evaluated per the current guidelines for selecting a remedy for the AOC. The preferred remedy is one that would meet Unrestricted (Residential) Land Use. RI/FS Reports in progress at the time of the Technical Memorandum's approval on February 11, 2014 will not be revised to include an evaluation of Commercial/Industrial Land Use as an Alternative, if it achieves no further action for Unrestricted (Residential) Land Use.

ES.2 FINDINGS AND RECOMMENDATIONS OF THE REMEDIAL INVESTIGATION

This section presents the data used in the RI, contaminant nature and extent, fate and transport, human health risk assessment (HHRA), and environmental risk assessment (ERA), followed by the conclusions of the RI.

ES.2.1 Data Use and Sample Selection Process

Quality-assured sample data from the 2003 Phase I RI and 2010 Performance-Based Acquisition 2008 Remedial Investigation (PBA08 RI) were used to evaluate nature and extent of contamination at Load Line 9. These investigations used discrete sampling methods.

All available sample data collected at the locations were evaluated to determine suitability for use in various key RI data screens and evaluations (i.e., nature and extent, fate and transport, risk assessment). Evaluation of the data's suitability for use in the PBA08 RI involved two primary considerations: (1) whether the data represented current AOC conditions, and (2) sample collection methods [e.g., discrete vs. incremental sampling methodology (ISM)].

Samples from the 2002 lead azide screening and 2003 Phase I RI were evaluated to determine if conditions had changed substantively between earlier characterization efforts and the 2010 PBA08 RI. In October 2002, thermal decontamination and 5X certification of all buildings at Load Line 9 were initiated to burn structures in-place to remove potentially explosive residue from building material in order to achieve 5X status. From May 2006 to July 2007, floor slabs, foundations, and footers of 22 buildings were removed to a minimum of 4 ft bgs. Phase I RI samples from soil borings LL9sb-048 through LL9sb-053 were collected under buildings that were subsequently demolished and were potentially affected by these demolition activities. These samples were omitted from the site-related contaminant (SRC) screen; however, they were retained for purpose of evaluating nature and extent and contaminant migration.

Data collected in 2010 and 2011 as part of the PBA08 RI focused on delineating the extent of contaminants identified in surface soil (0-1 ft bgs), subsurface soil (1-13 ft bgs), sediment, and surface water. The PBA08 RI sampled locations with the greatest likelihood of contamination (e.g., adjacent to production buildings or within sediment accumulation areas, such as ditches) and analyzed for chemicals identified in historical investigations.

ES.2.2 Summary of Nature and Extent of Contamination

Nature and extent of contamination in surface soil (0-1 ft bgs), subsurface soil (greater than 1 ft bgs), sediment, and surface water was evaluated in the RI. Data from the 2002 lead azide screening, 2003 Phase I RI, and 2010 and 2011 PBA08 RIs provided effective characterization of the nature and extent of the contamination at the AOC. Figure ES-1 shows the sample locations used to conduct this RI. To support the evaluation of nature and extent of contamination, SRC concentrations were compared to screening levels (SLs) corresponding to the lowest facility-wide cleanup goal (FWCUG) for the Resident Receptor (Adult and Child) and National Guard Trainee at a target hazard quotient (HQ) of 0.1 or target risk (TR) of 1E-06, as presented in the *Facility-wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2010a) (herein referred to as the FWCUG Report). It can be concluded that the vertical and horizontal extent of contamination is defined, and no further sampling is needed to evaluate Load Line 9.

Sites where explosives were identified as potential contaminants from previous use were thoroughly evaluated, including around former process buildings and across each exposure unit (EU). The maximum concentrations for explosives and propellants were all below their respective SLs and were not considered chemicals of potential concern (COPCs). In addition, the 2002 lead azide screening had field tests conducted for 2,4,6-trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) using the Jenkins method. No explosives were detected above reporting limits in any of the surface soil, sediment, or surface water samples.

The soil around the elevated water tank was evaluated by soil samples collected at LL9sb-024 and LL9sb-025. The concentrations of lead in surface and subsurface soil at these locations were below the regional screening level (RSL) of 400 mg/kg, with a maximum concentration of 320 mg/kg at LL9ss-024 in surface soil (0-1 ft bgs).

As identified in the Phase I RI Report, concentrations of contaminants are generally low, with a notable exception being a localized spot at LL9ss–011 in surface soil (0-1 ft bgs). Mercury was detected above the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1 with a maximum detected concentration (MDC) of 882 mg/kg observed at sample location LL9ss-011 adjacent to a former detonator destroying house (DT-34). Additional samples analyzed for mercury in April 2011 helped delineate the lateral extent of mercury contamination at this location. In addition, lead had a concentration of 1,330 mg/kg at this location, exceeding the residential RSL of 400 mg/kg and industrial RSL of 800 mg/kg.

Soil borings LL9ss-096 and LL9ss-097 had polycyclic aromatic hydrocarbon (PAH) concentrations greater than their respective Resident Receptor FWCUG at a TR of 1E-05, HQ of 1. Both soil borings were located near the former dining facility (DT-52) and former change house (DT-28) buildings. Although these buildings were not production buildings, they were most likely heated and had heavy vehicle traffic during operations. Subsurface samples were not collected at these locations; however, subsurface soil was characterized at the neighboring change house (DT-29) and did not contain PAH detections in deeper sample intervals (1-4 and 4-6 ft bgs). In addition, identified PAH contamination at the former RVAAP has been predominately in the surface soil (0-1 ft bgs).

Building DT-33 was the only building at Load Line 9 whose purpose was solvent storage. The samples associated with former Building DT-33 (LL9sb-055 and LL9sb-056) had no detectable concentrations of volatile organic compounds (VOCs) in the surface soil. In addition, there were no detected concentrations of polychlorinated biphenyls (PCBs) in the soil samples collected across the site, and none of the detected chemical concentrations in sediment or surface water were above the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1.

ES.2.3 Summary of Contaminant Fate and Transport

All SRCs identified in the surface soil, subsurface soil, and sediment at Load Line 9 were evaluated through the stepwise contaminant fate and transport evaluation. The evaluation included analyzing leaching and migration from soil and sediment to groundwater and determining whether contamination present in soil and sediment may potentially impact groundwater quality at the site.

Maximum concentrations of SRCs identified in surface and subsurface soil were evaluated using a series of generic screening steps to identify initial contaminant migration chemicals of potential concern (CMCOPCs). Initial CMCOPCs for soil were further evaluated using the Seasonal Soil Compartment Model (SESOIL) model to predict leaching concentrations and identify final CMCOPCs based on RVAAP facility-wide background concentrations and the lowest risk-based screening criteria among USEPA maximum contaminant levels (MCLs), USEPA tap water RSLs, or RVAAP groundwater FWCUGs for the Resident Receptor Adult. A sediment screening analysis was performed for sediment samples at the AOC. Chemical-specific dilution attenuation factors (DAFs) were calculated using co-located surface water and sediment concentrations for identified sediment SRCs. These DAFs were used in the sediment screening analysis to identify the final CMCOPCs based on RVAAP facility-wide background concentrations and the lowest risk-based screening criteria. Final CMCOPCs were evaluated using the Analytical Transient 1-, 2-, 3-Dimensional (AT123D) model to predict groundwater concentrations beneath source areas and at the nearest downgradient groundwater receptor to the AOC (e.g., stream).

The evaluation of modeling results with respect to current AOC groundwater data and model limitations identified the following CMCOPCs:

- Among the soil CMCOPCs, arsenic, cobalt, manganese, mercury, and naphthalene were predicted to exceed the screening criteria in groundwater beneath the source area, and only naphthalene was predicted to be above its criteria at the downgradient receptor location.
- Among the sediment CMCOPCs, mercury, nitroguanidine, pentaerythritol tetranitrate (PETN), benzo(a)anthracene, benzo(b)fluoranthene, and naphthalene were predicted to exceed the screening criteria in groundwater beneath the source area; however, none of these CMCOPCs were predicted to be above criteria in the downgradient receptor location.

A qualitative assessment of the sample results and considerations of the limitations and assumptions of the models were performed to identify if any contaminant migration chemicals of concern (CMCOCs) are present in soil and sediment at Load Line 9 that may impact the groundwater beneath the source or at the downstream receptor location. This qualitative assessment concluded that there were no CMCOCs present in soil and sediment that may impact the groundwater beneath the source or at the downstream receptor location. No further action is required of soil and sediment at Load Line 9 for the protection of groundwater.

ES.2.4 Summary of Human Health Risk Assessment

The HHRA identified chemicals of concern (COCs) and conducted risk management analysis to determine if COCs pose unacceptable risk to the Resident Receptor. If there is no unacceptable risk to the Resident Receptor, it can be concluded that there is no unacceptable risk to the National Guard Trainee and Industrial Receptor. However, if unacceptable risk is identified for the Resident Receptor, the risk to the National Guard Trainee and Industrial Receptor is evaluated.

Media of concern at Load Line 9 are surface soil, subsurface soil, surface water, and sediment. Soil data associated with Load Line 9 were aggregated into surface and subsurface soil at the former production area (FPA), non-production area (NPA), and dry well area (DWA). Surface water and sediment were evaluated at the Drainage Ditches and the DWA.

No COCs were identified for any receptor at any EU in subsurface soil, sediment, or surface water. Additionally, there were no COCs identified for any receptor for surface soil in the DWA.

Lead, mercury, and four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] were identified as COCs to be carried forward for potential remediation. Lead and mercury are COCs to be carried forward for potential remediation at the NPA in the area of the former detonator destroying house (DT-34) for all three Land Uses. Elevated levels of lead and mercury may be present in this area as a result of lead azide and mercury fulminate used in detonators.

The PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were identified as COCs to be carried forward for potential remediation at the FPA in the area of the former change house (DT-28) for Unrestricted (Residential) Land Use. Additionally, benzo(a)pyrene was identified as a COC in this area to be carried forward for potential remediation for Industrial and Military Training Land Uses. PAHs are present at the NPA, but at lower concentrations than the FPA. For example, the maximum concentration of benzo(a)pyrene in the NPA is 0.24 mg/kg, compared to the Residential (Adult and Child) FWCUG of 0.221 mg/kg. PAH concentrations at the NPA are similar to those reported for normal atmospheric deposition and do not warrant evaluation in an FS. COCs identified for potential remediation at Load Line 9 are summarized in Table ES-1.

ES.2.5 Summary of Ecological Risk Assessment

The ERA Level I presents important ecological resources on or near the AOC and evaluates the potential for current contamination to impact ecological resources. At Load Line 9, there are 18 integrated chemicals of potential ecological concern (COPECs) identified in deep surface soil at the FPA and 12 integrated COPECs in deep surface soil at the NPA. In addition, there are five integrated COPECs in sediment at the Drainage Ditches (beryllium, mercury, benzenemethanol, nitroguanidine, and PETN), two integrated COPECs in sediment at the DWA (beryllium and mercury), one integrated COPEC in surface water at the Drainage Ditches (mercury), and two integrated COPECs in surface water at the DWA (mercury and nitrocellulose). Ecological resources at Load Line 9 were compared to the list of important ecological places and resources. None of the 39 important places and resources were present, and there is nothing ecologically significant at Load Line 9. The ERA summarizes in detail the chemicals and resources to demonstrate that there is contamination at Load Line 9, but no important or significant ecological resources are present. Consequently, the Level I Scoping Level Risk Assessment concluded that no further action is necessary to be protective of ecological resources.

ES.2.6 Conclusions of the Remedial Investigation

Based on the investigation results, Load Line 9 has been adequately characterized and nature and extent has been defined. The fate and transport assessment concluded that chemicals in soil and sediment are not adversely impacting groundwater quality and are not predicted to have future impacts. The ERA concluded that there are no important or ecologically significant resources at the AOC; consequently, no further action is recommended from the ecological risk perspective.

The HHRA identified lead and mercury as surface soil COCs to be carried forward for potential remediation in the vicinity of LL9ss-011, in the area of the former detonator destroying house (DT-34) to be protective of the Resident Receptor, National Guard Trainee, and Industrial Receptor. In addition, the PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were identified as surface soil COCs to be carried forward for potential remediation in the vicinity of LL9ss-096 and LL9ss-097, in the area of the former change house (DT-28) for Unrestricted (Residential) Land Use.

ES.3 SUMMARY AND RECOMMENDATION OF THE FEASIBILITY STUDY

To address COCs in surface soil (0-1 ft bgs), an FS was presented. This FS developed a remedial action objective (RAO), identified appropriate cleanup goals (CUGs) for remedial actions, identified applicable and relevant or appropriate requirements (ARARs), screened potential remedial technologies and process options, and developed and evaluated remedial alternatives.

ES.3.1 Remedial Action Objective

The RAO for Load Line 9 is to prevent Resident Receptor exposure to surface soil (0-1 ft bgs) with 1) concentrations above lead and mercury CUGs at sample location LL9ss-011 and 2) concentrations above benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene CUGs at sample locations LL9ss-096 and LL9ss-097. Figure ES-2 presents the estimated extent of surface soil requiring remediation.

ES.3.2 Remedial Alternatives

Remedial technologies and process options were screened to identify potential remedial alternatives that can achieve the RAO. The remedial alternatives developed are presented below:

- Alternative 1: No Action.
- Alternative 2: Excavation and Off-site Disposal - Attain Unrestricted (Residential) Land Use.
- Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097 – Attain Unrestricted (Residential) Land Use.

Alternative 1: No Action is required for evaluation under the NCP and provides the baseline against which other remedial alternatives are compared. This alternative assumes all current actions (e.g., access restrictions and environmental monitoring) are discontinued and that no future actions will take place to protect human receptors or the environment. Consequently, COCs at the AOC are not removed or treated.

Alternative 2: Excavation and Off-site Disposal - Attain Unrestricted (Residential) Land Use involves removing surface soil (0-1 ft bgs) to achieve CUGs for the Resident Receptor COCs in the vicinity of sample locations LL9ss-011 and LL9ss-096/097. The estimated 1,165 yd^3 (ex-situ) of soil would require removal and disposal from these two distinct locations under this alternative. Excavations would be backfilled with approved, clean soil from a local commercial supplier. Disturbed areas would be restored to grade and re-vegetated using an Ohio Army National Guard (OHARNG)-approved seed mixture and mulched. No Land Use controls (LUCs) or five-year reviews pursuant to CERCLA would be required because this alternative attains a level of protection for unrestricted use of the AOC.

Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097 – Attain Unrestricted (Residential) Land Use involves soil removal and disposal and thermal treatment. The estimated 24 yd^3 (ex-situ) of surface soil contaminated with mercury and lead at location LL9ss-011 would involve removal and disposal under this alternative. The estimated 1,141 yd^3 of surface soil contaminated with PAHs at locations LL9ss-096/097 would undergo thermal treatment to achieve CUGs for the Resident Receptor COCs. The soil would be excavated and placed into a thermal treatment system to remove COCs from soil. Once the treated soil is sampled and confirmed to be below CUGs, the treated soil will be placed back into the excavated area. Both disturbed areas will be restored to grade, using backfill as necessary, re-vegetated using an OHARNG-approved seed mixture, and mulched. No LUCs or five-year reviews pursuant to CERCLA would be required because this alternative attains a level of protection for unrestricted use of the AOC.

The three alternatives were compared to CERCLA threshold and balancing criteria and a comparative analysis was completed to justify the selection of a recommended alternative for soil at Load Line 9. Table ES-2 summarizes the comparative analysis of the alternatives.

ES.3.3 Recommended Alternative

The recommended alternative for Load Line 9 is Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097– Attain Unrestricted (Residential) Land Use. Alternative 3 meets the threshold and primary balancing criteria and is protective of the Resident Receptor by thermally treating PAH-contaminated soil and disposing the mercury and lead contaminated soil offsite at an engineered landfill. The cost of Alternative 3 is $296,732 and has no operation and maintenance (O&M) costs, as implementing the alternative results in attaining Unrestricted (Residential) Land Use. In addition, Alternative 3 is a green and highly sustainable alternative for on-site treatment and unrestricted reuse of soil and implements a treatment alternative to reduce the toxicity, mobility, and volume of contamination.

Alternative 1: No Action was also evaluated. However, since the threshold criterion of overall protectiveness of human health is not met, this alternative was eliminated from consideration. In the event that a thermal treatment system is not on site at the former RVAAP, Alternative 2: Excavation and Off-site Disposal – Attain Unrestricted (Residential) Land Use is readily available and may be implemented. Excavation and off-site disposal alternatives have been implemented multiple times during restoration efforts at the former RVAAP. As with Alternative 3, Alternative 2 is effective in the long term and attains Unrestricted (Residential) Land Use.

The next step in the CERCLA process is to prepare a PP to solicit public input with respect to the recommended alternative for Load Line 9 soil, sediment, and surface water. The PP will provide a brief summary of the history, characteristics, risks, of Load Line 9, as well as the basis for the recommended alternative. Comments on the PP received from the public will be considered in preparing a ROD to document the final remedy. The ROD will also include a responsiveness summary addressing comments received on the PP.

Table ES–1. COCs in Surface Soil for Potential Remediation at Load Line 9

			FWCUG or RSL		
COC	**EU or Sample Location**	**EPC or Sample Concentration**	**Resident Receptor (Adult and Child)**	**Industrial Receptor**	**National Guard Trainee**
Lead	**NPA**	**239 (159)**	400	800	800
	DT-34 (Detonator Destroying House)				
	LL9ss-011	1330			
Mercury	**NPA**	**161 (114)**	**22.7**	**40**	1722
	DT-34 (Detonator Destroying House)				
	LL9ss-011	882			
	LL9ss-131	65			
	LL9ss-132	280			
	LL9ss-133	520			
Benz(a)anthracene	**FPA**	**2.52 (1.91)**	**2.21**	29	47.7
	DT-28 (Change House)				
	LL9ss-096	17			
	LL9ss-097	1			
Benzo(a)pyrene	**FPA**	**2.27 (1.72)**	**0.221**	**2.9**	**4.77**
	DT-28 (Change House)				
	LL9ss-096	15			
	LL9ss-097	1.7			
Benzo(b)fluoranthene	**FPA**	**3.04 (2.3)**	**2.21**	29	47.7
	DT-28 (Change House)				
	LL9ss-096	20			
	LL9ss-097	2.4			
Dibenz(a,h)anthracene	**FPA**	**0.344 (0.26)**	**0.221**	2.9	4.77
	DT-28 (Change House)				
	LL9ss-096	2.2			
	LL9ss-097	0.36			

All concentrations are mg/kg.

Bold and shaded = EPC or sample concentration exceeds shaded FWCUG or RSL and chemical is identified as a COC for this location and receptor.

COC = Chemical of concern.

EPC = Exposure point concentration = 95% upper confidence limit (UCL) on the mean or maximum detected concentration if the 95% UCL exceeds the maximum detected concentration. Value in (parenthesis) is the EPC for the 0-4 ft below ground surface soil exposure depth.

EU = Exposure unit.

FPA = Former production area.

FWCUG = Facility-wide cleanup goal at a target risk of 1E-05 or target hazard quotient of 1.

NPA = Non-production area.

RSL = Regional screening level at a target risk of 1E-05 or target hazard quotient of 1.

Table ES–2. Summary of Comparative Analysis of Remedial Alternatives

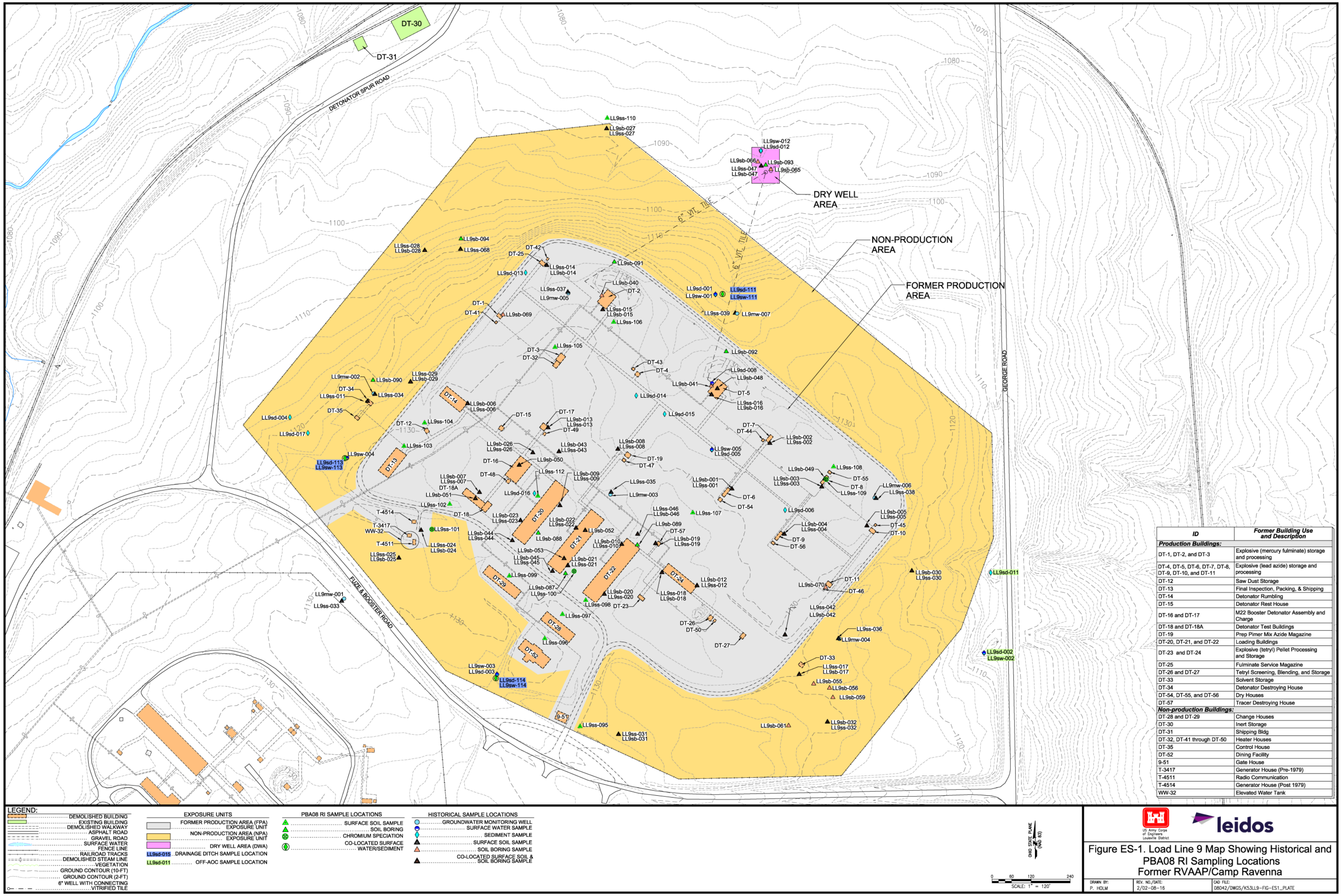
NCP Evaluation Criteria	**Alternative 1: No Action**	**Alternative 2: Excavation and Off-site Disposal - Attain Unrestricted (Residential) Land Use**	**Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097– Attain Unrestricted (Residential) Land Use**
Threshold Criteria	***Result***	***Result***	***Result***
1. Overall Protectiveness of Human Health and the Environment	Not protective	Protective	Protective
2. Compliance with ARARs	Not compliant	Compliant	Compliant
Balancing Criteria	***Ranking***	***Ranking***	***Ranking***
3. Long-term Effectiveness and Permanence	Not applicable	1	2
4. Reduction of Toxicity, Mobility, or Volume through Treatment	Not applicable	1	2
5. Short-term Effectiveness	Not applicable	1	2
6. Implementability	Not applicable	2	1
7. Cost	Not applicable ($0)	1 ($410,360)	2 ($296,732)
Balancing Criteria Score	*Not applicable*	*6*	*9*

Any alternative considered "not protective" for overall protectiveness of human health and the environment or "not compliant" for compliance with ARARs is not eligible for selection as the recommended alternative. Therefore, that alternative is not ranked as part of the balancing criteria evaluation.

Scoring for the balancing criteria is as follows: Most favorable = 2, least favorable = 1. The alternative with the highest total balancing criteria score is considered the most feasible.

ARAR = Applicable and Relevant or Appropriate Requirement.

NCP = National Contingency Plan.



ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

Figure ES-1. Load Line 9 Map Showing Historical and PBA08 RI Sampling Locations - Former RVAAP/Camp Ravenna

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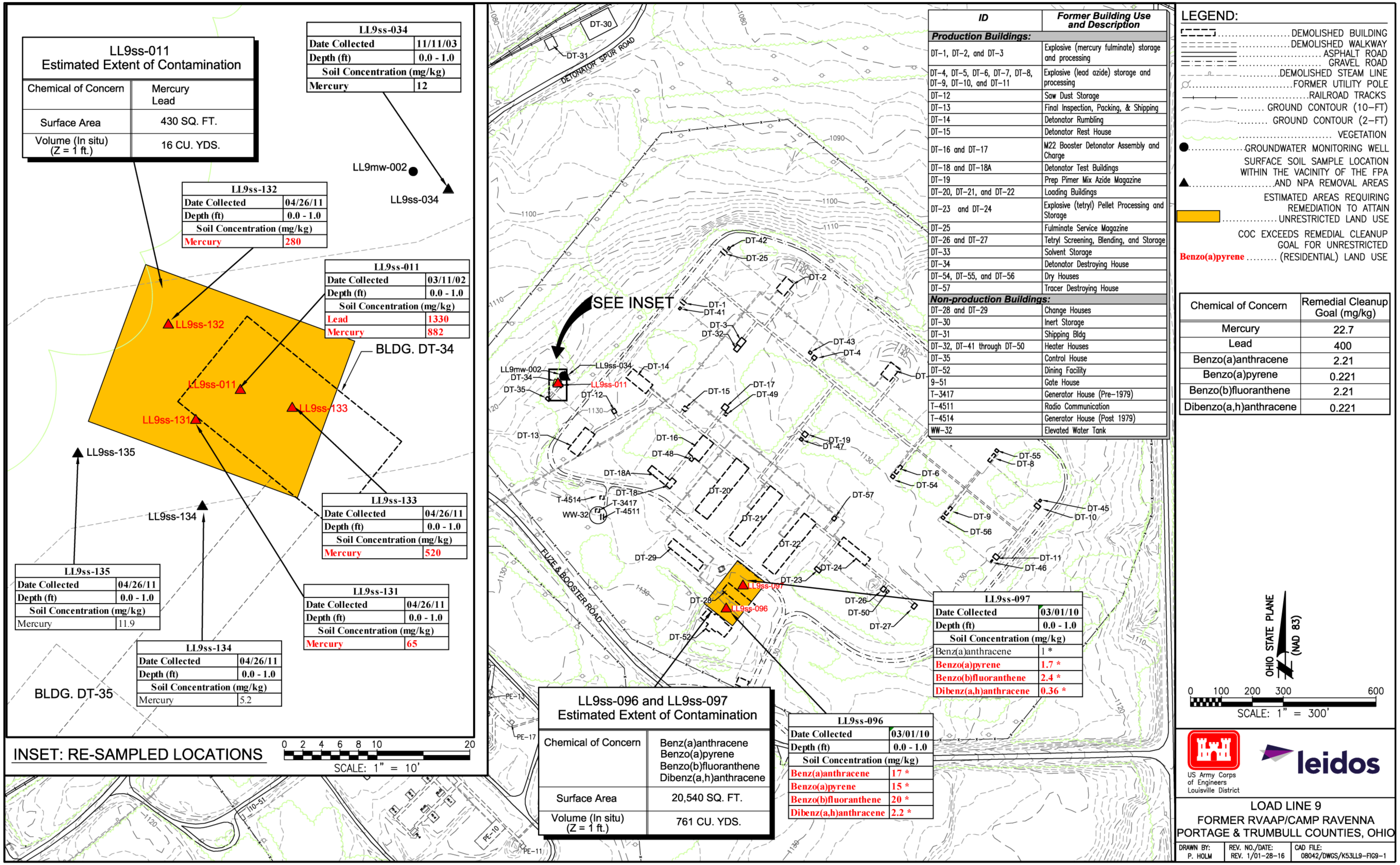

LL9ss-011 Estimated Extent of Contamination	
Chemical of Concern	Mercury Lead
Surface Area	430 SQ. FT.
Volume (In situ) (Z = 1 ft.)	16 CU. YDS.

LL9ss-034	
Date Collected	11/11/03
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	12

LL9ss-132	
Date Collected	04/26/11
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	280

LL9ss-011	
Date Collected	03/11/02
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Lead	1330
Mercury	882

LL9ss-133	
Date Collected	04/26/11
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	520

LL9ss-135	
Date Collected	04/26/11
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	11.9

LL9ss-131	
Date Collected	04/26/11
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	65

LL9ss-134	
Date Collected	04/26/11
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	5.2

LL9ss-096 and LL9ss-097 Estimated Extent of Contamination	
Chemical of Concern	Benz(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenz(a,h)anthracene
Surface Area	20,540 SQ. FT.
Volume (In situ) (Z = 1 ft.)	761 CU. YDS.

LL9ss-097	
Date Collected	03/01/10
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Benz(a)anthracene	1 *
Benzo(a)pyrene	1.7 *
Benzo(b)fluoranthene	2.4 *
Dibenz(a,h)anthracene	0.36 *

LL9ss-096	
Date Collected	03/01/10
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Benz(a)anthracene	17 *
Benzo(a)pyrene	15 *
Benzo(b)fluoranthene	20 *
Dibenz(a,h)anthracene	2.2 *

ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

LEGEND:

▭	DEMOLISHED BUILDING
═	DEMOLISHED WALKWAY
═	ASPHALT ROAD
═	GRAVEL ROAD
─	DEMOLISHED STEAM LINE
○	FORMER UTILITY POLE
┼	RAILROAD TRACKS
─	GROUND CONTOUR (10-FT)
─	GROUND CONTOUR (2-FT)
∿	VEGETATION
●	GROUNDWATER MONITORING WELL
▲	SURFACE SOIL SAMPLE LOCATION WITHIN THE VACINITY OF THE FPA AND NPA REMOVAL AREAS
🟧	ESTIMATED AREAS REQUIRING REMEDIATION TO ATTAIN UNRESTRICTED LAND USE
Benzo(a)pyrene	COC EXCEEDS REMEDIAL CLEANUP GOAL FOR UNRESTRICTED (RESIDENTIAL) LAND USE

Chemical of Concern	Remedial Cleanup Goal (mg/kg)
Mercury	22.7
Lead	400
Benzo(a)anthracene	2.21
Benzo(a)pyrene	0.221
Benzo(b)fluoranthene	2.21
Dibenzo(a,h)anthracene	0.221

LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	REV. 1/01-28-16	08042/DWGS/K53LL9-FIG9-1

Figure ES-2. Estimated Extents of Surface Soil Requiring Remediation

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1.0 INTRODUCTION

This document was revised by Leidos under the U.S. Army Corps of Engineers (USACE), Louisville District Contract No. W912QR-15-C-0046. This Remedial Investigation/Feasibility Study (RI/FS) Report addresses soil, sediment, and surface water at Load Line 9 within the former Ravenna Army Ammunition Plant (RVAAP) [now known as Camp Ravenna Joint Military Training Center (Camp Ravenna)] in Portage and Trumbull counties, Ohio (Figures 1-1 and 1-2). Load Line 9 is designated as area of concern (AOC) RVAAP-42.

This report has been prepared in accordance with the requirements of the Ohio Environmental Protection Agency (Ohio EPA) *Director's Final Findings and Orders* (DFFO) for RVAAP, dated June 10, 2004 (Ohio EPA 2004). The DFFO requires conformance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and National Contingency Plan (NCP) to implement an RI to characterize the AOC, develop an FS Report (if remediation is necessary) to evaluate remedial alternatives to address contamination presenting unacceptable risk to human health and the environment, present a preferred remedial alternative in a proposed plan (PP), and document stakeholder selection and acceptance of the preferred final remedy in a record of decision (ROD). Figure 1-3 presents this process.

This document is a combined RI/FS Report and includes:

- A description of the operational history and environmental setting for the AOC.
- A summary of all historical assessments and investigations at Load Line 9.
- A description of the nature and extent of contamination, including the identification of site-related contaminants (SRCs) by screening applicable data against background, essential human nutrients, and frequency of detection/weight-of-evidence (WOE) screening.
- An evaluation of contaminant fate and transport by identifying contaminant migration chemicals of potential concern (CMCOPCs) and contaminant migration chemicals of concern (CMCOCs) that may pose a future threat to groundwater.
- A human health risk assessment (HHRA) to identify chemicals of potential concern (COPCs) and chemicals of concern (COCs).
- An ecological risk assessment (ERA) to identify chemicals of potential ecological concern (COPECs) and chemicals of ecological concern.
- Conclusions of the RI Report, including the identification and extent of COCs, which form the basis for conducting the FS.
- Identification of remedial action objectives (RAOs) for contaminated media at the AOC.
- Identification of applicable or relevant and appropriate requirements (ARARs).
- Identification of general response actions (GRAs) and screening of a range of remedial technologies to reduce risk to human health and the environment at the AOC from COCs identified in the RI Report.
- Development of remedial alternatives from appropriate GRAs and remedial technologies and evaluation of alternatives against criteria specified by CERCLA.
- Conclusions of the FS and a preferred alternative.

Based on the outcome of the evaluation in this RI/FS Report, the preferred alternative will be submitted for public review and comment in a PP. Public comments will be considered in the final selection of a remedy, which will be documented in a ROD.

1.1 PURPOSE

The purpose of the Performance-Based Acquisition 2008 Remedial Investigation (PBA08 RI) at Load Line 9 was to supplement data from previous sampling events to delineate the nature and extent of contamination, evaluate contaminant fate and transport, and complete an HHRA and ERA to support remedial decisions. Depending on the results of the RI, a conclusion of no further action is provided or a recommendation to complete an FS to evaluate potential remedies and future actions will be made. The purpose of the FS is to identify RAOs and appropriate cleanup goals (CUGs), screen remedial technologies, develop remedial alternatives to meet the RAOs and attain CUGs, and perform a detailed evaluation of remedial alternatives to identify a preferred remedy.

1.2 SCOPE

The scope of this RI/FS Report is to present: (1) the nature and extent of contamination, fate and transport of contaminants in the environment, and risk assessments for surface soil, subsurface soil, sediment, and surface water at the AOC; (2) the results of the evaluation of remedial alternatives for meeting RAOs for any CERCLA-related COCs identified in the media at the AOC; and (3) a conclusion of no further action or a preferred alternative to present to the public in a PP. If remedial actions are warranted, the preferred alternative will achieve required risk reductions to protect human health and the environment and attain all ARARs. In accordance with CERCLA, remedial alternatives are to be cost effective; use permanent solutions and alternative treatment technologies to the maximum extent practicable; and satisfy the preference for treatment that reduces volume, toxicity, or mobility to the maximum practical extent.

For the purposes of this report, the term “surface soil” includes dry sediment. Dry sediment refers to unconsolidated inorganic and organic material within conveyances, ditches, or low-lying areas that occasionally may be covered with water, usually following a precipitation event or due to snowmelt. Dry sediment is not covered with water for extended periods and typically is dry within seven days of a precipitation event. Dry sediment does not function as a permanent habitat for aquatic organisms, although it may serve as a natural medium for the growth of terrestrial organisms. Dry sediment is addressed the same as surface soil [0-1 ft below ground surface (bgs)] in terms of contaminant nature and extent, fate and transport, and risk exposure models. The term “sediment,” as used in this report, refers to wet sediment within conveyances, ditches, wetlands, or water bodies that is inundated for extended periods. This terminology is consistent with the *Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2010a), herein referred to as the FWCUG Report.

Potential impacts to groundwater from soil (e.g., contaminant leaching) are evaluated in this report, as protectiveness to groundwater is included in the fate and transport analysis and evaluation of remedial alternatives for these media. However, groundwater will be evaluated as an individual AOC for the entire facility (designated as RVAAP-66) and addressed in a separate RI/FS Report. With the exception of an elevated water tank, all buildings and structures at the AOC have been demolished and were not evaluated as continuing sources of contamination in this report.

As discussed in Section 2.4.1, only sanitary sewers are present at Load Line 9; no storm sewer system exists within the AOC boundary. The sanitary sewers in the Load Line 9 functional area (FA) are part of the George Road Sewage Treatment Plant Network. As part of the RVAAP-67 Facility-wide Sewers RI, sampling and evaluation of the sewer sediment, sewer water, and pipe bedding material media was performed and identified inorganic chemicals and polycyclic aromatic hydrocarbons (PAHs) as the predominant sewer SRCs. Fate and transport modeling was performed, and an HHRA and ERA were conducted for sewers at Load Line 9. These evaluations recommend no further action with respect to the Facility-wide Sewers within Load Line 9. The full evaluation and conclusion are presented in the *Draft Remedial Investigation/Feasibility Study Report for RVAAP-67 Facility-Wide Sewers* (USACE 2012a).

1.3 REPORT ORGANIZATION

This report is organized in accordance with Ohio EPA and U.S. Environmental Protection Agency (USEPA) CERCLA RI/FS guidance and applicable USACE guidance. The following is a summary of the components of the report and a list of appendices:

- Section 2.0 provides a description and history of the former RVAAP and the AOC, presents potential sources of contamination, presents potential receptors, and summarizes co-located or proximate sites.
- Section 3.0 describes the environmental setting at Camp Ravenna and Load Line 9, including the geology, hydrogeology, climate, and receptor population.
- Section 4.0 summarizes previous assessments and investigations at Load Line 9, as well as the data used to support this RI.
- Section 5.0 discusses the occurrence and distribution of contamination at the AOC.
- Section 6.0 presents an evaluation of contaminant fate and transport.
- Section 7.0 includes the methods and results of the HHRA and ERA.
- Section 8.0 provides the conclusions and recommendations of the RI.
- Section 9.0 outlines the development of RAOs for the chemicals and media of concern.
- Section 10.0 summarizes potential federal and state chemical-, location-, and action-specific ARARs for potential remedial actions.
- Section 11.0 presents GRAs and the identification and screening of technology types and process options considered for possible use in remediation.
- Section 12.0 develops remedial alternatives from technologies and process options that passed initial screening and presents an initial evaluation against effectiveness, implementability, and cost.
- Section 13.0 presents the detailed and comparative analyses of viable remedial action alternatives developed to address chemicals and media of concern using the seven criteria specified by CERCLA guidance.
- Section 14.0 presents the conclusions of the FS and the preferred remedial alternative.

- Section 15.0 summarizes the framework for conducting the necessary agency and public involvement activities.
- Section 16.0 provides a list of references used to develop this report.
- Appendices:

  Appendix A: Field Sampling Logs;
  Appendix B: Project Quality Assurance Summary;
  Appendix C: Data Quality Control Summary Report;
  Appendix D: Laboratory Analytical Results and Chains-of-Custody;
  Appendix E: Fate and Transport Modeling Results;
  Appendix F: Investigation-derived Waste Management Reports;
  Appendix G: Human Health Risk Assessment Tables;
  Appendix H: Ecological Risk Assessment Information and Data;
  Appendix I: PBA08 Remedial Investigation Summary; and
  Appendix J: Detailed Cost Estimates.

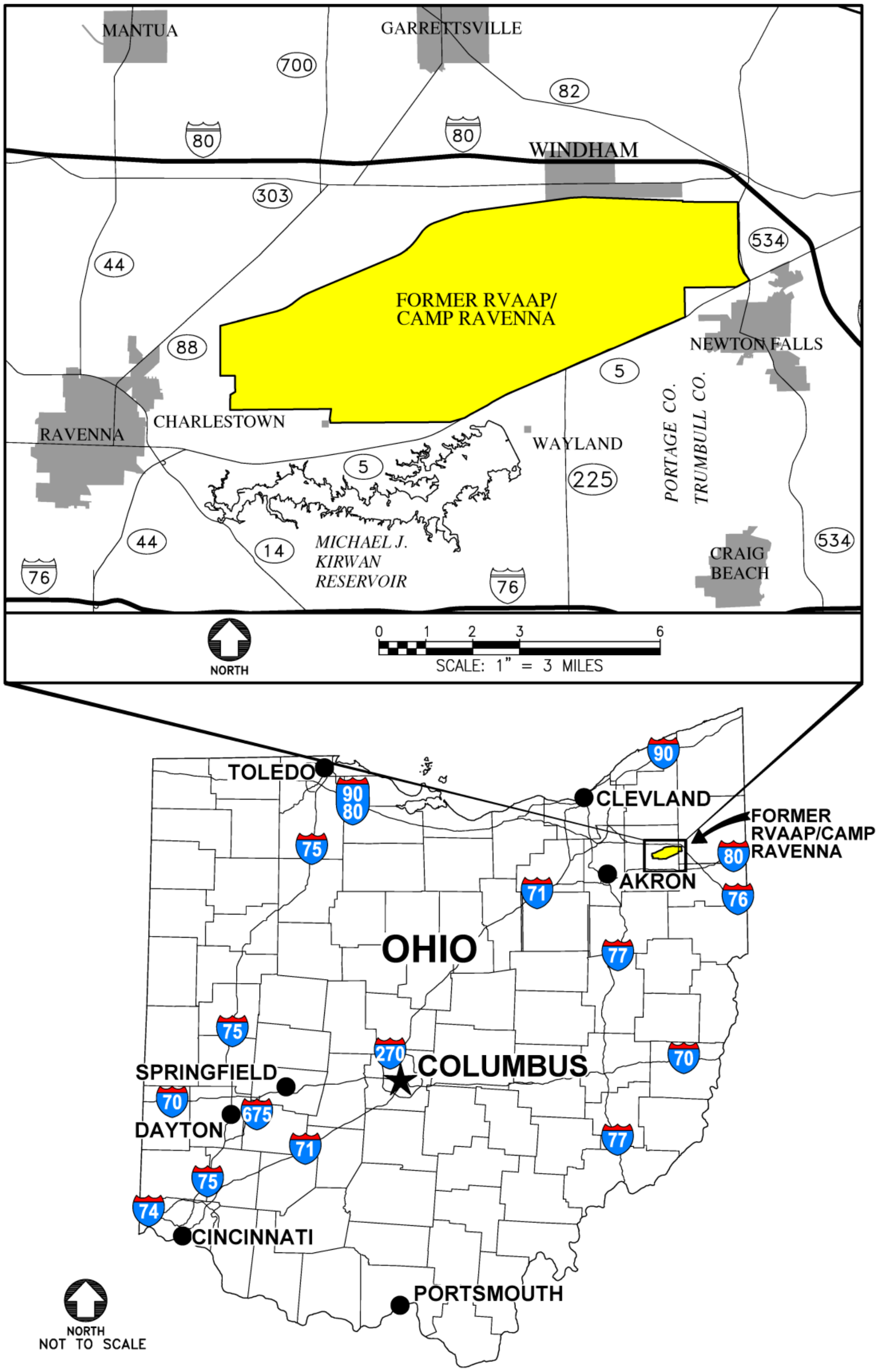

Figure 1-1. General Location and Orientation of Camp Ravenna

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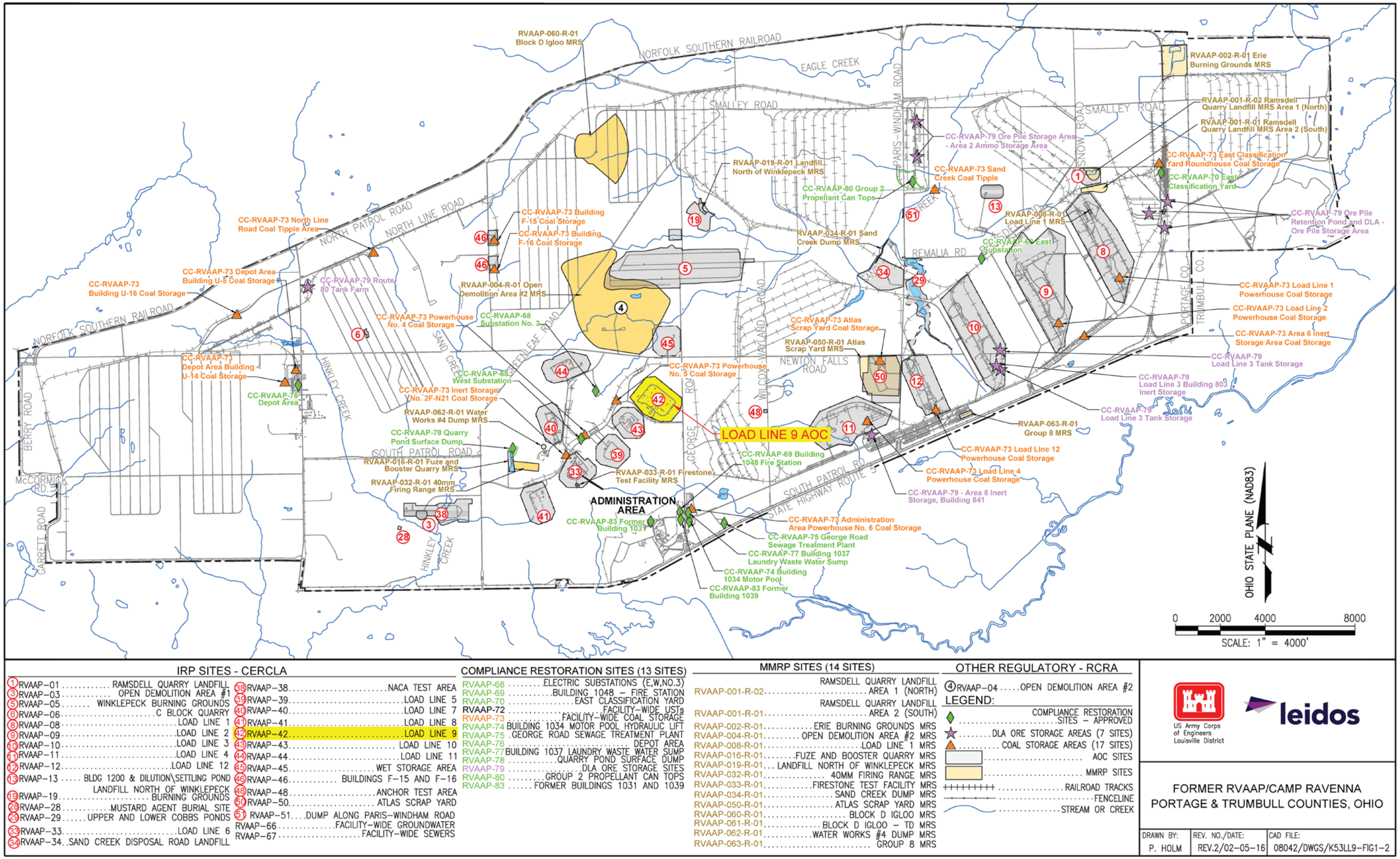

Figure 1-2. Location of AOCs and Munitions Response Sites at Camp Ravenna

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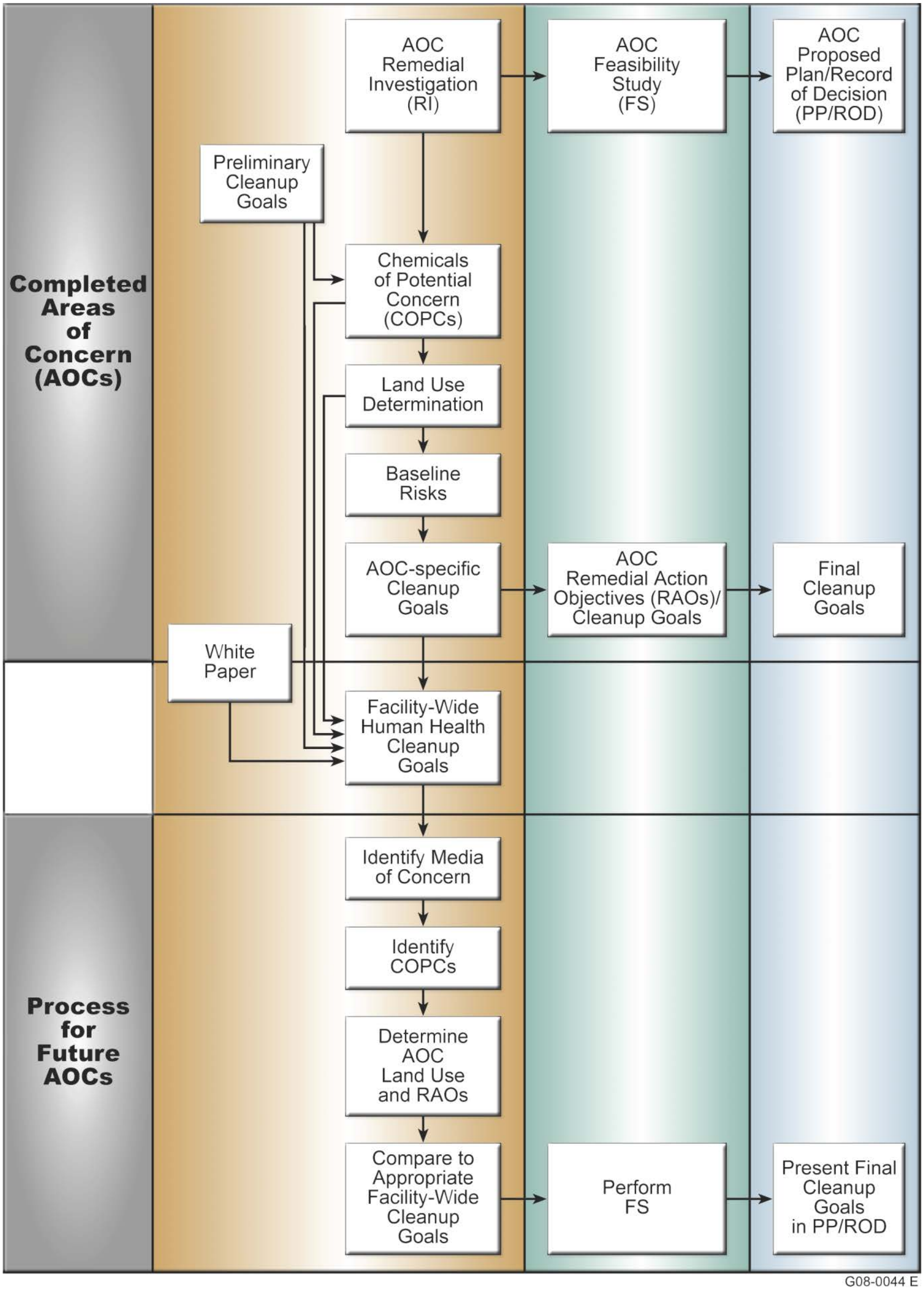

Figure 1-3. Process for Developing Remedial Decisions at Areas of Concern (USACE 2010a)

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2.0 BACKGROUND

This section provides a description of the facility. In addition, it summarizes Load Line 9's operational history, potential sources, building demolition activities, potential human health and ecological receptors, co-located or proximate sites, and potential site-related releases.

2.1 FACILITY-WIDE BACKGROUND INFORMATION

2.1.1 General Facility Description

The facility, consisting of 21,683 acres, is located in northeastern Ohio within Portage and Trumbull counties, approximately 4.8 kilometers (3 miles) east/northeast of the city of Ravenna and approximately 1.6 kilometers (1 mile) northwest of the city of Newton Falls (Figure 1-1). The facility, previously known as RVAAP, was formerly used as a load, assemble, and pack facility for munitions production. As of September 2013, administrative accountability for the entire acreage of the facility has been transferred to the U.S. Property and Fiscal Officer (USP&FO) for Ohio and subsequently licensed to the Ohio Army National Guard (OHARNG) for use as a military training site (Camp Ravenna). References in this document to RVAAP relate to previous activities at the facility as related to former munitions production activities or to activities being conducted under the restoration/cleanup program.

In 1978, the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) conducted an Installation Assessment of RVAAP to review the potential for contaminant releases at multiple former operations areas, as documented in Installation Assessment of Ravenna Army Ammunition Plant (USATHAMA 1978). According to the assessment, from 1941–1945 Load Lines 5-11 produced 19,257,297 miscellaneous fuzes, 44,297,485 miscellaneous boosters, 79,580,576 miscellaneous detonators, 226,387,306 percussion elements, and 50,660,725 primers.

The former RVAAP received bulk 2,4,6-trinitrotoluene (TNT) product during operational activities and did not manufacture/produce dinitrotoluene (DNT) or TNT. A facility where DNT is manufactured will have the following isomers of DNT in the finished product: 2,4-DNT; 2,6-DNT; 2,5-DNT; 3,4-DNT; 2,3-DNT; and 3,5-DNT. This is not applicable to the former RVAAP. Degradation of TNT to 2,4-DNT occurs in soil; however, 2,4-DNT and 2,6-DNT do not degrade to the lesser isomers. It is the Army's position that testing DNT isomers other than 2,4- and 2,6-DNT is unnecessary and has no additional value of being protective to human health and the environment at the former RVAAP (RVAAP 2013).

2.1.2 Demography and Land Use

Camp Ravenna occupies east-central Portage County and southwestern Trumbull County. Census projections for 2010 indicated the populations of Portage and Trumbull counties are 161,419 and 210,312, respectively. Population centers closest to Camp Ravenna are Ravenna, with a population of 11,724, and Newton Falls, with a population of 4,795.

The facility is located in a rural area and is not close to any major industrial or developed areas. Approximately 55% of Portage County, in which the majority of Camp Ravenna is located, consists of either woodland or farmland acreage. The closest major recreational area, the Michael J. Kirwan Reservoir (also known as West Branch Reservoir), is located adjacent to the western half of Camp Ravenna, south of State Route 5.

Camp Ravenna is federally owned and is licensed to the OHARNG for use as a military training site. Restoration activities at Camp Ravenna are managed by the Army National Guard and OHARNG. Training and related activities at Camp Ravenna include field operations and bivouac training, convoy training, maintaining equipment, C-130 aircraft drop zone operations, helicopter operations, and storing heavy equipment.

2.2 LOAD LINE 9 BACKGROUND INFORMATION

2.2.1 Operational History

Load Line 9, formerly known as the detonator line, is a 69-acre, fenced AOC located north of Fuze and Booster Road, west of George Road, and northeast of Load Line 10 in the south-central portion of Camp Ravenna (Figure 1-2 and Figure 2-1).

From 1941–1945, Load Line 9 operated at full capacity to produce fuze component parts for artillery projectiles. Load Line 9 was deactivated at the end of World War II, and the process equipment was removed. Load Line 9 has not been used since 1945, and no historical information exists to indicate Load Line 9 was used for any other processes, other than what is presented above.

All buildings within the AOC were demolished in 2003, and slabs and foundations were removed in 2003 and 2007. An old elevated water tank (WW-32) and perimeter fence are still in place. The elevated water tank is no longer connected to a water distribution system, and neither the elevated water tank nor the perimeter fence are currently maintained. Gravel perimeter roads are inside the AOC, as well as two dirt mounds immediately north-northeast of the locations of former Buildings DT-2 and DT-5. Small construction drainage ditches border the gravel perimeter road. Buildings DT-30 and DT-31 (shipping and storing inert material) remain northwest of the Load Line 9 boundary along Detonator Spur Road and are not part of the AOC.

2.2.2 Potential Sources

Historical facilities at Load Line 9 included 54 process and support buildings ranging in size from 34–8,141 ft^2. The locations of the former primary operational buildings are shown on Figure 2-1 and the aerial photograph shown on Figure 2-2. During World War II, there were 36 buildings directly associated with munitions production activities and 18 non-production buildings used at Load Line 9. Not all buildings were labeled consecutively at the load line; some building identifications remain unused.

Former buildings and site features that are not expected to be potential sources of contamination are presented and described below.

- Buildings DT-30 and DT-31 were used for shipping and storing inert material and were located northwest of Load Line 9 boundary on Detonator Spur Road;
- Building DT-35 was the control house;
- Building DT-52 was the dining facility;
- Building 9-51 was the time clock alley;
- Building 4511 was utilized for radio communication; and
- Drainage Ditches.

Table 2-1 presents a summary of potential sources of contamination at Load Line 9 and identifies potential sources, previous uses, if there were documented releases to the environment, and potential contaminants associated with the previous use. Some of the potential contaminants are documented; however, some professional judgment was made to determine if additional contaminants should be considered as a product of historical use of the site.

The 1978 Installation Assessment identified the major contaminants of the former RVAAP to be TNT, composition B [a combination of TNT and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)], sulfates, nitrates, lead styphnate, and lead azide. Additional potential contaminants at Load Line 9 based on operation history include mercury fulminate and heavy metals (lead, chromium, mercury, and arsenic) from munitions assembly activities; volatile organic compounds (VOCs) from former Building DT-33 that was utilized for solvent storage; polychlorinated biphenyls (PCBs) from on-site transformers; and PAHs from former Buildings DT-32 and DT-41 through DT-50 that were used as a heater houses.

2.2.3 Building Decontamination and Demolition

2.2.3.1 Building Thermal Decontamination and 5X Certification

In October 2002, Thermal Decontamination and 5X Certification of all buildings at Load Line 9 were initiated to burn structures in-place to remove potentially explosive residue from building material in order to achieve a 5X status. These activities and their results are presented in the *Thermal Decomposition and 5X Certification of Load Lines 6, 9 and Wet Storage Area Igloos 1, 1A, 2, & 2A* (MKM 2005) and are described below.

1. Paint on the interior of each building was sampled for PCBs and determined to be less than 50 parts per million (ppm), which indicates it is not regulated under 40 Code of Federal Regulations (CFR) 761.
2. The floors of each building were swept to remove the loose paint chips and other potentially contaminated debris. One cubic yard of paint chips and debris was removed from the floors, containerized, sampled, and disposed.

3. Hazardous items of environmental concern, including mercury-containing fluorescent lights and PCB light ballasts, were removed from all buildings in order to promote safe execution of the decontamination, burning, demolition, and removal operations.
4. Asbestos-containing roofing material (transite and composition rolled roof material) was removed from all the buildings; 127,119 ft^2 of asbestos-containing roofing material was removed from Load Line 9. All asbestos-containing material (ACM) was disposed offsite in accordance with federal, state, and local rules laws and regulations.

Based upon historical use of explosives at these facilities, the target decomposition temperature for Load Line 9 was 800°F. The buildings were loaded with clean, wooden pallets to augment the burning process. The target temperature was sustained for a period of 30 minutes.

After the thermal decontamination, the surface debris, ash, floor slabs, footers, and steel were removed. The footers at Buildings DT-3, DT-4, DT-6, DT-7, DT-8, DT-9, DT-10, DT-11, DT-12, DT-15, DT-17, DT-19, DT-23, DT-25, DT-26, DT-27, DT-33, DT-34, DT-35, and 9-51 were completely removed at the contractor’s discretion and as approved by RVAAP representatives. Additionally, the sumps at Buildings DT-1, DT-2, DT-5, and DT-11 were removed, and the basements at Buildings DT-28 and DT-29 were demolished in place to 3 ft bgs.

Prior to removal, the water contained in the sumps and basements was sampled to determine proper disposition. Based upon analytical results, all sump water (1,100 gal) was disposed offsite as hazardous waste. There were no indications of poor integrity of the sumps noted in the completion report. Lead liners were removed and recycled. Asbestos liners were removed, double bagged, and disposed as ACM. The sump cavities were backfilled to grade. However, contaminant concentrations in the basement water were low enough for Ohio EPA to allow ground application, but there are no specific records of the amount of water land applied.

Upon completing the demolition activities, all areas were re-graded, seeded, and mulched. Final AOC restoration operations were completed in November 2003.

2.2.3.2 Footer and Floor Slab Removal

From May 2006 to July 2007, Lakeshore Engineering Services, Inc. (LES) demolished and disposed buildings and their contents within Load Line 5, Load Line 7, Building 1039, and Building T-1604. As part of this effort, LES removed aboveground structures and floor slabs and footers to a minimum of 4 ft bgs at Load Line 9. These activities are discussed in the *Project Completion Report Munitions Response for the Demolition of Load Lines 5, 7, Building 1039, Transite Removal at Building T-1604, Removal of Remaining Concrete and Miscellaneous Debris at Load Lines 6, 9 and 11* (LES 2007b).

At Load Line 9, the floor slabs, foundations, and footers of former Buildings DT-2, DT-5, DT-13, DT-14, DT-16, DT-18, DT-18A, DT-20, DT-22, DT-24, DT28, DT-29, DT-32, DT-41, DT-42, DT-45, DT-46, DT-47, DT-52, DT-55, DT-56, and DT-57 were removed to a minimum of 4 ft bgs. All unused telephone poles and steam stanchions were removed from the load line and disposed accordingly. Upon completion, all disturbed areas were re-graded and seeded. Re-grading was performed in a manner to ensure positive drainage and allow for unimpeded mowing and ground maintenance. A site walkthrough was completed with the RVAAP Facility Manager to identify and remove any miscellaneous debris. Final AOC restoration operations were completed in July 2007.

2.2.4 AOC Boundary

Load Line 9 is bound by the existing perimeter fence, as presented in Figure 2-1. Load Line 9 is located north of Fuze and Booster Road, west of George Road, and northeast of Load Line 10. Separate investigations have occurred at the surrounding AOCs.

The AOC boundary encompasses the former production area (FPA) and non-production area (NPA). The FPA is 33.2 acres and is located within the gravel perimeter road. The buildings within the FPA were historically used to produce and store fuze component parts for artillery projectiles. The NPA is 35.8 acres and includes the area between the perimeter road and perimeter fence. The NPA contains the location of former solvent storage (DT-33), former detonator destroying house (DT-34), and associated control house (DT-35). The shipping and inert material storage buildings (DT-30 and DT-31) were located outside of the AOC along Detonator Spur Road and are not included within this AOC.

Also included in this RI is the dry well area (DWA). The DWA contains a 6-inch well that is approximately 190 ft north of the AOC perimeter.

2.2.5 Spatial Aggregates

For evaluation of the AOC, Load Line 9 was divided into three soil spatial aggregates and three sediment/surface water spatial aggregates. These spatial aggregates are presented on Figure 2-3. The three soil spatial aggregates are the FPA, NPA, and DWA. The FPA encompasses all production and non-production buildings. The NPA surrounds the FPA to the fence line, where no known activities occurred. The DWA was evaluated as a potential hotspot in the risk assessment. The three sediment and surface water spatial aggregates are the DWA, Drainage Ditches, and Off-AOC. The Drainage Ditches encompass the intermittent drainage conveyances and gullies constructed to direct surface water runoff. The Off-AOC samples (LL9sd-002, LL9sd-011, and LL9sw-002) were collected in 2003 outside the AOC fence line and are included in the nature and extent evaluation.

2.3 POTENTIAL RECEPTORS AT LOAD LINE 9

The following sections discuss potential human and ecological receptors at Load Line 9.

2.3.1 Human Receptors

Camp Ravenna is a controlled-access facility. Load Line 9 is located in the south-central portion of the facility and is not currently used for training (Figure 1-2).

In February 2014, the Army and Ohio EPA amended the risk assessment process to address changes in the RVAAP restoration program. The *Final Technical Memorandum: Land Uses and Revised Risk Assessment Process for the RVAAP Installation Restoration Program* (ARNG 2014) (herein referred to as the Technical Memorandum) identified three Categorical Land Uses and Representative Receptors to be considered during the RI phase of the CERCLA process:

1. Unrestricted (Residential) Land Use – Resident Receptor (Adult and Child) (formerly called Resident Farmer).
2. Military Training Land Use – National Guard Trainee.
3. Commercial/Industrial Land Use – Industrial Receptor (USEPA Composite Worker).

Unrestricted (Residential) Land Use is considered protective for all three Land Uses at Camp Ravenna. Therefore, if an AOC meets the requirements for Unrestricted (Residential) Land Use, then the AOC is also considered to have met the requirements of the other Land Uses (i.e., Commercial/Industrial and Military Training), and the other Land Uses do not require evaluation.

As stated in Paragraph 6.d of the Technical Memorandum, if an AOC fails to meet the Unrestricted (Residential) Land Use, then an FS will be completed that evaluates cleanup options for all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use]. Remedial alternatives for meeting each Land Use are to be evaluated per the current guidelines for selecting a remedy for the AOC. The preferred remedy is one that would meet Unrestricted (Residential) Land Use. RI/FS Reports in progress at the time of the Technical Memorandum's approval on February 11, 2014 will not be revised to include an evaluation of the Commercial/Industrial Land Use as an Alternative, if it achieves no further action for Unrestricted (Residential) Land Use.

2.3.2 Ecological Receptors

Camp Ravenna has a diverse range of vegetation and habitat resources. Habitats present within the facility include large tracts of closed-canopy hardwood forest, scrub/shrub open areas, grasslands, wetlands, open-water ponds and lakes, and semi-improved administration areas (OHARNG 2014).

An abundance of wildlife is present on the facility: 35 species of land mammals, 214 species of birds, 41 species of fish, and 34 species of amphibians and reptiles have been identified. The northern long-eared bat (*Myotis septentrionalis*; federally threatened) exists at Camp Ravenna. There are no other federally listed species and no critical habitat occurs (OHARNG 2014). Ohio state-listed plant and animal species have been identified through confirmed sightings and/or biological inventories at the facility and are presented in Table 2-2. The interior of the AOC is currently vegetated with grasses and shrub/scrub vegetation in unpaved areas and former building footprints, and has mature forest on the perimeter. Additional information specific to ecological resources at Load Line 9 is included in Section 7.3.

2.4 CO-LOCATED OR PROXIMATE SITES

The following subsections summarize sites that are co-located or proximate to Load Line 9 but are addressed separately.

2.4.1 Facility-wide Sewers

The defunct sanitary sewers within the perimeter of Load Line 9 are being investigated and assessed as part of the Facility-wide Sewers AOC (RVAAP-67). Storm sewers are not present at Load Line 9. Sanitary sewer sediment, pipe bedding material, and sewer water were evaluated as currently summarized in the *Draft Remedial Investigation/Feasibility Study Report for RVAAP-67 Facility-Wide Sewers* (USACE 2012a). The sanitary sewers in the Load Line 9 FA were part of network that flowed to the George Road Sewage Treatment Plant network. While cracks and joint separations within the sanitary sewer system have been observed due to the advanced age of the system, the pipes are generally intact, which limits vertical migration from sewer sediment to the exterior of the piping system.

Sewer water and sediment samples were collected during the 2003 Phase I RI (MKM 2007). The co-located samples were collected at two manholes within Load Line 9. Inspections and explosives field screening tests were conducted at the Load Line 9 FA during a 2007 *Summary of CERL Findings, RVAAP Sewer System (*USACE-CERL 2007) and the *Explosive Evaluation of Sewers* (LES 2007a). During this investigation, wipe samples were collected from nine sanitary sewer manholes and tested using Expray® and DropEx field screening methods. None of the sanitary sewer wipe samples tested positive for explosive residues.

Samples of sewer sediment, sewer water, and pipe bedding materials (e.g., soil or backfill beneath the pipe) were also collected in 2009 and 2010 as part of the Facility-wide Sewers RI (USACE 2012a). The compiled data provided effective characterization of the nature and extent of the contamination at the Load Line 9 FA, and no further sampling was recommended. All SRCs found in the subsurface sewer media samples within the Load Line 9 FA and evaluated through the stepwise fate and transport screening evaluation were eliminated as posing future impacts to groundwater.

The HHRA did not identify COCs at the Load Line 9 FA for the National Guard Trainee or Resident Receptor. Since the Load Line 9 FA has no sewer outfalls, no further action was recommended from an ecological perspective. In summary, the Facility-wide Sewers RI recommended no further action for the Load Line 9 sanitary sewers. The Facility-wide Sewers RI predated the Technical Memorandum that specified evaluation of a Commercial/Industrial Land Use; however, the Load Line 9 FA was determined to be protective for Unrestricted (Residential) Land Use. Therefore, an evaluation of Commercial/Industrial Land Use would not be required.

2.4.2 Facility-wide Groundwater

As part of the Installation Restoration Program (IRP), the Army implements the Facility-wide Groundwater Monitoring Program (FWGWMP) in accordance with previous agreements made with

Ohio EPA. The FWGWMP was initiated in 2005 and involves quarterly sampling of selected wells within the former RVAAP.

In 2009, for the FWGWMP, groundwater samples were collected from each of the seven wells associated with Load Line 9 (monitoring well LL9mw-001 is southwest of the AOC boundary). In 2010, groundwater data from wells LL9mw-002 and LL9mw-004 was collected for the FWGWMP. Most chemical concentrations in the groundwater were below the maximum contaminant level (MCL) and regional screening level (RSL) [target risk (TR) of 1E-05, hazard quotient (HQ) of 1]. The exceptions were arsenic in both wells in 2010, and iron and manganese in well LL9mw-004 (EQM 2015a). Additional groundwater level monitoring was performed in May 2014 at the seven monitoring wells at Load Line 9; however, no samples were collected (EQM 2015a).

Facility-wide groundwater is currently at the RI phase of the CERCLA process. Any future decisions or actions respective to groundwater at Load Line 9 will be addressed as part of that facility-wide AOC.

2.4.3 Fuze and Booster Area Settling Tanks

The RVAAP-26 Fuze and Booster Area Settling Tanks AOC is comprised of 15 tanks in various load lines in the former RVAAP. The 15 tanks have also been referred to as “settling basins” or simply “basins” and were used for settling out explosive contamination from wastewater during production activities from 1941–1945 and 1969–1970. Two of the tanks are former concrete underground settling basins measuring 10 ft by 8 ft by 8 ft (4,800 gal) and 8 ft by 8 ft by 6 ft (2,880 gal) that were located at Load Line 9 and were removed in November 1988. These tanks were located at former Buildings DT-2 (Fulminate Mix House) and DT-5 (Azide Mix House) (USACE 1996).

Settled sludge was periodically collected from the tanks (every one to three months) and transferred to one of the burning grounds for thermal destruction. The final method of disposal of the water from the tanks is not definitely known. It may have been pumped onto the ground surface or into the sewer systems (USAEHA 1994). The soil surrounding the process buildings sourcing the effluent to the settling tanks may also be of concern because building washout operations historically resulted in the release of waste water on the ground adjacent to the building exits.

In 1971, all the tanks were emptied, cleaned, and covered. These tanks were removed by the installation in November 1988 (Jacobs 1989 and USACE 1996). Regarding all settling tanks in the Fuze and Booster Area, the 1989 Resource Conservation and Recovery Act (RCRA) Facility Assessment states, “there is a high potential for releases to soil and groundwater from this unit. The integrity of the tank and associated plumbing is not known. Extensive contamination may have occurred.” Releases from these tanks were suspected, but not known.

As stated in the 2004 Installation Action Plan, the RVAAP-26 Fuze and Booster Area Settling Tanks AOC was considered Response Complete under the IRP since each load line became its own AOC. Explosive contamination in surface and subsurface soil was evaluated during the Phase I RI and PBA08 RI, as discussed in Section 4.0.

2.4.4 Munitions Response Sites

There is no munitions response site within or adjacent to the AOC boundary identified as part of the Military Munitions Response Program.

2.4.5 Compliance Restoration Sites

There are no compliance restoration sites, such as former or existing underground storage tanks (USTs), within or adjacent to the AOC boundary.

2.5 POTENTIAL SITE-RELATED RELEASES

As presented in Table 2-1, there have been no documented site-related releases at Load Line 9. Table 2-1 presents potential contaminants that may be present in Load Line 9 media from previous use of the site.

Table 2–1. Potential Source Area Description and Potential Impacts

Potential Sources or Areas for Investigation	Previous Use and/or Description	Documented Release	Potential Contaminants from Use
Building DT–1	1941–1945 - Utilized for explosive processing – (fulminate napkin prep building).	None	Mercury fulminate
Building DT-2	1941–1945 - Utilized for explosive processing (fulminate mix house). DT-2 had a concrete settling tank for settling out explosive contamination from wastewater (part of former RVAAP-26 AOC).	None	Mercury fulminate
Building DT-3	1941–1945 - Utilized for explosive processing (fulminate dry house).	None	Mercury fulminate
Building DT-4	1941–1945 - Utilized for explosive (lead azide) processing - Azide receptacle house.	None	Lead azide
Building DT-5	1941–1945 - Utilized for explosive (lead azide) processing - Azide mix house DT-5 also had a concrete settling tank for settling out explosive contamination from wastewater (part of former RVAAP-26 AOC).	None	Lead azide
Building DT-6	1941–1945 - Utilized for explosive (lead azide) processing -Azide dry house	None	Lead azide
Building DT-7	1941–1945 - Utilized for explosive (lead azide) processing - Azide screen house	None	Lead azide
Building DT-8	1941–1945 - Utilized for explosive (lead azide) processing - Azide dry house.	None	Lead azide
Building DT-9	1941–1945 - Utilized for explosive (lead azide) processing - Azide dry house.	None	Lead azide
Building DT-10	1941–1945 - Utilized for explosive (lead azide) processing - Vacuum pump house	None	Lead azide, mercury fulminate
Building DT-11	1941–1945 - Utilized for explosive (lead azide) processing - Azide napkin prep.	None	Lead azide
Building DT–12	1941–1945 - Stored saw dust.	None	Mercury fulminate, lead azide
Building DT–13	1941–1945 - Utilized for final inspection, packing, & shipping.	None	Mercury fulminate, lead azide
Building DT–14	1941–1945 - Utilized for detonator rumbling.	None	Mercury fulminate, lead azide
Building DT–15	1941–1945 - Utilized as detonator rest house.	None	Mercury fulminate, lead azide
Buildings DT–16 and DT-17	1941–1945 - Utilized for the assembly and charge of M22 boosters.	None	Mercury fulminate, lead azide
Buildings DT–18 and DT-18A	1941–1945 - Detonator test buildings.	None	Mercury fulminate, lead azide
Building DT–19	1941–1945 - Utilized as prep primer mix (azide) magazine.	None	Lead azide
Buildings DT–20, DT-21, and DT-22	1941–1945 - Utilized as loading buildings.	None	Mercury fulminate, lead azide
Buildings DT–23	1941-1945 - Explosive (tetryl) pellet storage.	None	Tetryl
Building DT-24	1941-1945 - Explosive (tetryl) pellet processing.	None	Tetryl
Building DT–25	1941–1945 - Utilized as mercury fulminate service magazine.	None	Mercury fulminate

Table 2–1. Potential Source Area Description and Potential Impacts (continued)

Potential Sources or Areas for Investigation	Previous Use and/or Description	Documented Release	Potential Contaminants from Use
Building DT–26	1941–1945 - Utilized for tetryl screening & blending, and storage.	None	Tetryl
Building DT-27	1941–1945 - Utilized for tetryl screening & blending, and storage.	None	Tetryl
Buildings DT-28 and DT-29	1941–1945 - Utilized as change houses where workers changed out of work clothing at end of shift.	None	Metals, explosives
Building DT–33	1941–1945 - Utilized for solvent storage.	None	Mercury fulminate, lead azide, solvents
Building DT–34	1941–1945 - Served as the detonator destroying house.	None	Mercury fulminate, lead azide
Buildings DT–54, DT-55, and DT-56	1941–1945 -Utilized as dry houses.	None	Mercury fulminate, lead azide
Building DT-57	1941–1945 - Utilized as the tracer destroying house.	None	Metals, Explosives
Buildings DT-32, DT-41 through DT-50	1941–1945 - Heater houses.	None	Metals, PAHs
WW-32	Elevated water tank	None	Lead
Building T-3417	Served as the former generator house for portable power generation. A historical drawing (#1500.9, dated April 1971), indicated this building was located within the footprint of the elevated water tank (WW-32). However, this drawing was revised in October 1979, which indicated T-3417, but did show a new generator house, T-4514, just north of WW-32.	None	Diesel fuel, oils
Building T-4514	Served as the generator house for portable power generation. A historical drawing (#1500.9, dated April 1971, revised in 1979) indicated this new or relocated location just north of the elevated water tank (WW-32).	None	Diesel fuel, oils
Dry Well Area (DWA)	The DWA is a 6-inch well that existed approximately 190 ft north of the AOC perimeter that served as a drainage conduit from Load Line 9 [potential releases from the fulminate and azide dry houses (DT-2 and DT-5) through 6-inch vitrified earthen lines].	None	Mercury fulminate, lead azide
Transformers	Historical records indicated four transformers: one serviced the maintenance shop, two serviced all other buildings, and one serviced the elevated water tank. All transformers were tested for PCBs (147, 186, 216, and 32 ppm PCBs, respectively). Three transformers were removed on October 1, 1992, and the water tank transformer was removed on July 1, 1993, and transferred to Building 854 (RVAAP-27, PCB storage) awaiting final disposition by the Defense Reutilization Material Office.	None	PCBs

AOC = Area of concern.
ft = Feet.
PAHs = Polycyclic aromatic hydrocarbons
PCB = Polychlorinated biphenyl.
ppm = Parts per million.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
RVAAP = Ravenna Army Ammunition Plant.
TNT = 2,4,6-Trinitrotoluene.

Table 2–2. Federal- and State-listed Species List

CAMP RAVENNA JOINT MILITARY TRAINING CENTER RARE SPECIES LIST	
December 2014	
I. Species confirmed to be on Camp Ravenna property by biological inventories and confirmed sightings.	
A. Federal Threatened	
1. Northern long-eared bat, *Myotis septentrionalis*	
B. State Endangered	
1. American bittern, *Botaurus lentiginosus* (migrant) 2. Northern harrier, *Circus cyaneus* 3. Sandhill Crane, *Grus Canadensis* (probable nester) 4. Black bear, *Ursus americanus* 5. Mountain Brook Lamprey, *Ichthyomyzon greeleyi* 6. Brush-tipped emerald, *Somatochlora walshii* 7. Graceful Underwing, *Catocala gracilis*	8. Tufted Moisture-loving Moss, *Philonotis Fontana var. caespitosa* 9. Appalachian quillwort, *Isoetes engelmannii* 10. Handsome sedge, *Carex formosa* 11. Narrow-necked Pohl's Moss, *Pohlia elongata var. elongate* 12. Philadelphia panic-grass, *Panicum philadelphicum* 13. Variegated scouring-rush, *Equisetum variegatum*
C. State Threatened	
1. Barn owl, *Tyto alba* 2. Least bittern, *Ixobrychus exilis* 3. Trumpeter swan, *Cygnus buccinators* (migrant) 4. Bobcat, *Felis rufus* 5. Caddis fly, *Psilotreta indecisa*	6. Hobblebush, Viburnum alnifolium 7. Simple willow-herb, *Epilobium strictum* 8. Lurking leskea, *Plagiothecium latebricola* 9. Strict blue-eyed grass, *Sisyrinchium montanum*
D. State Potentially Threatened Plants	
1. Arborvitae, *Thuja occidentalis* 2. False hop sedge, *Carex lupiliformis* 3. Greenwhite sedge, *Carex albolutescens* 4. Long Beech Fern, *Phegopteris connectilis* (*Thelypteris phegopteris*) 5. Pale sedge, *Carex pallescens*	6. Sharp-glumed manna-grass, *Glyceria acutifolia* 7. Straw sedge, *Carex straminea* 8. Water avens, *Geum rivale* 9. Woodland Horsetail, *Equisetum sylvaticum* 10. Shining ladies'-tresses, *Spiranthes lucida*
E. State Species of Concern	
1. Big brown bat, *Eptesicus fuscus* 2. Deer mouse, *Peromyscus maniculatus* 3. Eastern red bat, *Lasiurus borealis* 4. Hoary bat, *Lasiurus cinereus* 5. Little brown bat, *Myotis lucifugus* 6. Northern long-eared bat, *Myotis septentrionalis* 7. Pygmy shrew, *Sorex hovi* 8. Southern bog lemming, *Svnaptomys cooperi* 9. Star-nosed mole, *Condylura cristata* 10. Tri-colored bat, *Perimyotis subflavus* 11. Woodland jumping mouse, *Napaeozapus insignis* 12. Sharp-shinned hawk, *Accipiter striatus* 13. Marsh wren, *Cistothorus palustris* 14. Henslow's sparrow, *Ammodramus henslowii* 15. Cerulean warbler, *Dendroica cerulean* 16. Prothonotary warbler, *Protonotaria citrea* 17. Bobolink, *Dolichonyx oryzivorus*	18. Northern bobwhite, *Colinus virginianus* 19. Common moorhen, *Gallinula chloropus* 20. Great egret, *Ardea alba* (migrant) 21. Sora, *Porzana carolina* 22. Virginia Rail, *Rallus limicola* 23. Yellow-bellied Sapsucker, *Sphyrapicus varius* 24. Creek heelsplitter, *Lasmigona compressa* 25. Eastern box turtle, *Terrapene carolina* 26. Four-toed Salamander, *Hemidacrylium scutatum* 27. Eastern garter snake, *Thamnophis sirtalis* 28. Smooth green snake, *Opheodrys vernalis* 29. Eastern sand darter, *Ammocrypta pellucida* 30. *Stenonema ithica* (mayfly) 31. *Apamea mixta* (moth) 32. *Brachylomia algens* (moth) 33. Scurfy quaker, Homorthodes furfurata 34. Sedge wren, Cistothorus platensis

Table 2–2. Federal- and State-listed Species List (continued)

CAMP RAVENNA JOINT MILITARY TRAINING CENTER RARE SPECIES LIST
December 2014

F. State Special Interest

1. American black duck, *Anas rubripes*
2. Canada warbler, Wilsonia Canadensis
3. Dark-eyed junco, *Junco hyemalis* (migrant)
4. Hermit thrush, *Catharus guttatus* (migrant)
5. Least flycatcher, *Empidonax minimus*
6. Magnolia warbler, *Dendroica magnolia*
7. Northern waterthrush, *Seiurus noveboracensis*
8. Winter wren, *Troglodytes troglodytes*
9. Back-throated blue warbler, *Dendroica caerulescens*
10. Brown creeper, *Certhia Americana*
11. Mourning warbler, *Oporornis Philadelphia*
12. Pine siskit, *Carduelis pinus*
13. Purple finch, *Carpodacus purpureus*
14. Red-breasted nuthatch, *Sitta Canadensis*
15. Golden-crowned kinglet, *Regulus satrapa*
16. Blackburnian warbler, *Dendroica fusca*
17. Gadwall, *Anas strepera*
18. Green-winged teal, *Anas crecca*
19. Northern shoveler, *Anas clypeata*
20. Redhead duck, *Aytya Americana*
21. Ruddy duck, *Oxyura jamaicensis*
22. Wilson’s snipe, *Gallinago delicata*
23. Subflava sedge borer, *Capsula subflava*

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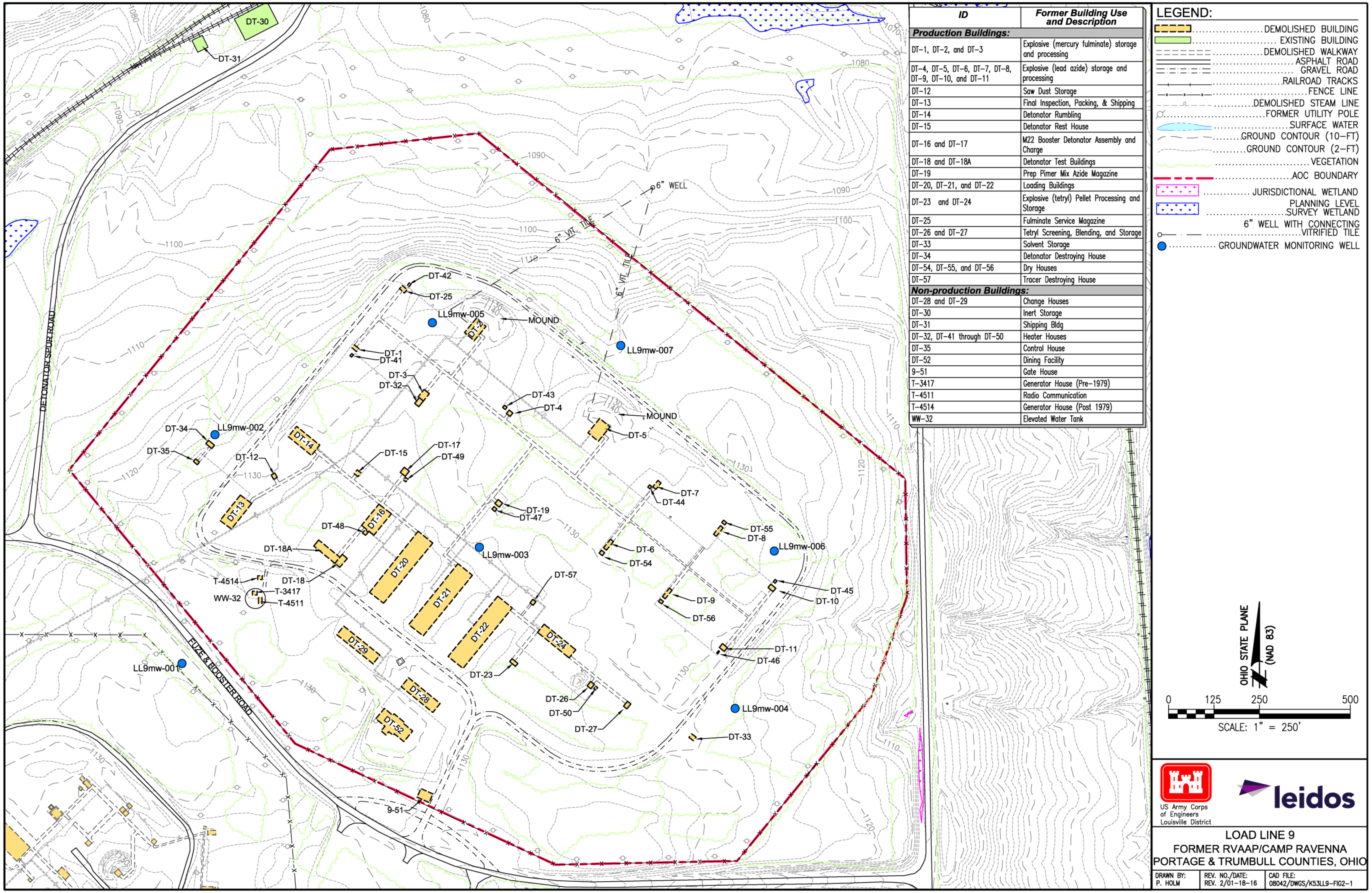
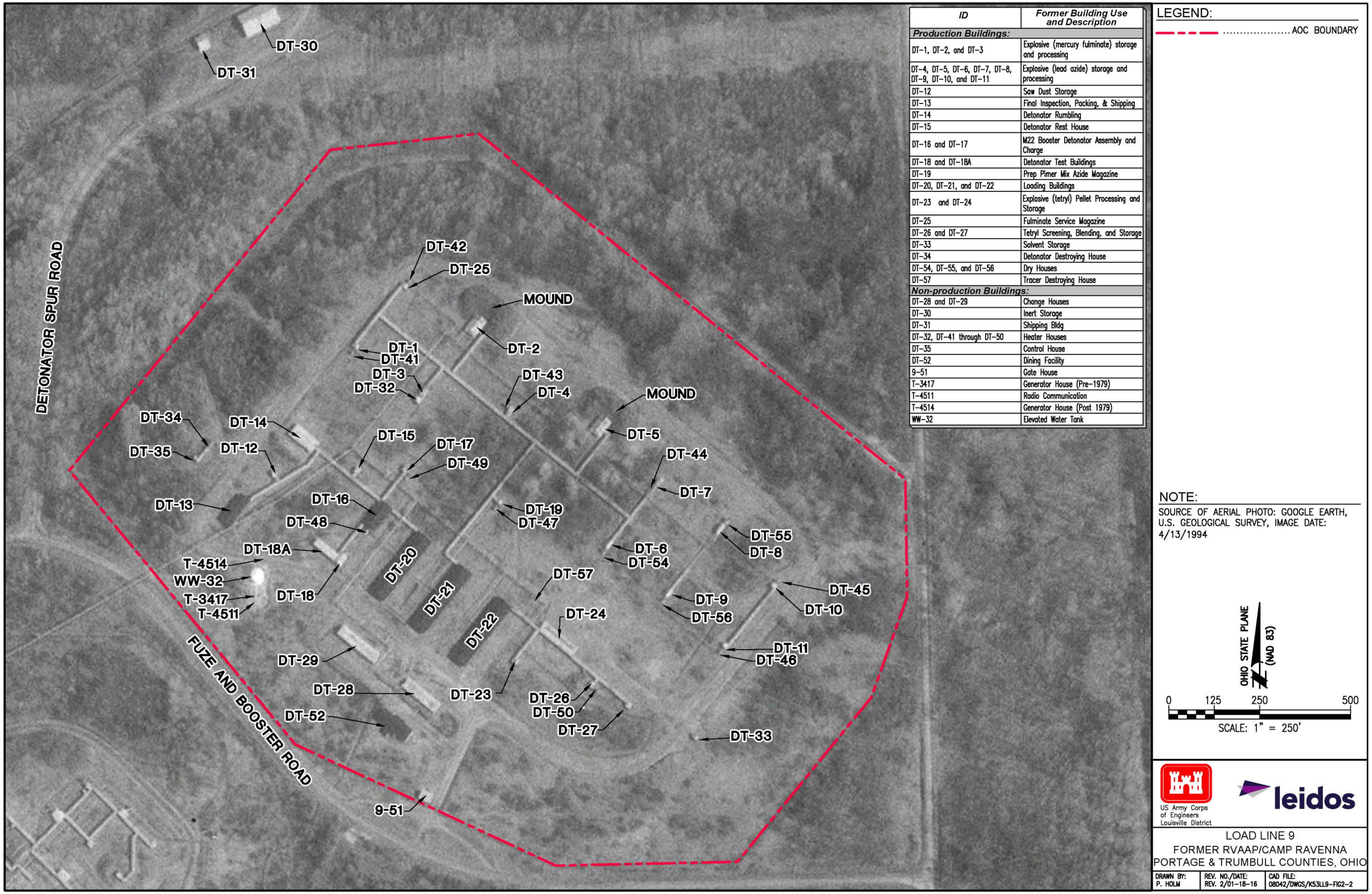


ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

Figure 2-1. Load Line 9 Map and AOC Features



ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
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Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

LEGEND:

- - - .... AOC BOUNDARY

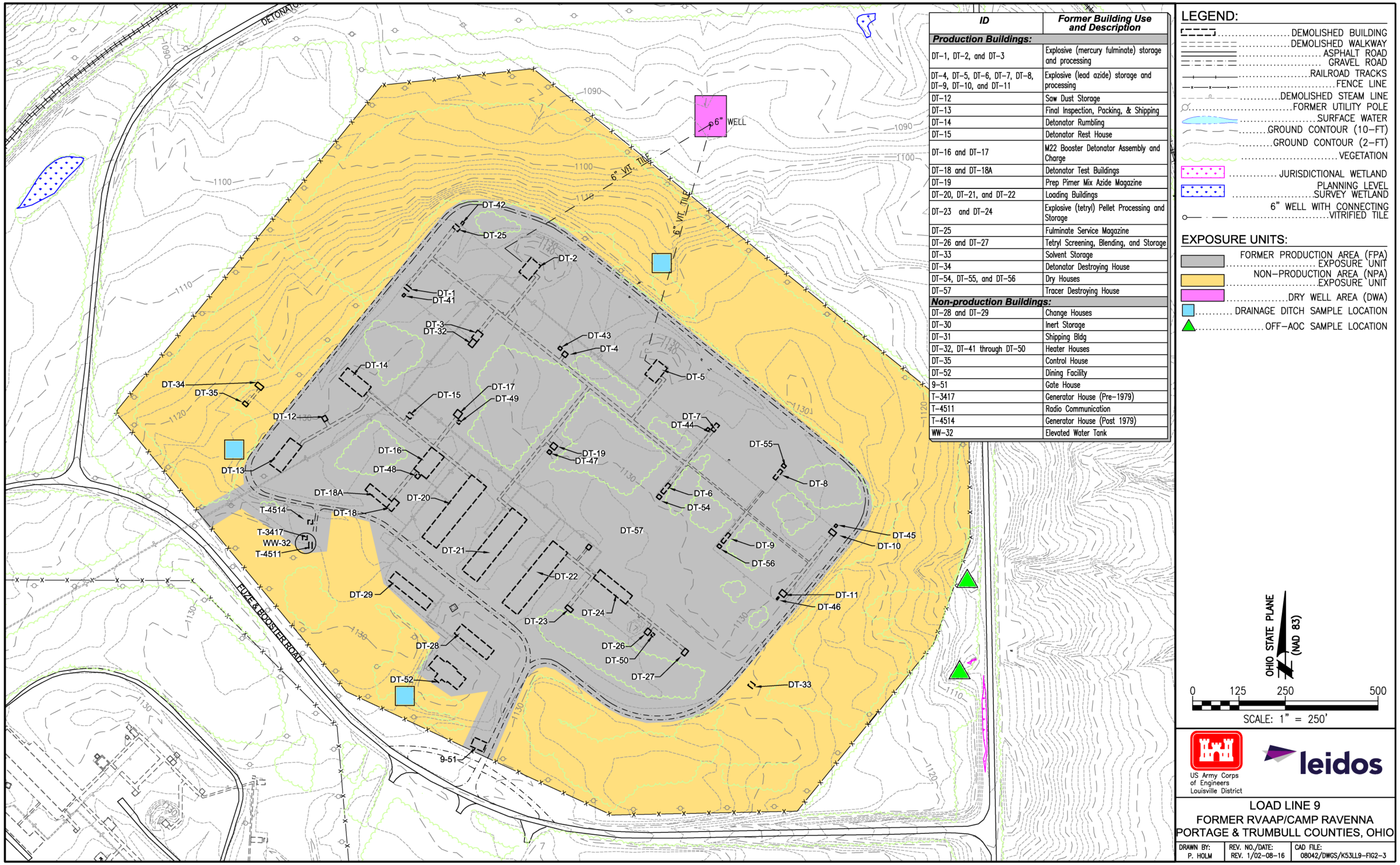
NOTE:

SOURCE OF AERIAL PHOTO: GOOGLE EARTH, U.S. GEOLOGICAL SURVEY, IMAGE DATE: 4/13/1994

LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	REV. 2/01-18-16	08042/DWGS/K53LL9-FIG2-2

Figure 2-2. Load Line 9 Site Features Prior to Building Demolition (Aerial Photo dated 4/13/94)



ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
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DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

Figure 2-3. Load Line 9 Aggregates

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3.0 ENVIRONMENTAL SETTING

This section describes the physical features, topography, geology, hydrogeology, and environmental characteristics of Camp Ravenna at Load Line 9 that are factors in identifying the potential contaminant transport pathways, receptor populations, and exposure scenarios to evaluate human health and ecological risk.

3.1 CAMP RAVENNA PHYSIOGRAPHIC SETTING

Camp Ravenna is located within the southern New York Section of the Appalachian Plateaus physiographic province (USGS 1968). This province is characterized by elevated uplands underlain primarily by Mississippian and Pennsylvanian age bedrock units that are horizontal or gently dipping. The province is characterized by its rolling topography, with incised streams having dendritic drainage patterns. The southern New York Section has been modified by glaciation, which rounded ridges, filled major valleys, and blanketed many areas with glacially-derived unconsolidated deposits (e.g., sand, gravel, and finer-grained outwash deposits). As a result of glacial activity in this section, old stream drainage patterns were disrupted in many locales, and extensive wetland areas developed.

3.2 SURFACE FEATURES AND AOC TOPOGRAPHY

The topography of Camp Ravenna is gently undulating, with an overall decrease in ground elevation from a topographic high of approximately 1,220 ft above mean sea level (amsl) in the far western portion of the facility to low areas at approximately 930 ft amsl in the far eastern portion of the facility.

USACE mapped the facility topography in February 1998 using a 2-ft contour interval with an accuracy of 0.02 ft. USACE based the topographic information on aerial photographs taken during the spring of 1997. The USACE survey is the basis for the topographical information illustrated in figures included in this report.

Load Line 9 is a 69-acre, fenced AOC located north of Fuze and Booster Road, west of George Road, and northeast of Load Line 10 in the south-central portion of Camp Ravenna (Figures 1-2 and 2-1). With the exception of an old elevated water tank (WW-32), all buildings and structures have been demolished and building slabs and footers have been removed. Additionally, the sumps at Buildings DT-1, DT-2, DT-5, and DT-11 were removed, and the basements at DT-28 and DT-29 were demolished in place to 3 ft below grade (MKM 2005). Soil in the vicinity of former production buildings was extensively disturbed during building demolition activities. The work areas were re-graded, and the area was vegetated in 2003 and 2007. Off-site backfill may have been used to regrade the site. In 2007, 33 loads of backfill material from Load Line 9 were used to fill the basement of the former Building 1039 (Chemical Laboratory) to within 2 ft of grade (MKM 2005 and LES 2007b).

Topographic relief at the AOC is moderate, with a topographic high in the south-central portion of the AOC that slopes radially downward to the AOC boundaries and the topographic low in the northwestern boundary of the AOC. Ground elevations within Load Line 9 range from approximately

1,088–1,136 ft amsl (Figure 3-1). Surface water follows topographic relief and drains into drainage ditches and overland to the northwest portion of the AOC.

3.3 SOIL AND GEOLOGY

3.3.1 Regional Geology

The regional geology at Camp Ravenna consists of horizontal to gently dipping bedrock strata of Mississippian and Pennsylvanian age, overlain by varying thicknesses of unconsolidated glacial deposits. The bedrock and unconsolidated geology at Camp Ravenna and the geology specific to Load Line 9 are presented in the following subsections.

3.3.2 Soil and Glacial Deposits

Bedrock at Camp Ravenna is overlain by deposits of the Wisconsin-age Lavery Till in the western portion of the facility and the younger Hiram Till and associated outwash deposits in the eastern two-thirds of the facility (Figure 3-2). Unconsolidated glacial deposits vary considerably in their character and thickness across Camp Ravenna, from zero in some of the eastern portions of the facility to an estimated 150 ft in the south-central portion.

Thin coverings of glacial material have been completely removed as a consequence of human activities at locations such as Ramsdell Quarry. Bedrock is present at or near the ground surface in locations such as at Load Line 1 and the Erie Burning Grounds (USACE 2001a). Where this glacial material is still present, its distribution and character indicate its origin as ground moraine. These tills consist of laterally discontinuous assemblages of yellow-brown, brown, and gray silty clays to clayey silts, with sand and rock fragments. Lacustrine sediment from bodies of glacial-age standing water has also been encountered in the form of deposits of uniform light gray silt greater than 50-ft thick in some areas (USACE 2001a).

Soil at Camp Ravenna is generally derived from the Wisconsin-age silty clay glacial till. Distributions of soil types are discussed and mapped in the *Soil Survey of Portage County, Ohio*, which describes soil as nearly level to gently sloping and poor to moderately well drained (USDA 1978). Much of the native soil at Camp Ravenna was disturbed during construction activities in former production and operational areas of the facility.

The Sharon Member of the Pennsylvanian Pottsville Formation is the primary bedrock beneath Camp Ravenna. In the western half of the facility, the upper members of the Pottsville Formation, including the Connoquenessing Sandstone (also known as the Massillon Sandstone), Mercer Shale, and uppermost Homewood Sandstone, have been found. The regional dip of the Pottsville Formation measured in the western portion of Camp Ravenna is between 5–11.5 ft per mile to the south.

3.3.3 Geologic Setting of Load Line 9

The bedrock formation observed at Load Line 9, as inferred from existing geologic data, is the Pennsylvanian age Pottsville Formation, Homewood Sandstone Member (Figure 3-3). The Homewood Sandstone Member, the uppermost unit of the Pottsville Formation, exhibits irregular and widely spaced bedding planes and vertical joints. The Homewood is fine-grained sandstone composed of well-rounded quartz grains and substantial quantities of mica. It is bonded with iron oxides and clay matter. Soil borings at Load Line 9 indicate the presence of bedrock at ground surface in the northwestern portion of the AOC to 15.5 ft bgs at LL9mw-001 just outside the southwest boundary of the AOC. Cross-sections of the Load Line 9 subsurface were created from monitoring well lithology records to illustrate lateral distribution and variation of the discontinuous glacial sediment atop bedrock (MKM 2007).

The two soil types observed at the AOC are the Loudonville silt loam (2-6% slopes) and the Dekalb channery loam (2-6% slopes and 6-12% slopes). The Dekalb channery loam (DkB), which comprises 70% of the AOC, is a moderately sloping, well-drained soil formed from residuum weathered from sandstone where unweathered bedrock is generally less than 40 inches bgs. The Dekalb channery fine sandy loam has a low water capacity where depth to the water table is greater than 6 ft bgs. The Loudonville silt loam covers the remaining 30% of the AOC. The Loudonville silt loam is a gently sloping, well drained silt formed from residuum weathered from sandstone where unweathered bedrock is generally less than 48 inches bgs (USDA 2010).

As observed in PBA08 RI soil borings, the composition of unconsolidated deposits at the AOC generally consist of silty clay, with fine sand overlaying native yellowish-red to yellowish-brown, medium dense, silty, micaceous sands. The sands have trace sandstone fragments, and sand content generally increases with depth. Groundwater was not encountered prior to reaching the bedrock interface in the PBA08 RI soil borings. PBA08 RI boring logs, which contain geologic descriptions of unconsolidated deposits at Load Line 9, are included in Appendix A. Geologic descriptions of subsurface soil samples collected during the PBA08 RI are generally consistent with the conclusions from the Phase I RI. Cross-sections of the Load Line 9 subsurface were created from monitoring well lithology records to illustrate lateral distribution and variation of the discontinuous glacial sediment (MKM 2007).

Geotechnical analyses conducted during the Phase I RI classified the soil as a lean clay with sand and sandy, silty clay (MKM 2007). Twelve geotechnical samples for grain size were also obtained from sediment samples collected at Load Line 9 during the Phase I RI. No geotechnical samples were collected during the PBA08 RI.

3.4 HYDROGEOLOGY

3.4.1 Regional Hydrogeology

Sand and gravel aquifers are present in the buried-valley and outwash deposits in Portage County, as described in the *Phase I Remedial Investigation Report for High-Priority Areas of Concern* (USACE

1998). Generally, these saturated zones are too thin and localized to provide large quantities of water for industrial or public water supplies; however, yields are sufficient for residential water supplies. Lateral continuity of these aquifers is unknown. Recharge of these units is derived from surface water infiltration of precipitation and surface streams. Specific groundwater recharge and discharge areas at Camp Ravenna have not been delineated.

The thickness of the unconsolidated interval at Camp Ravenna ranges from thin to absent in the eastern and northeastern portion of Camp Ravenna, to an estimated 150 ft in the central portion of the facility. The groundwater table occurs within the unconsolidated zone in many areas of the facility. Because of the heterogeneous nature of the unconsolidated glacial material, groundwater flow patterns are difficult to determine with a high degree of accuracy. Vertical recharge from precipitation likely occurs via infiltration along root zones, desiccation cracks, and partings within the soil column. Laterally, most groundwater flow likely follows topographic contours and stream drainage patterns, with preferential flow along pathways (e.g., sand seams, channel deposits, or other stratigraphic discontinuities) having higher permeabilities than surrounding clay or silt-rich material. Figure 3-4 illustrates facility-wide potentiometric surface data in the unconsolidated interval from the January 2010 contemporaneous measurement event (EQM 2010).

Within bedrock units at Camp Ravenna, the principle water-bearing aquifer is the Sharon Sandstone/Conglomerate. Depending on the existence and depth of overburden, the Sharon Sandstone/Conglomerate ranges from an unconfined to a leaky artesian aquifer. Water yields from on-site water supply wells completed in the Sharon Sandstone/Conglomerate ranged from 30–400 gallons per minute (gpm) (USATHAMA 1978). Well yields of 5–200 gpm were reported for on-site bedrock wells completed in the Sharon Sandstone/Conglomerate (Kammer 1982). Other local bedrock units capable of producing water include the Homewood Sandstone, which is generally thinner and only capable of well yields less than 10 gpm, and the Connoquenessing Sandstone. Wells completed in the Connoquenessing Sandstone in Portage County have yields ranging from 5–100 gpm but are typically less productive than the Sharon Sandstone/Conglomerate due to lower permeabilities (Winslow et al. 1966).

Figure 3-5 shows the potentiometric surface within bedrock strata at Camp Ravenna in January 2010 (EQM 2010). The bedrock potentiometric map shows a more uniform and regional eastward flow direction than the unconsolidated zone that is not as affected by local surface topography. Due to the lack of well data in the western portion of Camp Ravenna, general flow patterns are difficult to discern. For much of the eastern half of Camp Ravenna, bedrock potentiometric elevations are higher than the overlying unconsolidated potentiometric elevations, indicating an upward hydraulic gradient. This evidence suggests there is a confining layer that separates the two aquifers. In the far eastern area, the two potentiometric surfaces are at approximately the same elevation, suggesting hydraulic communication between the two aquifers is occurring.

3.4.2 Load Line 9 Hydrologic/Hydrogeologic Setting

Seven groundwater monitoring wells were installed at Load Line 9 during the Phase I RI. Initial depths to groundwater encountered during well installation varied from 10–23.4 ft bgs. All monitoring wells have groundwater elevations collected under the FWGWMP. All monitoring wells at Load Line 9 were screened and currently monitor bedrock groundwater in the Homewood Sandstone. Groundwater was not observed in the unconsolidated overburden at Load Line 9.

The potentiometric surface of the AOC from the January 2010 monitoring event is shown in Figure 3-1. The estimated groundwater flow directions reflect the January 2010 facility-wide potentiometric data presented in the *Facility-Wide Groundwater Monitoring Program Report on the January 2010 Sampling Event* (EQM 2010). Water level elevations at the AOC had a range of 1,110.36–1,124.15 ft amsl. The potentiometric surface shows the groundwater flowing radially away from the south central portion of the AOC, with a dominant northeasterly flow direction. Available historical data do not show large seasonal fluctuations in the general groundwater flow direction. The average hydraulic gradient is approximately 0.0231 ft/ft.

Results of rising and falling head slug tests performed at the seven monitoring wells during the Phase I RI indicate an average hydraulic conductivity of 3.89E-04 cm/s (MKM 2007). Table 3-1 presents the hydraulic conductivity results for each well at Load Line 9.

3.4.3 Surface Water

The following sections describe the regional and AOC-specific surface water.

3.4.3.1 Regional Surface Water

Camp Ravenna resides within the Mahoning River watershed, which is part of the Ohio River basin. The west branch of the Mahoning River is the main surface stream in the area. The west branch flows adjacent to the west end of the facility, generally in a north to south direction, before flowing into the Michael J. Kirwan Reservoir, located to the south of State Route 5 (Figure 1-1). The west branch flows out of the reservoir and parallels the southern Camp Ravenna boundary before joining the Mahoning River east of Camp Ravenna. The western and northern portions of Camp Ravenna display low hills and a dendritic surface drainage pattern. The eastern and southern portions are characterized by an undulating to moderately level surface, with less dissection of the surface drainage. The facility is marked with marshy areas and flowing and intermittent streams whose headwaters are located in the upland areas of the facility.

The three primary watercourses that drain Camp Ravenna are (Figure 1-2):

- South fork of Eagle Creek,
- Sand Creek, and
- Hinkley Creek.

These watercourses have many associated tributaries. Sand Creek, with a drainage area of 13.9 square miles (36 km^2), generally flows in a northeast direction to its confluence with the south fork of Eagle Creek. In turn, the south fork of Eagle Creek continues in a northerly direction for 2.7 miles to its confluence with Eagle Creek. The drainage area of the south fork of Eagle Creek is 26.2 square miles, including the area drained by Sand Creek. Hinkley Creek originates just southeast of the intersection between State Route 88 and State Route 303 to the north of the facility. Hinkley Creek, with a drainage area of 11 square miles, flows in a southerly direction through the facility and converges with the west branch of the Mahoning River south of the facility (USACE 2001a).

Approximately one-third of Camp Ravenna meets the regulatory definition of a wetland, with the majority of the wetland areas located in the eastern portion of the facility. Wetland areas at Camp Ravenna include seasonal wetlands, wet fields, and forested wetlands. Many of the wetland areas are the result of natural drainage or beaver activity; however, some wetland areas are associated with anthropogenic settling ponds and drainage areas.

Approximately 50 ponds are scattered throughout the facility. Many were constructed within natural drainage ways to function as settling ponds or basins for process effluent and runoff. Others are natural in origin, resulting from glacial action or beaver activity. Water bodies at Camp Ravenna support aquatic vegetation and biota as described in Section 2.3.2. Storm water runoff is controlled primarily by natural drainage, except in former operations areas where an extensive storm sewer network helps to direct runoff to drainage ditches and settling ponds. In addition, the storm sewer system was one of the primary drainage mechanisms for process effluent while production facilities were operational.

3.4.3.2 Load Line 9 Surface Water

Surface water drainage generally follows the topography of Load Line 9 and drains to the north-northwest. No perennial surface water features are present within Load Line 9 or in the immediate vicinity. Surface water at Load Line 9 occurs intermittently as storm water runoff flowing through constructed drainage conveyances or overland to the northwestern portion of the AOC (Figure 3-1). These ditches contain water for short periods of time only during precipitation or periods of snow melt. Surface water flowing overland, in ditches, or other drainage features is the primary migration pathway for contamination to leave the AOC. A storm sewer system is not present at Load Line 9.

During the PBA08 RI, surface water was observed flowing to the north/northwest away from the AOC boundary. The closest perennial surface water feature is a tributary to Sand Creek approximately 1,100 ft to the north-northwest; however, there is no connecting stream to the AOC. The tributary flows in a northeast direction to its confluence with Sand Creek, and ultimately discharges into Eagle Creek (Figure 1-2). Drainage from the southern and eastern portions of Load Line 9 flow into larger drainage ditches that border Fuze and Booster Road and George Road. No planning or jurisdictional wetlands exist within the fenced AOC boundary. However, there are small wetlands near the AOC to the northeast, southeast, and southwest. There is no known connection between Load Line 9 and any off-site wetlands.

3.5 CLIMATE

The general climate of the Camp Ravenna area is continental and is characterized by moderately warm and humid summers, reasonably cold and cloudy winters, and wide variations in precipitation from year to year. The climate data presented below for the Camp Ravenna area were obtained from available National Weather Service records for the 30-year period of record from 1981–2010 at the Youngstown Regional Airport, Ohio (http://www.weather.gov/climate/xmacis.php?wfo=cle). Wind speed data for Youngstown, Ohio, are from the National Climatic Data Center (http://www1.ncdc.noaa.gov/pub/data/ccd-data/wndspd14.txt) for the available 30-year period of record from 1984–2014.

Average annual rainfall at Camp Ravenna area is 38.86 inches, with the highest monthly average occurring in July (4.31 inches) and the lowest monthly average occurring in February (2.15 inches). Average annual snowfall totals approximately 62.9 inches, with the highest monthly average occurring in January (17.1 inches). Due to the influence of lake-effect snowfall events associated with Lake Erie (located approximately 35 miles to the northwest of Camp Ravenna), snowfall totals vary widely throughout northeastern Ohio.

The average annual daily temperature in the Camp Ravenna area is 49.3ºF, with an average daily high temperature of 70.9ºF and an average daily low temperature of 26.1ºF. The record high temperature of 100ºF occurred in July 1988, and the record low temperature of -22ºF occurred in January 1994. The prevailing wind direction at Camp Ravenna is from the southwest, with the highest average wind speed occurring in January (10.3 miles per hour) and the lowest average wind speed occurring in August (6.5 miles per hour). Thunderstorms occur on approximately 35 days per year and are most abundant from April through August. Camp Ravenna is susceptible to tornadoes; minor structural damage to several buildings on facility property occurred as the result of a tornado in 1985.

Table 3–1. Hydraulic Conductivities Measured During the Phase I RI

Monitoring Well ID	Screened Interval (ft bgs)	Geologic Material Adjacent to Screen	Hydraulic Conductivity (cm/s)
LL9mw-001	11–21	Sand / Sandstone	2.57E-04
LL9mw-002	10–20	Sandstone	3.21E-04
LL9mw-003	11.5–21.5	Sandstone	2.90E-04
LL9mw-004	22–32	Sandstone / Siltstone	7.92E-04
LL9mw-005	10–20	Sandstone	2.11E-04
LL9mw-006	16–26	Sandstone	2.31E-04
LL9mw-007	8.5–18.5	Sandstone	4.61E-04

Source = *Phase I Remedial Investigation for Load Line 9* (MKM 2007).
bgs = Below ground surface.
cm/s = Centimeters per second.
ft= Feet.
ID = Identification.

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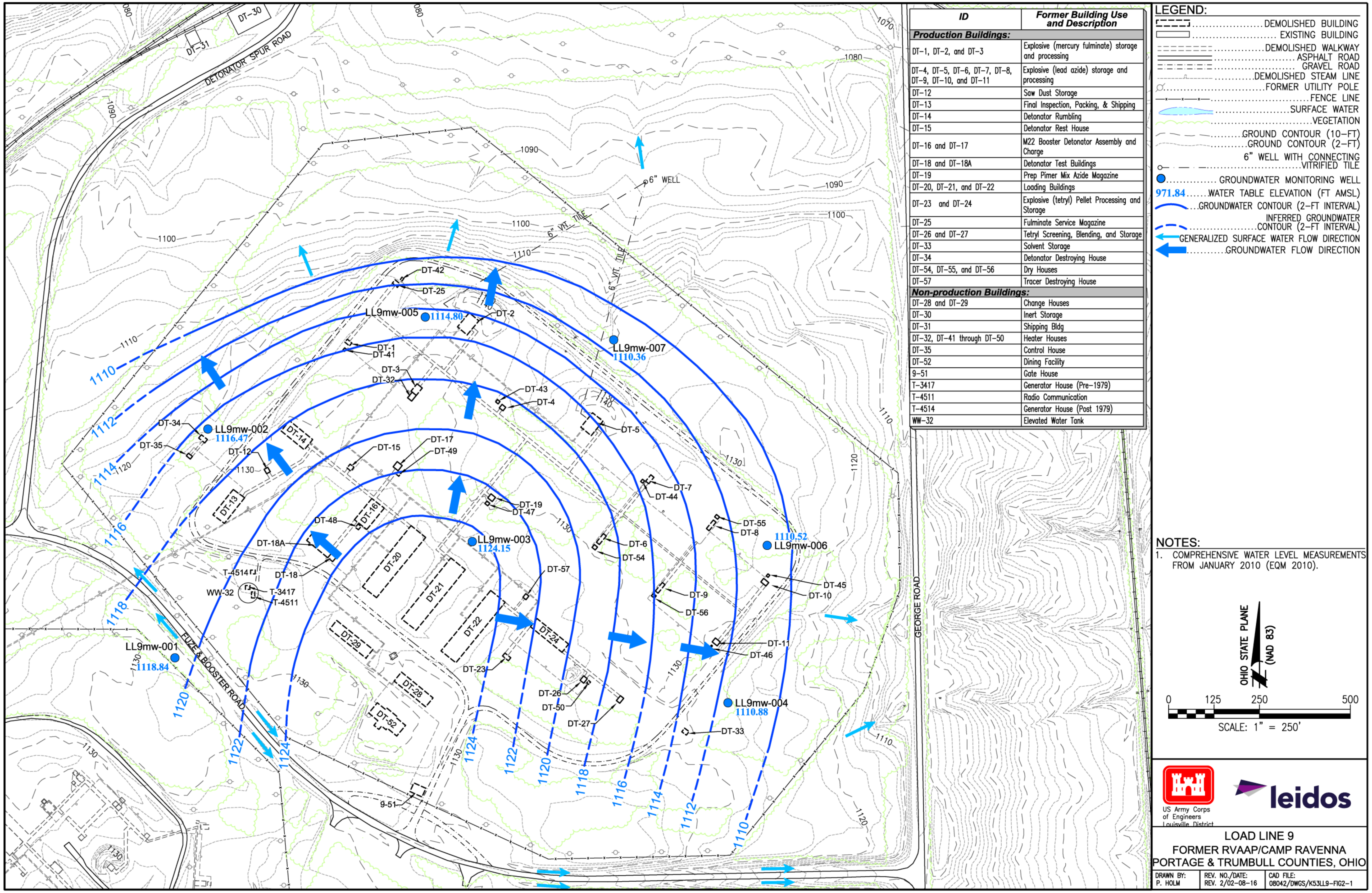

ID	Former Building Use and Description
Production Buildings:	
DT–1, DT–2, and DT–3	Explosive (mercury fulminate) storage and processing
DT–4, DT–5, DT–6, DT–7, DT–8, DT–9, DT–10, and DT–11	Explosive (lead azide) storage and processing
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DT–14	Detonator Rumbling
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DT–20, DT–21, and DT–22	Loading Buildings
DT–23 and DT–24	Explosive (tetryl) Pellet Processing and Storage
DT–25	Fulminate Service Magazine
DT–26 and DT–27	Tetryl Screening, Blending, and Storage
DT–33	Solvent Storage
DT–34	Detonator Destroying House
DT–54, DT–55, and DT–56	Dry Houses
DT–57	Tracer Destroying House
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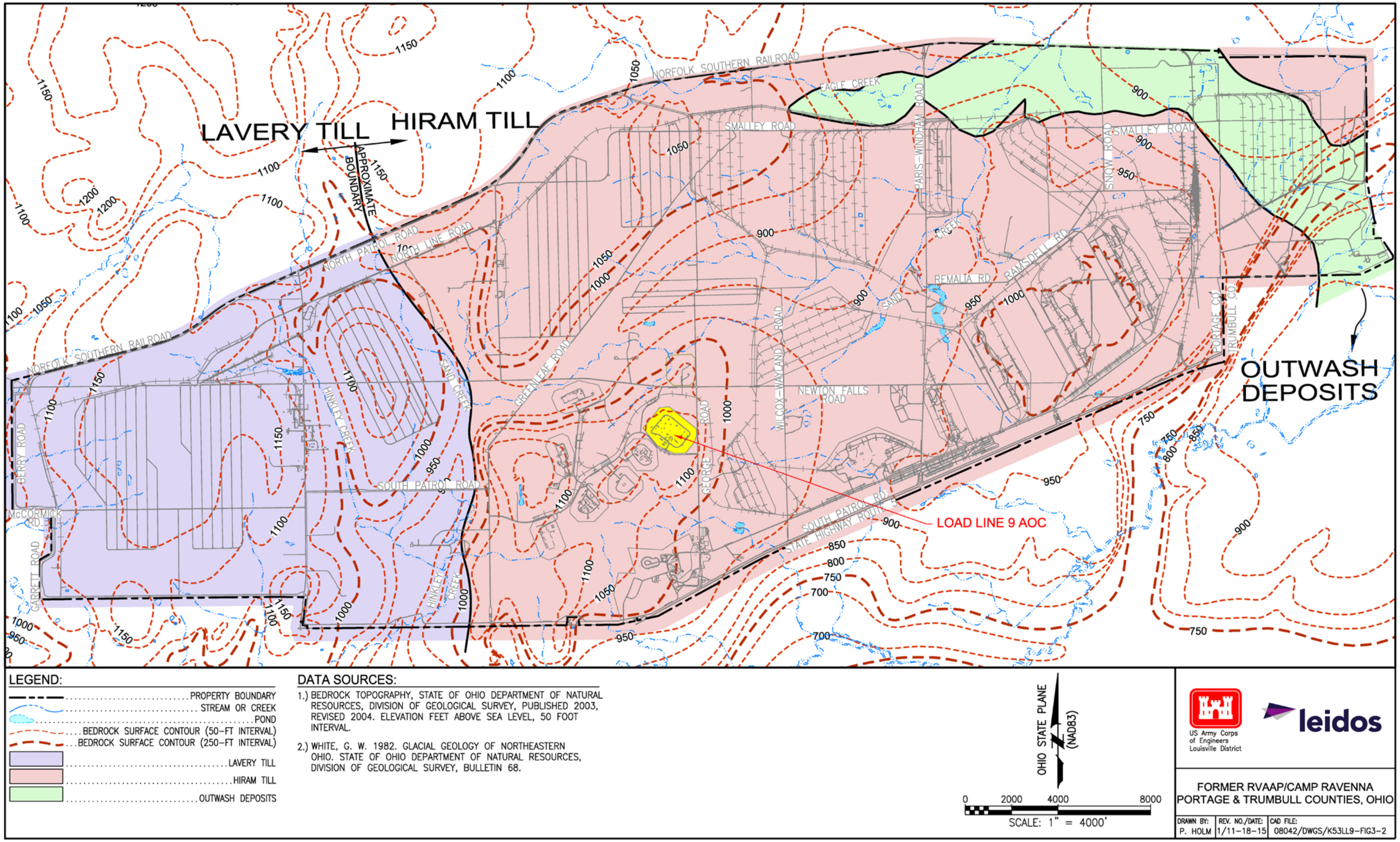
DT–28 and DT–29	Change Houses
DT–30	Inert Storage
DT–31	Shipping Bldg
DT–32, DT–41 through DT–50	Heater Houses
DT–35	Control House
DT–52	Dining Facility
9–51	Gate House
T–3417	Generator House (Pre–1979)
T–4511	Radio Communication
T–4514	Generator House (Post 1979)
WW–32	Elevated Water Tank

NOTES:

1. COMPREHENSIVE WATER LEVEL MEASUREMENTS FROM JANUARY 2010 (EQM 2010).

Figure 3-1. Topography, Groundwater Flow, and Surface Water Flow at Load Line 9



DATA SOURCES:

1.) BEDROCK TOPOGRAPHY, STATE OF OHIO DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGICAL SURVEY, PUBLISHED 2003, REVISED 2004. ELEVATION FEET ABOVE SEA LEVEL, 50 FOOT INTERVAL.

2.) WHITE, G. W. 1982. GLACIAL GEOLOGY OF NORTHEASTERN OHIO. STATE OF OHIO DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGICAL SURVEY, BULLETIN 68.

Figure 3-2. Geologic Map of Unconsolidated Deposits on Camp Ravenna

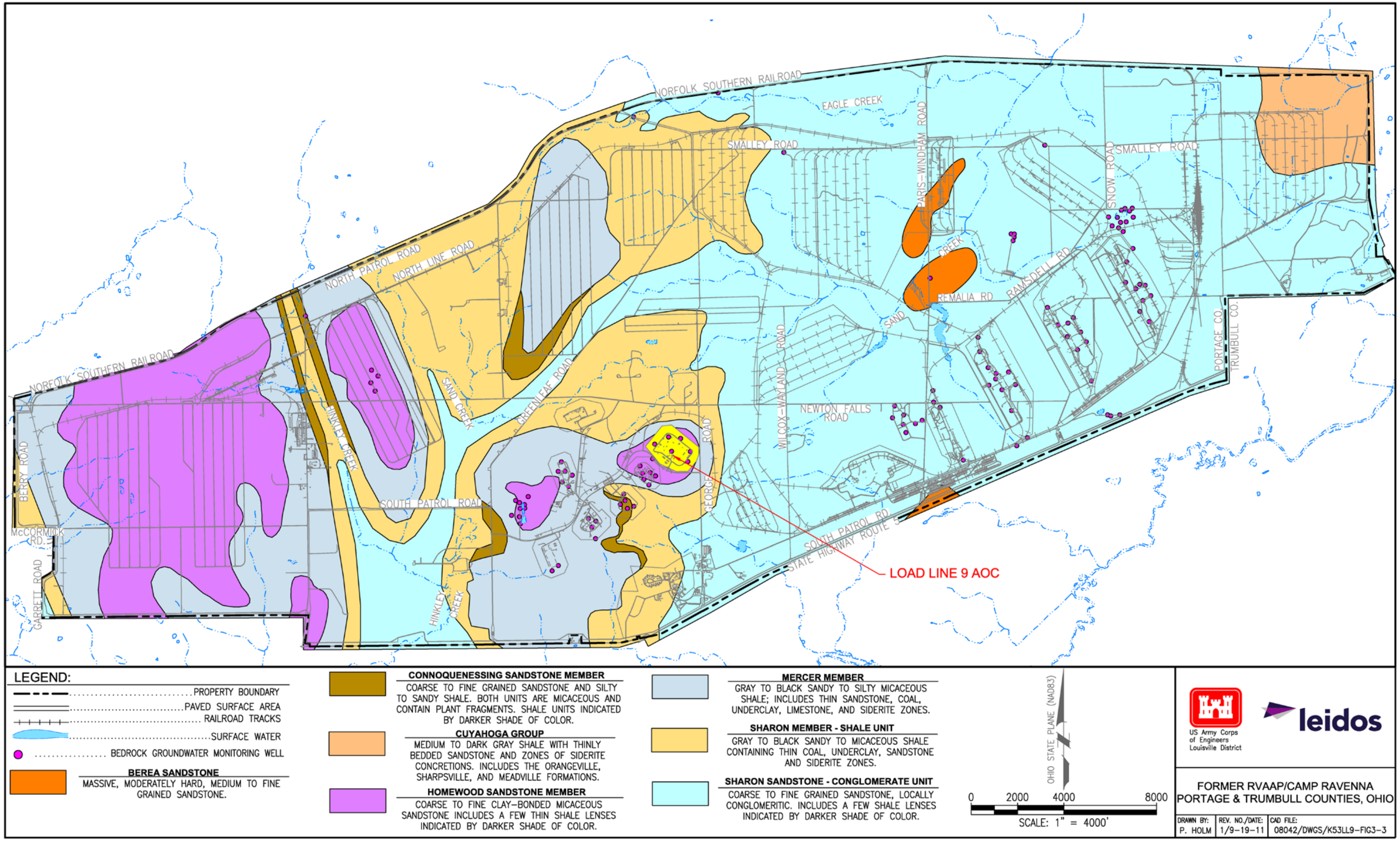
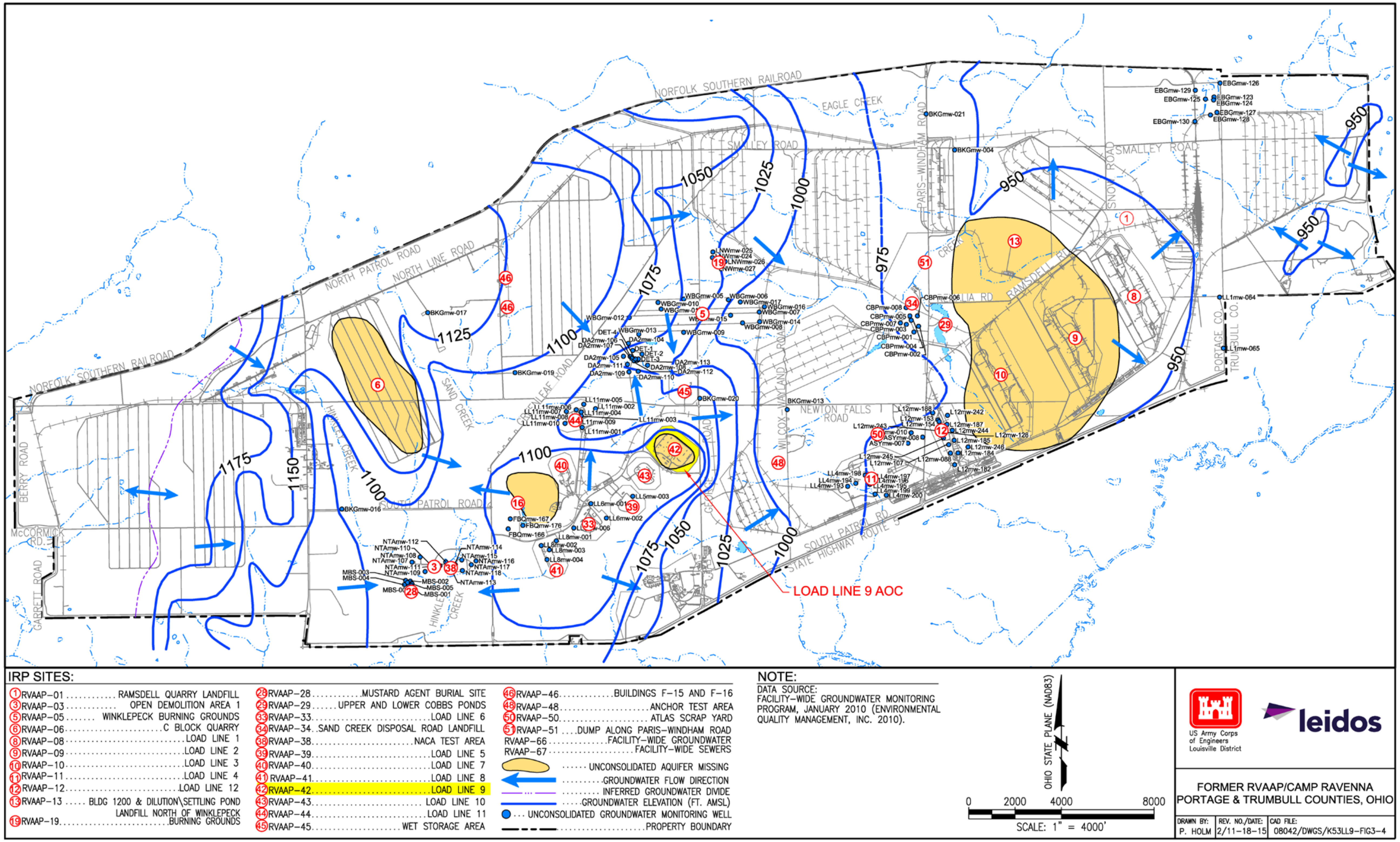


Figure 3-3. Geologic Bedrock Map and Stratigraphic Description of Units on Camp Ravenna



IRP SITES:

①RVAAP–01	RAMSDELL QUARRY LANDFILL
③RVAAP–03	OPEN DEMOLITION AREA 1
⑤RVAAP–05	WINKLEPECK BURNING GROUNDS
⑥RVAAP–06	C BLOCK QUARRY
⑧RVAAP–08	LOAD LINE 1
⑨RVAAP–09	LOAD LINE 2
⑩RVAAP–10	LOAD LINE 3
⑪RVAAP–11	LOAD LINE 4
⑫RVAAP–12	LOAD LINE 12
⑬RVAAP–13	BLDG 1200 & DILUTION\SETTLING POND
⑲RVAAP–19	LANDFILL NORTH OF WINKLEPECK BURNING GROUNDS
㉘RVAAP–28	MUSTARD AGENT BURIAL SITE
㉙RVAAP–29	UPPER AND LOWER COBBS PONDS
㉝RVAAP–33	LOAD LINE 6
㉞RVAAP–34	SAND CREEK DISPOSAL ROAD LANDFILL
㊳RVAAP–38	NACA TEST AREA
㊴RVAAP–39	LOAD LINE 5
㊵RVAAP–40	LOAD LINE 7
㊶RVAAP–41	LOAD LINE 8
㊷RVAAP–42	LOAD LINE 9
㊸RVAAP–43	LOAD LINE 10
㊹RVAAP–44	LOAD LINE 11
㊺RVAAP–45	WET STORAGE AREA
㊻RVAAP–46	BUILDINGS F–15 AND F–16
㊽RVAAP–48	ANCHOR TEST AREA
㊿RVAAP–50	ATLAS SCRAP YARD
(51)RVAAP–51	DUMP ALONG PARIS–WINDHAM ROAD
RVAAP–66	FACILITY–WIDE GROUNDWATER
RVAAP–67	FACILITY–WIDE SEWERS
	UNCONSOLIDATED AQUIFER MISSING
	GROUNDWATER FLOW DIRECTION
	INFERRED GROUNDWATER DIVIDE
	GROUNDWATER ELEVATION (FT. AMSL)
●	UNCONSOLIDATED GROUNDWATER MONITORING WELL
	PROPERTY BOUNDARY

NOTE:
DATA SOURCE:
FACILITY–WIDE GROUNDWATER MONITORING PROGRAM, JANUARY 2010 (ENVIRONMENTAL QUALITY MANAGEMENT, INC. 2010).

OHIO STATE PLANE (NAD83)

0 2000 4000 8000
SCALE: 1" = 4000'

US Army Corps of Engineers
Louisville District

leidos

FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	2/11–18–15	08042/DWGS/K53LL9–FIG3–4

Figure 3-4. Potentiometric Surface of Unconsolidated Aquifer at Camp Ravenna

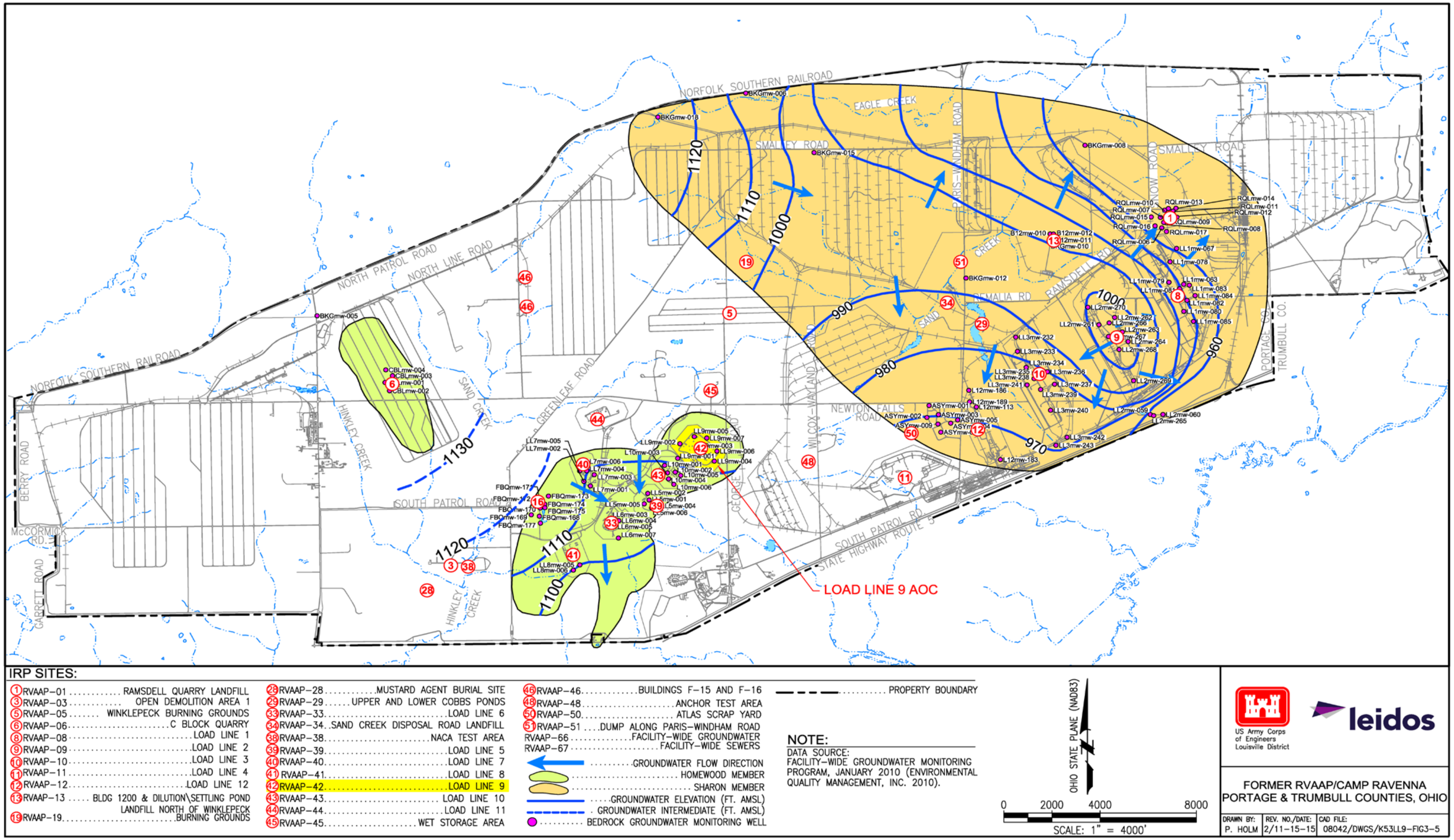


Figure 3-5. Potentiometric Surface of Bedrock Aquifers at Camp Ravenna

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4.0 SITE ASSESSMENTS, INVESTIGATIONS, AND DATA ASSEMBLY

This section summarizes all previous site assessments and investigations conducted at Load Line 9. These previous activities ranged from assessments to prioritize an AOC to investigations that collected data used in support of the RI.

4.1 LOAD LINE 9 PREVIOUS ASSESSMENTS AND EVALUATIONS

This section summarizes previous assessments and evaluations conducted at Load Line 9. These activities were generally performed to do an initial evaluation and/or prioritization assessment of the AOC. The data collected as part of these prioritization assessments and evaluations are not used in the nature and extent, fate and transport, HHRA, or ERA due to their age and lack of data quality documentation.

4.1.1 Installation Assessment of Ravenna Army Ammunition Plant

The *Installation Assessment of Ravenna Army Ammunition Plant* incorporated a review of historical operational information and available environmental data to assess the potential for contaminant releases from operational facilities. No sampling was performed at Load Line 9 as part of the assessment. The assessment identified the following conditions at RVAAP, applicable to Load Line 9 (USATHAMA 1978):

- Areas of RVAAP, including the production areas (i.e., Load Lines 5, 7, 8, 9, 10, and 12), burning grounds, test areas, and demolition areas were identified as AOCs contaminated with explosive waste, including TNT, composition B, lead azide, lead styphnate, and black powder;
- Mercury fulminate, tetryl, and lead azide were the only wastes identified for Load Line 9;
- Load lines were rehabilitated in 1951; and
- No environmental stress was identified at RVAAP.

4.1.2 RCRA Facility Assessment

The purpose of the RCRA Facility Assessment was to perform a visual inspection of known AOCs and conduct historical documentation research to identify new AOCs and solid waste management units (SWMUs), as applicable (Jacobs 1989). The RCRA Facility Assessment did not include specific assessments or conclusions regarding Load Line 9, and no sampling was performed at Load Line 9 as part of the assessment. However, the RVAAP-26 Fuze and Booster Area Settling Tanks AOC was included in the assessment, as discussed in Section 2.4.3.

4.1.3 Preliminary Assessment Screening of Boundary Load Line Areas

Load Line 9 was included in the *Preliminary Assessment Screening of Boundary Load Line Areas* conducted by the U.S. Army Environmental Hygiene Agency (USAEHA). This assessment included a review of historical records and facility personnel interviews. No sampling was performed at Load Line 9 as part of the assessment.

The assessment indicated that potential contaminants could be expected on building interiors, in exterior soil, and in holding tanks and settling ponds. In addition, because wastewater was discharged to the storm sewer following treatment, storm sewer and surface water discharge points may be potential contaminant pathways. The assessment recommended further environmental investigation for Load Line 9 (USAEHA 1994).

4.1.4 RVAAP Preliminary Assessment

The *Preliminary Assessment for the Characterization of Areas of Contamination* researched RVAAP history, process operations, and historical data to identify AOCs (USACE 1996). Load Line 9 was not included in the assessment, with the exception of the RVAAP-26 Fuze and Booster Area Settling Tanks AOC, as discussed in Section 2.4.3.

The assessment provided the following general conclusions for RVAAP AOCs (all conclusions may not apply to Load Line 9; rather, these are general conclusions for all AOCs):

- COPCs at RVAAP AOCs were identified as explosives [TNT; RDX; octahydor-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX); composition B; and lead azide] and heavy metals (lead and mercury).
- The primary sources of potential contamination were identified as wastewater effluent from the munitions assembly and demilitarization process, open burning and detonation of explosives, and landfill operations. Primary contaminant release mechanisms from load lines were process effluent discharges to surface water (drainage ditches, settling ponds, and streams) and process building wastewater wash-out to surface soil. Media of concern were identified as soil, sediment, groundwater, and surface water.
- The greatest potential for release of contaminants from load lines to groundwater likely occurred from wastewater effluent discharge to unlined earthen settling ponds. Concrete settling tanks, open drainage ditches, and storm sewers were also identified as concerns relative to groundwater.
- Known releases of contamination to surface water and soil have occurred from load line (assembly and demilitarization) operations.

The greatest potential for historical off-site contaminant migration during load line operations was identified as surface water. The greatest potential for current off-site contaminant migration was identified as groundwater and surface water.

4.1.5 Relative Risk Site Evaluation for Newly Added Sites

In 1998, the U.S. Army Center for Health Promotion and Preventative Medicine (USACHPPM) completed the *Relative Risk Site Evaluation for Newly Added Sites* (USACHPPM 1998) to “provide sufficient data to score RVAAP’s newly discovered previously uninvestigated sites…” This document identified and provided a risk evaluation for 13 newly discovered and previously uninvestigated sites for the purpose of prioritizing future remedial or corrective activities. Of the 13 identified AOCs, 5 were assigned a Relative Risk Site Evaluation (RRSE) score of “high,” and the remaining 8 were assigned a score of “medium.”

The RRSE also included collecting surface and subsurface soil samples at Load Line 9. The data collected at the site “…are minimal Level III data, as defined by U.S. EPA, and are not intended to be used as definitive evidence of contamination presence or absence or to support health risk assessment.” This section summarizes the samples collected as part of the RRSE data, the chemicals detected, and the associated prioritization recommendations, but the analytical results are not presented and are not used in subsequent evaluations in this RI/FS Report.

The RRSE evaluated the soil pathway (human receptor endpoint) using data from the six surface soil samples collected near the former production buildings at Load Line 9. These samples were analyzed for explosives and inorganic chemicals. The groundwater pathway (human receptor endpoint) was evaluated using data from one subsurface soil sample collected from 6–8 ft bgs, east of Building DT-5. This sample was analyzed for explosives and inorganic chemicals.

One sediment sample was planned for collection during this evaluation, but since no settling ponds or sediment pathways were evident, sediment and surface water were not evaluated as part of the RRSE.

Groundwater concentrations were calculated by modeling analytical data from a subsurface soil sample collected from 6–8 ft bgs. Six inorganic chemicals (arsenic, barium, chromium, copper, lead, and zinc) were identified for groundwater based on model calculations. No other analytes were identified for groundwater. A total of 16 inorganic chemicals were detected in surface soil. Concentrations of analytes detected in surface soil and calculated for groundwater are presented in Appendix D of the RRSE (USACHPPM 1998).

The groundwater and surface soil pathways were evaluated as follows:

1. Groundwater
    a. Contaminant Hazard Factor: Moderate.
    b. Migration Pathway Factor: Potential. There is no evidence that site contaminants are migrating. However, there are no physical barriers in place to prevent migration.
    c. Receptor Pathway Factor: Potential. It is unknown if any wells are directly downgradient from this AOC; however, groundwater near the AOC may be used for irrigation or drinking water.
2. Surface soil
    a. Contaminant Hazard Factor: Moderate.

b. Migration Pathway Factor: Potential. There is no evidence that site contaminants are migrating. However, there are no physical barriers in place to prevent migration.
c. Receptor Pathway Factor: Potential. While this area is surrounded by a fence with locked gates, hunters, scrappers, and firewood cutters may have access to the site.

Human receptor endpoints were evaluated based on the available soil and groundwater data. The RRSE scored Load Line 9 as a "medium-priority" AOC due to potentially contaminated surface soil and groundwater potentially migrating and affecting human and ecological receptors (USACHPPM 1998).

4.2 LOAD LINE 9 REMEDIAL INVESTIGATIONS

This section summarizes previous investigations conducted at Load Line 9. These investigations collected data of sufficient provenance and quality to be used to support the evaluations in this RI, including the nature and extent, fate and transport, HHRA, and/or ERA.

The previous Phase I RI Report presented SRCs and/or COPCs based on data evaluation protocols in use at the time the investigations were completed. The data and information is used in this report; however, an updated screening process and addition of new data and information may result in a different list of SRCs and/or COPCs.

References to "RVAAP full-suite analytes" generally include analyses of target analyte list (TAL) metals, explosives, propellants (nitrocellulose and nitroguanidine), semi-volatile organic compounds (SVOCs), VOCs, PCBs, and pesticides.

4.2.1 Lead Azide Screening

The U.S. Army Operations Support Command contracted MKM Engineers, Inc., in conjunction with USACE, to perform a lead azide screening operation at Load Lines 6, 9, and 10 for health and safety purposes and to obtain additional information on areas of potential contamination. The purpose of this lead azide screening operation is three fold:

1. Provide necessary data to ensure the safety of workers during RI sampling activities (e.g., azide concentrations greater than 20,000 ppm).
2. Use screening data, in conjunction with historical data, to help determine the appropriate analytical suite, location, and number of samples required for completing subsequent RIs at the load lines.
3. Substantiate the accuracy of new General Physics Laboratory screening method for explosives·(modified 8330).

The rationale and results of the lead azide screening are presented in Appendices A and B of the *Final Sampling and Analysis Plan Addendum for the Remedial Investigation of Load Line 9* (MKM 2003). The field activities were conducted in March 2002 and results are summarized in the *Report for the*

Phase I Remedial Investigation at Load Line 9 (MKM 2007). Figure 4-1 presents the locations of samples collected during this investigation.

Eleven surface soil samples from locations LL9ss-001 through LL9ss-011 were field screened for lead azide and each was field tested for TNT and RDX using the Jenkins method. Additionally, six of the soil samples from LL9ss-001, LL9ss-003, LL9ss-005, LL9ss-007, LL9ss-009, and LL9ss-011 were analyzed for explosives and all samples were analyzed for metals at an off-site laboratory. There were no explosives detected above the reporting limit. Metals exceeded background concentrations and/or Region 9 residential soil preliminary remediation goals (PRGs) in 5 of the 11 samples.

Four surface water samples, LL9sw-001, LL9sw-005, LL9sw-007, and LL9sw-008, were collected and submitted for metals and explosives analysis. Three locations LL9sw-002, LL9sw-004, and LL9sw-006 had no surface water present for sample collection. There were no explosives detected above the reporting limit. Metals exceeded background concentrations, Region 9 tap water PRGs, or both in three of the four samples.

Eight sediment samples, LL9sd-001 through LL9sd-008, were collected during the lead azide screening. Six of the samples were collected from ditches, and two of the samples were collected from sumps. The sediment samples were co-located with the surface water sample locations. No explosives were detected above the method detection limits (MDLs). Metals exceeded the background concentrations, Region 9 residential soil PRGs, or both, in four of the eight samples analyzed.

Results from the March 2002 sample screening indicated that there is no detectable safety concern related to azide contamination at Load Line 9. The March 2002 screening results also indicated that there is minimal contamination of secondary explosives at Load Line 9. These sample results were included in the overall evaluation summarized in the Phase I RI Report.

4.2.2 Phase I Remedial Investigation

In 2003, sampling was conducted at Load Line 9 in accordance with the *Final Sampling and Analysis Plan Addendum for the Remedial Investigation of Load Line 9* (MKM 2003). The Phase I RI was performed to accomplish the following:

- Define the vertical and horizontal extent of contamination at Load Line 9;
- Gather sufficient data to conduct a baseline human health risk assessment (BHHRA) and a screening ecological risk assessment (SERA);
- Define potential transport pathways and receptor populations; and
- Provide sufficient data for selecting remedial action alternatives.

Results of this Phase I RI are presented in the *Report for the Phase I Remedial Investigation at Load Line 9* (MKM 2007) and are summarized in the following subsections.

4.2.2.1 Field Activities

The following field activities were conducted during the Phase I RI in 2003 at Load Line 9 to assess the potential impacts from former operations:

- Excavated test trenches;
- Collected discrete surface soil (0–1 ft bgs) samples;
- Collected subsurface soil (greater than 1 ft bgs) samples;
- Collected surface water samples;
- Collected sediment samples;
- Collected subfloor samples;
- Collected samples adjacent to sumps; and
- Surveyed sampling locations.

The following activities also took place; however, these activities are pertinent to other co-located AOCs associated with Load Line 9 (e.g., Facility-wide Groundwater and Facility-wide Sewers) and are not discussed in this section:

- Installed, developed, and sampled seven monitoring wells;
- Conducted in-situ permeability testing (slug tests);
- Collected samples adjacent to sanitary sewers;
- Collected geotechnical samples from monitoring well borings;
- Surveyed monitoring well locations.

Soil (surface and subsurface), sediment, and surface water samples were analyzed for TAL metals and explosives. Additionally, 10% of samples were analyzed for RVAAP full-suite analytes.

Figure 4-2 presents the locations sampled under the Phase I RI. Table 4-1 presents the sample locations, associated operations, and suite of chemicals analyzed as part of the Phase I RI (including the 2002 lead azide screening). Tables 4-2 through 4-5 present the results of the analytes detected from samples collected during the Phase I RI (including the 2002 lead azide screening).

Analytical laboratory procedures were completed in accordance with applicable professional standards, USEPA requirements, government regulations and guidelines, and specific project goals and requirements. Samples were analyzed as specified by the Facility-wide Sampling and Analysis Plan (FWSAP) current at the time of the investigation, the *Final Sampling and Analysis Plan Addendum for the Remedial Investigation of Load Line 9* (MKM 2003), and USACE Louisville Chemistry Guidance (USACE 2002). The data quality objectives (DQOs) were established for the Phase I RI and complied with USEPA Region 5 guidance. The requisite number of quality assurance (QA)/quality control (QC) samples was obtained during the investigation. The data validation determined that the data met the completeness requirements for the project (100% complete), was usable, and that it satisfied the DQOs for the project.

4.2.2.2 Nature and Extent of Contamination

A total of 15 metals, 2 SVOCs, and 2 propellants were detected in surface soil (0–1 ft bgs), and 13 metals were detected in subsurface soil (1–11 ft bgs) above RVAAP background concentrations (USACE 2001b) and/or Region 9 residential soil PRGs at that time. The 13 metals detected in surface water were above RVAAP background concentrations and/or Region 9 tap water PRGs. A total of 15 metals, 2 propellants, and 4 SVOCs were detected in sediment above RVAAP background concentrations and/or Region 9 residential soil PRGs. Figure 4-5 presents locations that exceed current screening criteria.

4.2.2.3 Baseline Human Health Risk Assessment

A BHHRA was included in the Phase I RI for Load Line 9. The BHHRA utilized the screening process in effect at that time, based on the protocol established in the *RVAAP Facility-Wide Human Health Risk Assessor Manual – Amendment 1* (herein referred to as the FWHHRAM), in order to identify potential contaminants of concern (USACE 2005b). Risks were evaluated for the receptors available at that time [National Guard Trainee (the primary receptor of concern), National Guard Resident/Trainer, Hunter/Trapper, Security Guard/Maintenance Worker, and Resident Farmer (Adult and Child)]. The COPCs identified in the quantitative BHHRA are summarized in Table 4-6.

The BHHRA indicated that several significant uncertainties associated with the risk assessment were identified and must be considered carefully when making any risk management decisions, including the fact that the nature and extent of the contamination in soil, sediment, surface water, and groundwater at Load Line 9 has not been completely defined. Therefore, the results of the BHHRA are preliminary and subject to change based on the data collected in a Phase II RI.

4.2.2.4 Screening Ecological Risk Assessment

The SERA compared chemical concentrations detected in Load Line 9 environmental media to RVAAP facility-wide background concentrations for inorganic chemicals and ecological screening values (ESVs). The SERA followed screening methodology guidance presented in the *2003 RVAAP Facility-Wide Ecological Risk Work Plan* (USACE 2003a) (herein referred to as the FWERWP) and *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2003). Chemicals were retained if they did not have screening values. Table 4-7 presents a summary of the COPCs identified per type of species based on the ecological risk calculations.

The SERA concluded that the assessment is preliminary and subject to change based on data collected in a Phase II RI.

4.2.2.5 Conclusions and Recommendations

The Phase I RI concluded that concentrations of contaminants are generally low, with a notable exception being a localized spot of high metal concentrations for copper, mercury, lead, and zinc at

LL9ss–011 in surface soil. With the exception of LL9ss-011, metal concentrations are fairly uniform across the AOC.

Few organic chemicals that are directly related to site operations were selected as COPCs, thus indicating that the concentrations of detected organic chemicals are generally low enough not to pose a significant threat to the health of receptors. However, nature and extent have not been fully determined during this Phase I RI.

Sumps might have been a primary contamination source from operations water that was routinely diverted to them. However, sumps were removed during the Load Line 9 demolition and removal of the load line structures. Sewer lines that might have provided a contaminant transport pathway have been plugged. Thus, contaminant transport has been eliminated in these conveyances.

The fate and transport evaluation concluded that low concentrations and small total masses of energetic compounds at Load Line 9 are consistent with good health and safety practices. In particular, primary explosives such as metal azides (e.g., lead azide) and fulminates (e.g., mercury fulminate), which are very unstable with respect to physical shock, would not be expected to be released indiscriminately to non-operational areas.

The Phase I risk assessment demonstrated that potential risks exist for the National Guard Trainee and Resident Receptor (Adult and Child). Inorganic chemicals were identified as COPCs in surface soil, sediment, and surface water in the SERA. The results of the Phase I RI indicated the lateral and vertical extent of contamination of TAL metals and propellants in surface soil, subsurface soil, sediment, and surface water were not fully delineated, and additional investigation to address data gaps at Load Line 9 was recommended.

4.2.3 PBA08 Remedial Investigation

In November 2008, Leidos scientists performed a site walk of Load Line 9. The site walk was conducted to develop the Performance-based Acquisition 2008 Supplemental Investigation Sampling and Analysis Plan Addendum No. 1 (herein referred to as the PBA08 SAP), which supplemented the Phase I RI investigation and completed the RI phase of the CERCLA process. Numerous physical changes occurred at Load Line 9 between the 2003 Phase I RI sampling and the development of the PBA08 SAP. As discussed in Section 2.2.3, additional demolition activities took place in 2007. The PBA08 SAP considered the prior investigations and changes in AOC conditions during development of the DQOs and sampling scheme for completing the Load Line 9 RI. Section 4.4.4 of this report discusses the suitability and use of samples collected to support this RI, with respect to changes in AOC conditions. The PBA08 SAP was reviewed and approved by representatives of the Army and Ohio EPA in January 2010.

As part of the PBA08 RI DQOs, an initial screening approach was used to help focus the investigation on specific chemicals and areas to be further evaluated by assessing the nature and extent of contamination observed in historical samples (Section 3.2.2 of the PBA08 SAP). Decision flowcharts for PBA08 RI surface and subsurface sampling are presented in Figures 4-3 and 4-4, respectively. The screening approach presented in the PBA08 SAP compared sample results from previous investigations at Load Line 9 to chemical-specific facility-wide cleanup goals (FWCUGs) at the 1E-06 cancer risk level and non-carcinogenic risk HQ of 0.1, as presented in the FWHHRAM (USACE 2005b). The most protective FWCUGs for the three potential receptors are referred to as "screening criteria." Previous results were also compared to FWCUGs at the higher TR of 1E-05 and HQ of 1 to facilitate identifying potential source areas that may require additional sampling to refine the extent of contamination. Table 4-8 lists the chemicals with detected concentrations that exceeded screening criteria at the time of the PBA08 SAP in historical soil samples.

In February and March 2010, the PBA08 RI was implemented by collecting surface and subsurface soil using discrete sampling techniques. Six additional discrete surface soil samples were collected in April 2011 around location LL9ss-011 (Building DT-34). The results of the PBA08 RI sampling, combined with the results of the Phase I RI were used to evaluate the nature and extent of contamination, assess potential future impacts to groundwater, conduct HHRAs and ERAs, and evaluate the need for remedial alternatives.

No groundwater samples were collected during the PBA08 RI, as the current conditions of groundwater will be evaluated as an individual AOC for the entire facility (designated as RVAAP-66) and addressed in a separate RI/FS Report.

A sample log for each sample and lithologic soil description for each soil boring collected during the PBA08 RI is included in Appendix A. The DQOs, field activities, sampling methodologies, QA/QC, and management of analytical data for the PBA08 RI are further expanded upon in Appendix I.

4.2.3.1 Surface Soil Sampling Rationale

Source Area Investigation

Soil samples were collected during the PBA08 RI to assess contaminant occurrence and distribution in surface soil. The PBA08 RI samples were designed to delineate the extent of areas previously identified as having the greatest likelihood of contamination (e.g., adjacent to production buildings). Table 4-9 presents the specific rationale for each surface soil sample collected during the PBA08 RI. Table 4-10 presents the chromium speciation samples collected under PBA08 RI Table 4-11 presents the results of the analytes detected from surface soil samples collected during the PBA08 RI. All PBA08 RI sample locations are presented on Figure 4-5.

A total of 18 surface soil samples were collected at Load Line 9 (16 in the FPA and 2 in the NPA) during the PBA08 RI to further delineate surface soil above screening criteria presented in Table 4-9 and to completely characterize the AOC (Figure 4-5). Of the 18 surface soil samples collected, 4 sample locations were near former buildings not previously sampled, and 10 sample locations were collected near former sample locations that exceeded screening criteria to delineate the lateral extent of contamination. These samples include an additional surface soil sample originally planned for surface water and sediment sampling (LL9sw/sd-112) in the PBA08 SAP. However, the area was dry, so a surface soil sample was collected instead (location LL9ss-112). Four discrete samples were collected to evaluate chromium speciation (Section 4.2.3.1). All surface soil samples collected during the PBA08 RI were collected from 0–1 ft bgs in accordance with the bucket hand auger method described in Section 4.5.2.1.1 of the FWSAP (USACE 2001a). An updated version of the FWSAP was developed in February 2011 and approved by the Ohio EPA; however, the PBA08 RI was implemented prior to approval of this updated version. Discrete surface soil samples were analyzed for TAL metals, explosives, and PAHs. Two samples (15% of the total number of samples collected) were analyzed for RVAAP full-suite analytes. Two QC field duplicates and two QA split samples were collected to satisfy the QA/QC requirement of 10% of the total samples collected.

Chromium Speciation

As part of the PBA08 RI, four discrete chromium speciation samples were collected to evaluate the potential contribution of hexavalent chromium to the total chromium concentrations in soil. Samples from 0–1 ft bgs were collected in accordance with the bucket hand auger method described in Section 4.5.2.1.1 of the FWSAP (USACE 2001a). Three samples were collected from areas previously identified as having elevated total chromium concentrations, and one sample was collected from an area previously identified as having a total chromium concentration near the background concentration. Based on the data review presented in Appendix C, sample LL9SS-101-5479-SO was excluded from the chromium speciation assessment because sample results for hexavalent chromium were higher than the total chromium results. A speciation sample (LL9ss-101-5807-SO) was collected in October 2010 to replace the sample collected in March 2010. The rationale for the chromium speciation samples collected as part of the PBA08 RI is summarized in Table 4-10. The locations of these samples are presented in Figure 4-5 and results are presented in Table 4-11.

Mercury Assessment at LL9ss-011

Sample location LL9ss-011, at former Building DT-34 (detonator destroying house during World War II), had a high concentration of mercury in the surface soil. Six additional discrete surface soil samples (LL9ss-131 to LL9ss-135) were collected in April 2011 around location LL9ss-011 to further delineate lateral extent of mercury contamination in the surface soil.

4.2.3.2 Subsurface Soil Sampling Rationale and Methods

The PBA08 RI used discrete samples from soil borings to complete the characterization of subsurface soil. Subsurface soil sampling was conducted according to the decision rules approved in the PBA08 SAP. The subsurface soil borings were located based on three objectives:

- Borings at locations where previous surface soil sampling results exceeded screening criteria and vertical delineation was warranted.
- Borings at locations where previous surface soil sampling results only slightly exceeded screening criteria to confirm that contaminant concentrations did not increase with depth.
- Borings at locations not previously sampled to provide full characterization of surface and subsurface soil.

The subsurface soil was characterized by placing borings in various areas, including areas with previous surface soil results greater than the screening criteria, areas with previous results only slightly greater than the screening criteria, and areas not previously sampled. In all cases, soil samples were collected from the subsurface borings to further define the vertical extent of contamination in subsurface soil at the AOC (Figure 4-5). Table 4-12 presents the specific rationale for each subsurface soil sample collected for the PBA08 RI. Results of detected analytes are presented in Table 4-13.

To assess the depths of exposure of the Resident Receptor, each soil boring was attempted to be sampled at 0–1, 1–4, 4–7, and 7–13 ft bgs. However, the borings encountered refusal before 13 ft bgs in each of the soil borings. The deep sample interval was archived on site, while the 4–7 ft bgs interval sample was analyzed under an expedited five-day turnaround time. As specified in the PBA08 SAP, the deep sample interval would be analyzed for the following reasons:

1. One chemical had a concentration that exceeded screening criteria in the 4–7 ft bgs sample; or
2. To ensure at least 10% of all subsurface samples from 7–13 ft bgs were submitted for laboratory analysis for adequate characterization of subsurface soil to 13 ft bgs.

Bedrock was shallow at Load Line 9, so the deepest boring was only advanced to 8 ft bgs instead of the desired 13 ft bgs presented in the PBA08 SAP. Each interval was composited and homogenized in a stainless steel bowl, with the exception of VOC samples. The sample collected from the 7–8 ft bgs interval (where achievable) was archived on site, while the 4–7 ft bgs interval sample was analyzed under an expedited 5-day turnaround time. No subsurface samples were analyzed due to preliminary screening criteria exceedances within the 4–7 ft bgs sample intervals. One sample collected from the 7–8 ft bgs sample interval was submitted for laboratory analysis to ensure adequate characterization of 7–8 ft bgs was performed. All samples were analyzed for TAL metals, explosives, and PAHs; three samples were analyzed for RVAAP full-suite analytes to satisfy the PBA08 SAP sample requirements of a minimum of 15% frequency for full-suite analysis.

Three QC field duplicates and three QA split samples were collected from LL9sb-092 (0-1, 1-4, and 4-6 ft bgs) to satisfy the QA/QC sample requirements of 10% frequency for subsurface soil samples.

4.2.3.3 Surface Water and Sediment Rationale and Methods

Surface water and sediment samples were collected to characterize current conditions and assess potential exit pathways from the AOC (Figure 4-5). Three co-located surface water and sediment samples were collected during the PBA08 RI from ditches and shallow conveyances within and exiting the AOC. The samples were collected in accordance with the following decision rules approved in the PBA08 SAP:

- At AOCs where overland flow of contaminants could occur to nearby perennial streams, those streams will be sampled. The sample locations may be outside of the AOC boundaries but the samples represent the areas potentially impacted by the AOCs (Load Lines 5, 6, 7, 9, 10, and Wet Storage Area).

- At points where contamination may migrate out of the AOC area, such as a ditch or a stream near the AOC boundary, samples will be collected to characterize current conditions and determine whether contaminant migration may occur at surface water runoff exit points.

The surface water grab samples were collected by the hand-held bottle method in accordance with Section 4.3 of the PBA08 SAP and analyzed for the RVAAP full-suite analytes. Additionally, water quality parameters for temperature, pH, conductivity, dissolved oxygen, and turbidity were collected using calibrated water quality meters (Hanna Instrument Models 9828 and 98703). The sediment samples were collected in accordance with Section 4.2 of the PBA08 SAP. The samples consisted of a multi-aliquot composite with 10 aliquots selected randomly within a 5-ft radius of the identified sample location. Each aliquot was collected by a push probe to a maximum depth of 0.5 ft bgs. One sediment sample (and its associated QA/QC samples) was analyzed for RVAAP full-suite analytes. Table 4-14 presents the specific rationale for the surface water and sediment samples collected for the PBA08 RI. The locations of these samples are presented in Figure 4-5 and results are presented in Table 4-15 and Table 4-16 for surface water and sediment, respectively.

4.2.3.4 Changes from the Work Plan

Significant changes to the work plan are documented in field change requests (FCRs) (Appendix B). Changes made in the field based on site conditions are not documented on FCRs but on the field sampling logs (Appendix A). These changes are presented on Table 4-17. New coordinates for all station locations can be found on the field sampling logs.

4.3 FACILITY-WIDE BACKGROUND EVALUATION

Facility-wide background values for inorganic constituents in soil, sediment, surface water, and groundwater were developed in 1998, as documented in the *Phase II Remedial Investigation Report for the Winklepeck Burning Grounds* (USACE 2001b). These facility-wide background values were employed in the data reduction and screening process described in Section 4.4.2 and the remainder of the evaluations in this RI (e.g., nature and extent, fate and transport). Background locations were selected using aerial photographs and site visits from areas believed to be unaffected by RVAAP activities. Soil, sediment, surface water, and groundwater samples were collected from those locations to determine the range of background concentrations that could be expected in these media. Results from the site-specific background data collection were used to determine if detected metals and potential anthropogenic compounds (such as PAHs) are site-related, naturally occurring, or from non-RVAAP-related anthropogenic sources.

A total of 14 wells were installed in established background locations to collect filtered and unfiltered samples from the bedrock and unconsolidated zones. These samples were analyzed for TAL metals and cyanide for determining background concentrations.

Soil samples were collected from each of the background monitoring well locations from three intervals: 0–1, 1–3, and greater than 3 ft bgs. Because boring locations were changed during sampling based on the lithological requirements for well screen intervals, all depth intervals for soil were not sampled for each boring. Background surface soil samples were analyzed for TAL metals, cyanide, SVOCs, pesticides, PCBs, and VOCs. Surface water samples were analyzed for TAL metals and cyanide.

Seven stream locations upstream of RVAAP activities along Hinkley, Sand, and Eagle Creeks were sampled for sediment and surface water to characterize background conditions. Background sediment samples were analyzed for TAL metals, cyanide, SVOCs, pesticides, PCBs, and VOCs. Surface water samples were analyzed for TAL metals and cyanide.

Using the sampling results, an evaluation of outliers, data assessment, and statistical analyses were performed to determine background concentrations for each medium. For surface soil samples, PAHs, in addition to metals, were elevated in four samples. PAHs are related to combustion products and could indicate human disturbance at the locations where they were detected. Visits to the sampling locations and a review of aerial photography showing the area prior to the establishment of RVAAP indicated that these sampling locations were near homes or farms and could have been influenced by activities associated with those structures.

During the finalization of background concentrations at the former RVAAP, the Army and Ohio EPA agreed that formal background concentrations would only be applicable for inorganics. All organic analytes (e.g., PAHs, VOCs, explosives) were classified as anthropogenic and potentially related to RVAAP operations; therefore, no background values were established for these classes of compounds. The final, approved facility-wide background concentrations for inorganics are presented in Table 4-18.

4.4 DATA EVALUATION METHOD

Data evaluation methods for Load Line 9 are consistent with those established in the FWCUG Report. These methods were specified in the PBA08 SAP (USACE 2009a). The processes used to evaluate the analytical data involved three general steps: (1) defining data aggregates; (2) conducting data verification, reduction, and screening; and (3) presenting data.

4.4.1 Definition of Aggregates

Load Line 9 data were aggregated in three ways for evaluating contaminant nature and extent and completing the HHRA and ERA. The initial basic aggregation of data was by environmental medium: surface soil, subsurface soil, sediment, and surface water. For each medium-specific aggregate, an evaluation was conducted to determine if further aggregation was warranted with respect to AOC characteristics, historical operations, ecological habitat, and potential future remedial strategy and Land Use (e.g., spatial aggregates). Data for soil were further aggregated based on depth and sample type for consistency with RVAAP human health risk exposure units (EUs) and guidance established in the FWHHRAM and FWCUG Report.

Data aggregates for evaluating the nature and extent of contamination at Load Line 9 are as follows:

- Surface Soil (0–1 ft bgs). Using the above data aggregation criteria, surface soil within the geographic area of Load Line 9 were subdivided into three spatial aggregates: DWA, FPA, and NPA. The DWA is defined as the area around the 6-inch abandoned well, located approximately 190 ft northeast of the Load Line 9 fence line, that served as a drainage conduit from Load Line 9. The FPA is defined as the area encompassed within the gravel perimeter road surrounding the Load Line 9 main production area and includes the former building area next to the main entrance. The NPA is defined as the area between the production area perimeter road and the Load Line 9 fence line. The FPA contains all known or potential primary contaminant residual sources remaining from detonator production after building demolition and slab removal. The former buildings located within the NPA were limited to administrative and storage functions.
- Subsurface Soil (greater than 1 ft bgs). Includes data from discrete sample intervals 1–4, 4–7, and 7–8 ft bgs. This medium is subdivided into the DWA, FPA, and NPA on the same basis as surface soil.
- Sediment. Sediment samples were divided into three spatial aggregates: DWA, Drainage Ditches, and Off-AOC. The Drainage Ditches encompass the intermittent drainage conveyances and gullies which were constructed to direct surface water runoff to the three storm water discharge points. The Off-AOC samples (LL9sd-002 and LL9sd-011) were collected in 2003 outside the AOC fence line and are included in the nature and extent evaluation.
- Surface Water. This medium is subdivided into the DWA, Drainage Ditches, and Off-AOC on a similar basis as sediment. However, only one sample location was used for surface water in the Drainage Ditches within the FPA (LL9sw-005). The remainder of the surface water sample locations for the Drainage Ditches were in the NPA. The Off-AOC sample (LL9sw-002) was collected in 2003 outside the AOC fence line and is included in the nature and extent evaluation.

The soil data aggregates are further subdivided to define human health and ecological risk EUs in the risk assessments as discussed in Section 7.0 (e.g., shallow surface soil, deep surface soil, subsurface soil).

4.4.2 Data Verification, Reduction, and Screening

4.4.2.1 Data Verification

Data verification was performed on 57 surface soil, subsurface soil, sediment, and surface water samples (including QC duplicates) collected during the PBA08 RI in March–February 2010 and April 2011. Historical data were verified and completed as presented in the historical reports. Analytical results were reported by the laboratory in electronic format and loaded into the Ravenna Environmental Information Management System (REIMS) database. Data verification was performed to ensure all requested data were received and complete. Data qualifiers were assigned to each result based on the laboratory QA review and verification criteria.

Results were qualified as follows:

- "U"	not detected;
- "UJ"	not detected, reporting limit estimated;
- "J"	indicates the analyte was positively identified, but the associated numerical value is an approximate concentration of the analyte in the sample; and
- "R"	result not usable.

In addition to assigning qualifiers, the verification process also selected the appropriate result to use when re-analyses or dilutions were performed. Where laboratory surrogate recovery data or laboratory QC samples were outside of analytical method specifications, the verification chemist determined whether laboratory re-analysis should be used in place of an original reported result. If the laboratory reported results for both diluted and undiluted samples, diluted sample results were used for those analytes that exceeded the calibration range of the undiluted sample. A complete discussion of verification process results is contained in the data QC summary report (Appendix C). The data QC summary report also includes a summary table of the assigned data qualifiers and an accompanying rationale. Independent, third-party validation of 10% of the RI data, and 100% of the USACE QA laboratory data, was performed by a subcontractor to the USACE Louisville District.

4.4.2.2 <u>Data Reduction</u>

Calculating data summary statistics was the initial step in the data reduction process to identify SRCs. Eligible historic and current AOC data were extracted from the database. Results from QC splits and field duplicates, as well as rejected results, were excluded from the data screening process. All analytes having at least one detected value were included in the data reduction process. As stated in Section 5.4.7 of the FWSAP, "The duplicate is submitted as 'blind' to the laboratory and is used to determine whether the field sampling technique is reproducible and to check the accuracy of reported laboratory results." Therefore, duplicates are not used in the data screening process. All analytes having at least one detected value were included in the data reduction process.

Summary statistics calculated for each data aggregate included the minimum, maximum, and average (mean) values and the proportion of detected results to the total number of samples collected. For calculating mean values, non-detected results were addressed by using one-half of the reported detection limit as a surrogate value when calculating the mean result for each compound (USEPA 1989). Non-detected results with elevated detection limits (more than five times the contract-required detection limit) were excluded from the summary statistics in order to avoid skewing the mean value calculations.

4.4.2.3 <u>Data Screening</u>

After reduction, the data were screened to identify SRCs using the processes outlined below. Additional screening of identified SRCs against applicable criteria (e.g., EPA RSLs, FWCUGs, and ESVs) was conducted: (1) in the fate and transport evaluation (Section 6.0) to identify CMCOPCs, (2) in the HHRA to identify human health COPCs and COCs (Section 7.2), and (3) in the ERA to evaluate COPECs (Section 7.3). Figure 4-6 illustrates the screening process to identify SRCs and COPCs at Load Line 9 in accordance with the FWCUG Report. All chemicals that were not eliminated during the screening steps were retained as SRCs. The steps involved in the SRC screening are summarized below:

- **Data quality assessment**: Review the usability of the RI data set with respect to established DQOs as discussed in Section I.4.5 of Appendix I.
- **Background screening:** Compare the maximum detected concentrations (MDCs) of inorganic chemicals to background concentrations. If background concentrations are exceeded, the respective inorganic chemicals are retained as SRCs. No background concentrations were established for organic chemicals at Load Line 9. As such, all detected organic chemicals were retained as SRCs.
- **Screening of essential human nutrients**: Evaluate chemicals that are considered essential nutrients (e.g., calcium, chloride, iodine, iron, magnesium, potassium, phosphorous, and sodium) that are an integral part of the human food supply and are often added to foods as supplements. USEPA recommends these chemicals not be evaluated unless they are grossly elevated relative to background concentrations or would exhibit toxicity at the observed concentrations at an AOC (USEPA 1989). Recommended daily allowance (RDA) and recommended daily intake (RDI) values are available for all of these chemicals (Table 4-19). Screening values are calculated for receptors ingesting 100 mg of soil per day or 1 L of groundwater per day to meet their RDA/RDI. In the case of calcium, magnesium, phosphorous, potassium, and sodium, a receptor ingesting 100 mg of soil per day would receive less than the RDA/RDI value, even if the soil consisted of the pure mineral (i.e., soil concentrations at 1,000,000 mg/kg). Essential nutrients detected at or below their RDA/RDI-based screening levels (SLs) are eliminated as SRCs.
- **Frequency of detection/WOE screening:** The FWCUG Report and the *Final (Revised) USACE RVAAP Position Paper for the Application and Use of Facility-Wide Human Health Cleanup Goals* (USACE 2012b) (hereafter referred to as the Position Paper for Human Health CUGs) establish the protocol for frequency of detection and WOE screening. These guidance documents denote that analytes (with exception of explosives and propellants) detected in less than 5% of the discrete samples are screened out from further consideration, if the sample population is 20 or more samples and evidence exists that the analyte is not AOC-related. Chemicals that were never detected in a given medium are eliminated as SRCs. For chemicals with at least 20 samples and a frequency of detection of less than 5%, a WOE approach is used to determine if the chemical is AOC-related. The WOE evaluates magnitude and location (clustering) of detected results and if the distribution of detected results indicates a potential source of the chemical. If the detected results for a chemical show: (1) no clustering; (2) concentrations were not substantially elevated relative to detection limit; and (3) the chemical did not have an evident source, the results are considered spurious, and the chemical is eliminated from further consideration. This screen is applied to all organic chemicals and inorganic chemicals (with the exception of explosives and propellants); all detected explosives and propellants are considered SRCs regardless of frequency of detection. Frequency-of-detection/WOE screening was applied to the Load Line 9 surface soil data, as this data set was comprised of 20 or more samples.

4.4.3 Data Presentation

Data summary statistics and screening results for SRCs in surface soil, subsurface soil, sediment, and surface water at Load Line 9 are presented below for each media and spatial aggregate. Analytical results for SRCs are presented in Tables 4-20 through 4-22 for surface soil, Tables 4-23 through 4-25 for subsurface soil, Tables 4-26 and 4-27 for sediment, and Tables 4-28 and 4-29 for surface water.

The complete laboratory analytical data packages are included in Appendix D. In order to maximize efficiency for laboratory reporting and data management activities, all of the samples received at the laboratory on a given day were reported in a single data package. Therefore, results may be present in the data packages in Appendix D that are associated with different AOCs. All samples for Load Line 9 have sample identifications beginning with "LL9." Each table in Appendix D presents the results for each sampling location for a specific medium aggregate (e.g., surface soil, subsurface soil, sediment, and surface water), spatial aggregate (i.e., DWA, FPA, NPA, and Drainage Ditches), and class of analyte (e.g., explosives, inorganic chemicals, SVOCs, and VOCs).

The tables in Appendix D present the analytical results for samples collected during the 2002 lead azide screening, 2003 Phase I RI, and PBA08 RI. Sample locations from these investigations are presented on Figure 4-7. Analytical results are grouped by media (e.g., surface soil, subsurface soil) and class of analyte (e.g., explosives, inorganic chemicals) for ease of reference.

4.4.4 Data Evaluation

All quality-assured sample data were further evaluated to determine suitability for use in the various key RI data screens and evaluations (nature and extent, fate and transport, risk assessment). Evaluating data suitability for use in the PBA08 RI involved considering representativeness with respect to current AOC conditions. Table 4-30 presents the designated use for all available Load Line 9 samples.

4.4.4.1 <u>Soil</u>

Surface and subsurface soil samples at Load Line 9 were collected during the 2002 lead azide screening, 2003 Phase I RI, and the PBA08 RI. Soil in the vicinity of former production buildings was extensively disturbed during building demolition activities at Load Line 9. The work areas were re-graded, and the area was vegetated in 2003 and 2007. Sample data from 2002 and 2003 were evaluated to determine if conditions had changed substantively between earlier characterization efforts and PBA08 RI activities. All buildings at Load Line 9 were demolished prior to the Phase I RI activities. Between May 2006 and March 2007, 22 building floor slabs and foundations were removed to a minimum depth of 4 ft bgs. The work areas were re-graded, and the area was vegetated in 2003 and 2007. Off-site backfill may have been used to regrade the site. An unused elevated water tank is the only structure remaining at Load Line 9.

Phase I RI samples from soil borings LL9sb-048 through LL9sb-053 were collected under buildings that were subsequently demolished and were potentially affected by these demolition activities. These samples were omitted from the SRC screen; however, they were retained for purposes of nature and extent and contaminant migration evaluation.

The RRSE samples RV-261A, RV-261B, and RV-421 to RV-427 were not included in this RI evaluation, as the RRSE data collected at the site "…are minimal Level III data, as defined by U.S. EPA, and are not intended to be used as definitive evidence of contamination presence or absence or to support health risk assessment."

No surface or subsurface soil samples from the PBA08 RI data set were eliminated from the SRC screening process. This includes the April 2011 surface soil samples collected to further delineate the mercury contamination in the proximity of sample location LL9ss-011 (Building DT-34).

4.4.4.2 Sediment and Surface Water

For sediment and surface water data from the DWA and Drainage Ditches, if a PBA08 RI sample was obtained from a historical (2002 or 2003) sample location, the PBA08 RI result was considered to represent current conditions and was screened for SRCs. If the drainage had changed in a production area after building demolition, the historical sample was not used in the screening. In the case of the DWA, no PBA08 RI data were available for a sediment or surface water location sampled previously, so the historical data (LL9sd-012 and LL9sw-012) were utilized in the SRC screening. All historical sediment and surface water samples superseded in the SRC screen by PBA08 RI data were used only for evaluating contaminant nature and extent (e.g., temporal trends) and contaminant transport.

As noted in Section 2.2.3, the sump water was removed and disposed offsite, while basement water was applied per conditions of the Ohio EPA during building decontamination and demolition activities.

Sediment and surface water samples collected from the sanitary sewer system during the Phase I RI and Facility-wide Sewers RI are not included in the evaluation within this report, as those samples are evaluated as part of the Facility-wide Sewers AOC (designated as RVAAP-67).

Table 4–1. Phase I RI Sampling Locations

Phase I RI Sample Location	Sample Depth (ft bgs)	Analytes	Potential Sources or Areas for Investigation	Previous Use and/or Description	Documented Release	Potential Contaminants from Use
LL9ss/sb-001	0–1	Lead Azide and TNT/RDX Screening; Metals, Explosives	Building DT-6	1941-1945 –Utilized for explosive (lead azide) processing (Azide Dry House).	None	Metals, Explosives
	1–3	Metals, Explosives				
LL9ss/sb-002	0–1	Lead Azide and TNT/RDX Screening; Metals	Building DT-7	1941-1945 –Utilized for explosive (lead azide) processing (Azide Screen House).	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-003	0–1	Lead Azide and TNT/RDX Screening; Metals, Explosives	Building DT-8	1941-1945 –Utilized for explosive (lead azide) processing (Azide Dry House).	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-004	0–1	Lead Azide and TNT/RDX Screening; Metals	Building DT-9	1941-1945 –Utilized for explosive (lead azide) processing (Azide Dry House).	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-005	0–1	Lead Azide and TNT/RDX Screening; Metals, Explosives	Building DT-10	1941-1945 –Utilized for explosive (lead azide) processing (Vacuum Pump House).	None	Metals, Explosives
	1–3	Full suite				
	1–3	Full suite		QC Sample collected.		
LL9ss/sb-006	0–1	Lead Azide and TNT/RDX Screening; Metals	Building DT–14	1941-1945 –Utilized for Detonator Rumbling.	None	Metals, Explosives
	1–2	Metals				
LL9ss/sb-007	0–1	Lead Azide and TNT/RDX Screening; Metals, Explosives	Buildings DT–18 and DT-18A	1941-1945 –Utilized as Detonator Test Buildings.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-008	0–1	Lead Azide and TNT/RDX Screening; Metals	Building DT–19	1941-1945 –Utilized as Prep Primer Mix (Azide) Magazine.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-009	0–1	Lead Azide and TNT/RDX Screening; Metals, Explosives	Building DT–20	1941-1945 –Utilized as Loading Building.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-010	0–1	Lead Azide and TNT/RDX Screening; Metals	Building DT–22	1941-1945 –Utilized as Loading Building.	None	Metals, Explosives
	1–2.5	Metals				
LL9ss-011	0–1	Metals, Explosives	Subfloor of Building DT–34	Subfloor sample collected where a detonator destroying house (1941-1945) with a wood frame and a sand floor used to be. The explosives that were destroyed in this building included lead azide and mercury fulminate; but other metals, such as copper, may have been present in these explosives as well. This location is near the western side of the site where the terrain becomes relatively steep further to the west. There are no clear drainage channels in the immediate vicinity of that location.	None	Metals, Explosives
LL9ss/sb-012	0–1	Metals	Building DT-24	1941-1945 –Utilized for explosive (tetryl) pellet processing.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-013	0–1	Metals	Building DT-17	1941-1945 –Utilized for the charge of M22 boosters.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-014	0–1	Full suite	Building DT–25	1941-1945 –Utilized as mercury fulminate Service Magazine.	None	Metals, Explosives
	0–1	Full suite		QC sample collected.		
	1–3	Metals				
LL9ss/sb-015	0–1	Metals	Building DT-2	1941-1945 –Utilized for explosive (mercury fulminate) processing (mix house). Adjacent concrete settling tank for settling out explosive contamination from wastewater.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-016	0–1	Metals	Building DT-5	1941-1945 –Utilized for explosive (lead azide) processing (mix house). Adjacent concrete settling tank for settling out explosive contamination from wastewater.	None	Metals, Explosives
	0–1	Metals		QC sample collected		
	1–3	Metals				
LL9ss/sb-017	0–1	Metals	Building DT-33	1941-1945 –Utilized for Solvent Storage.	None	Solvents (VOCs)
	1–3	Metals				

Table 4-1. Phase I RI Sampling Locations (continued)

Phase I RI Sample Location	Sample Depth (ft bgs)	Analytes	Potential Sources or Areas for Investigation	Previous Use and/or Description	Documented Release	Potential Contaminants from Use
LL9ss/sb-018	0–1	Metals	Building DT-24	1941-1945 –Utilized for explosive (tetryl) pellet processing.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-019	0–1	Full suite	Building DT-57	1941-1945 –Utilized as the Tracer Destroying House.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-020	0–1	Metals	Building DT–22	1941-1945 –Utilized as Loading Building.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-021	0–1	Metals	Building DT–21	1941-1945 –Utilized as Loading Building.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-022	0–1	Metals	Building DT–21	1941-1945 –Utilized as Loading Building.	None	Metals, Explosives
	0–1	Metals		QC sample collected.		
	1–3	Metals				
LL9ss/sb-023	0–1	Metals	Building DT–20	1941-1945 –Utilized as Loading Building.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-024	0–1	Metals	WW-32	1941-1945 –Elevated water tank for the AOC. The water tank remains unused at the site.	None	Metals
	1–3	Metals				
LL9ss/sb-025	0–1	Full suite	WW-32	1941-1945 –Elevated water tank for the AOC. The water tank remains unused at the site.	None	Metals
	1–3	Metals				
LL9ss/sb-026	0–1	Metals	Building DT–16	1941-1945 –Utilized for the assembly of M22 boosters.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-027	0–1	Metals	Northern portion of NPA	Characterize area downgradient of FPA not previously sampled.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-028	0–1	Metals	Northwestern portion of NPA	Characterize area downgradient of FPA not previously sampled.	None	Metals, Explosives
	0–1	Metals		QC sample collected.		
	1–3	Metals				
LL9ss/sb-029	0–1	Metals	Western portion of NPA	Characterize area of NPA across from Building DT-14 (Detonator Rumbling) not previously sampled.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-030	0–1	Metals	Eastern portion of NPA	Characterize area downgradient of FPA not previously sampled.	None	Metals, Explosives
	1–3	Metals				
LL9ss/sb-031	0–1	Metals	Southern portion of NPA	Characterize area (east of entrance gate) not previously sampled.	None	Metals, Explosives
	1–3	Metals, Explosives				
LL9ss/sb-032	0–1	Metals	Southeastern portion of NPA	Characterize area downgradient of FPA not previously sampled.	None	Metals, Explosives
	1–3	Full suite				
LL9ss-033	0–1	Full suite	Southwest of AOC	Characterize surface soil at monitoring well location LL9mw-001, located outside AOC's southwest boundary near Load Line 10 perimeter fence.	None	Metals, Explosives
LL9ss-034	0–1	Full suite	Building DT–34	Characterize surface soil at monitoring well location LL9mw-002 at Building DT-34 (1941-1945 –Detonator Destroying House during WWII) in western portion of NPA.	None	Metals, Explosives
	0–1	Full suite		QC sample collected.		
LL9ss-035	0–1	Metals, Explosives	Central portion of FPA	Characterize surface soil at monitoring well location LL9mw-003, north of Building DT-21, in central portion of FPA.	None	Metals, Explosives
LL9ss-036	0–1	Metals	Southeastern portion of NPA	Characterize surface soil at monitoring well location LL9mw-004 southeast of FPA.	None	Metals, Explosives
	0–1	Metals		QC sample collected.		
LL9ss-037	0–1	Metals, Explosives	Northern portion of FPA	Characterize surface soil at monitoring well location LL9mw-005 in northern portion of FPA.	None	Metals, Explosives
LL9ss-038	0–1	Metals	Eastern portion of FPA	Characterize surface soil at monitoring well location LL9mw-006 in eastern portion of FPA.	None	Metals, Explosives
LL9ss-039	0–1	Metals, Explosives	Northern portion of NPA	Characterize surface soil at monitoring well location LL9mw-007, north of the FPA.	None	Metals, Explosives
	0–1	Metals, Explosives		QC sample collected.		
LL9sb-040	6–7	Full suite	Sump at Building DT-2	1941-1945 – DT-2 utilized for explosive (mercury fulminate) processing (mix house).	None	Metals, Explosives
LL9sb-041	6.5–7.5	Full suite	Sump at Building DT-5	1941-1945 – DT-5 utilized for explosive (lead azide) processing (mix house).	None	Metals, Explosives
LL9ss/sb-042	0–1	Metals	Adjacent to Sewer Line within FPA	Evaluate sewer line integrity in southeastern portion of FPA.	None	Metals, Explosives
	8-10	Metals				

Table 4-1. Phase I RI Sampling Locations (continued)

Phase I RI Sample Location	Sample Depth (ft bgs)	Analytes	Potential Sources or Areas for Investigation	Previous Use and/or Description	Documented Release	Potential Contaminants from Use
LL9ss/sb-043	0–1	Metals	Adjacent to Sewer Line within FPA	Evaluate sewer line integrity in central portion of FPA.	None	Metals, Explosives
	9-11	Full suite		QC sample collected.		
	9-11	Full suite				
LL9ss/sb-044	0–1	Metals	Dry Well at Building DT–20	1941-1945 Dry well at Building DT-20, utilized as Loading Building.	None	Metals, Explosives
	8-10	Metals				
LL9ss/sb-045	0–1	Metals	Dry Well at Building DT–21	1941-1945 Dry well at Building DT-21, utilized as Loading Building.	None	Metals, Explosives
	8-10	Metals				
LL9ss/sb-046	0–1	Metals	Dry Well at Building DT-22	1941-1945 Dry well at Building DT-22, utilized as Loading Building.	None	Metals, Explosives
	4–6	Metals				
LL9ss/sb-047	0–1	Metals	Dry Well Area (DWA)	The DWA is a 6-inch well that existed approximately 190 ft north of the AOC perimeter that served as a drainage conduit from Load Line 9. The DWA was sampled to determine whether releases from the fulminate and azide dry houses had occurred.	None	Metals, Explosives
	3–5	Metals				
LL9sb-048	0–1	Metals	Sub-floor of Building DT-5	1941-1945 –Sub-floor of Building DT-5, utilized for explosive (lead azide) processing (mix house).	None	Metals, Explosives
LL9sb-049	0–1	Metals	Sub-floor of Building DT-8	1941-1945 –Utilized for explosive (lead azide) processing (Azide Dry House) during WWII	None	Metals, Explosives
LL9sb-050	0–1	Full suite	Sub-floor of Building DT-16	1941-1945 –Utilized for the assembly of M22 boosters.	None	Metals, Explosives
LL9sb-051	0–1	Metals	Subfloor of Building DT–18	1941-1945 –Utilized as Detonator Test Building.	None	Metals, Explosives
LL9sb-052	0–1	Metals	Subfloor of Building DT–21	1941-1945 –Utilized as Loading Building. Subdivided in half.	None	Metals, Explosives
LL9sb-053	0–1	Metals, Explosives	Subfloor of Building DT–21	1941-1945 –Utilized as Loading Building. Subdivided in half.	None	Metals, Explosives
	0–1	Metals, Explosives		QC sample collected.		
LL9sb-055	1.5–3.5	VOCs, SVOCs, TPH-GRO/DRO	VOC Grid near Building DT–33	VOC screening grid established east of the solvent building at LL–9 (Building DT–33). The VOC screening grid was established and sampled to determine whether releases from the solvent building had occurred. Samples from the soil borings exhibiting the highest headspace readings were selected for analysis.	None	Solvents (VOCs)
LL9sb-056	2–4	VOCs, SVOCs, TPH-GRO/DRO	VOC Grid near Building DT–33	VOC screening grid established east of the solvent building at LL–9 (Building DT–33). The VOC screening grid was established and sampled to determine whether releases from the solvent building had occurred. Samples from the soil borings exhibiting the highest headspace readings were selected for analysis.	None	Solvents (VOCs)
LL9sb-059	3–5	VOCs, SVOCs, TPH-GRO/DRO	VOC Grid near Building DT–33	VOC screening grid established east of the solvent building at LL–9 (Building DT–33). The VOC screening grid was established and sampled to determine whether releases from the solvent building had occurred. Samples from the soil borings exhibiting the highest headspace readings were selected for analysis.	None	Solvents (VOCs)
LL9sb-061	1–3	VOCs, SVOCs, TPH-GRO/DRO	VOC Grid near Building DT–33	VOC screening grid established east of the solvent building at LL–9 (Building DT–33). The VOC screening grid was established and sampled to determine whether releases from the solvent building had occurred. Samples from the soil borings exhibiting the highest headspace readings were selected for analysis.	None	Solvents (VOCs)
LL9sb-065	3–5	Metals (explosives assessed during PBA08 RI)	DWA	The DWA is a 6-inch well that existed approximately 190 ft north of the AOC perimeter that served as a drainage conduit from Load Line 9. The DWA was sampled to determine whether releases from the fulminate and azide dry houses had occurred.	None	Metals
LL9sb-066	5–7	Metals (explosives assessed during PBA08 RI)	DWA	The DWA is a 6-inch well that existed approximately 190 ft north of the AOC perimeter that served as a drainage conduit from Load Line 9. The DWA was sampled to determine whether releases from the fulminate and azide dry houses had occurred.	None	Metals
LL9ss-068	0–1	Full suite	Northwestern portion of NPA	Characterize area downgradient of FPA not previously sampled; located in wooded area where surface debris (glass, metal, and other rubbish) was found. (RI contingency sample location).	None	Metals, Explosives
LL9sb-069	6.5–7.5	Metals	Building DT–1	1941-1945 –Utilized for explosive (mercury fulminate) processing (napkin prep building).	None	Metals, Explosives
LL9sb-070	6–7	Metals	Building DT–11	1941-1945 –Utilized for explosive (lead azide) processing (napkin prep building).	None	Metals, Explosives
LL9sd-001	0-1	Metals, Explosives	Drainage Ditch	Drainage ditch in NPA north of FPA.	None	Metals, Explosives
LL9sw-001	NA	Metals, Explosives		QC samples collected.		

Table 4-1. Phase I RI Sampling Locations (continued)

Phase I RI Sample Location	Sample Depth (ft bgs)	Analytes	Potential Sources or Areas for Investigation	Previous Use and/or Description	Documented Release	Potential Contaminants from Use
LL9sd-002	0-0.5	Metals	Drainage Ditch (Off-AOC)	Represents drainage off AOC, southeast of FPA.	None	Metals, Explosives
LL9sw-002	NA	Metals, Explosives				
LL9sd-003	0-1	Metals, Explosives	Drainage Ditch	Drainage ditch in southern portion of NPA, downgradient of Buildings DT-28, DT-29, and DT-52.	None	Metals, Explosives
LL9sw-003	NA	Metals, Explosives				
LL9sd-004	0-0.5	Metals	Drainage Ditch	Drainage ditch west of NPA near Buildings DT-34 and DT-35.	None	Metals, Explosives
LL9sw-004	NA	Metals, Explosives				
LL9sd-005	0-1	Metals, Explosives	Drainage Ditch	Drainage ditch near lead azide storage and processing buildings within the FPA.	None	Metals, Explosives
LL9sw-005	NA	Metals, Explosives				
LL9sd-006	0-0.5	Metals	Drainage Ditch	Drainage ditch near lead azide storage and processing buildings within the FPA.	None	Metals, Explosives
LL9sd-011	0-0.5	Metals	Drainage Ditch (Off-AOC)	Represents drainage off AOC, southeast of FPA.	None	Metals, Explosives
LL9sd-012	0-1	Metals	DWA	The DWA is a 6-inch well that existed approximately 190 ft north of the AOC perimeter that served as a drainage conduit from Load Line 9. The DWA was sampled to determine whether releases from the fulminate and azide dry houses had occurred.	None	Metals, Explosives
LL9sw-012	NA	Full suite				
LL9sw-012	NA	Full suite		QC sample collected.		
LL9sd-013	0-0.5	Metals	Drainage Ditch	Drainage ditch near Building DT-25 (Fulminate Service Magazine) in northern portion of FPA.	None	Metals, Explosives
LL9sd-014	0-0.5	Metals	Drainage Ditch	Drainage ditch near lead azide storage and processing buildings within the FPA.	None	Metals, Explosives
LL9sd-015	0-0.5	Full suite	Drainage Ditch	Drainage ditch near lead azide storage and processing buildings within the FPA.	None	Metals, Explosives
LL9sd-015	0-0.5	Full suite		QC sample collected.		
LL9sd-016	0-0.5	Metals	Drainage Ditch	Drainage ditch at Building DT-20 (Loading Building) within the FPA.	None	Metals, Explosives
LL9sd-016	0-0.5	Metals		QC sample collected.		
LL9sd-017	0-0.5	Metals	Drainage Ditch	Drainage ditch west of NPA near Buildings DT-34 and DT-35.	None	Metals, Explosives

Full Suite = TAL Metals, Explosives, Propellants, VOCs, SVOCs, PCBs, Pesticides and Cyanide.
AOC = Area of concern.
FPA = Former production area.
bgs = Below ground surface.
ft = Feet.
NA = Not applicable.
NPA = Non-production area.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
QC= Quality control.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
RI = Remedial investigation.
TNT = 2,4,6-Trinitrotoluene.
TPH-GRO/DRO = Total Petroleum Hydrocarbons-Gasoline Range Organics/Diesel Range Organics.
VOC = Volatile organic compound.
WWII = World War II.

Table 4–2. Analytes Detected in Phase I RI Discrete Surface Soil Samples

Station		**LL9ss-047**	**LL9ss-001**	**LL9ss-002**	**LL9ss-003**	**LL9ss-004**	**LL9ss-005**	**LL9ss-006**	**LL9ss-007**	**LL9ss-008**	**LL9ss-009**
Sample ID		**LL9ss-047-0001-SO**	**LL9ss-001-0001-SO**	**LL9ss-002-0001-SO**	**LL9ss-003-0001-SO**	**LL9ss-004-0001-SO**	**LL9ss-005-0001-SO**	**LL9ss-006-0001-SO**	**LL9ss-007-0001-SO**	**LL9ss-008-0001-SO**	**LL9ss-009-0001-SO**
Date		**11/06/03**	**03/11/02**	**12/04/03**	**03/11/02**	**12/04/03**	**03/11/02**	**12/11/03**	**03/11/02**	**12/10/03**	**03/11/02**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed											
Analyte	**Background Criteria**	**TAL Metals**	**TAL Metals, Explosives**	**TAL Metals**	**TAL Metals, Explosives**	**TAL Metals**	**TAL Metals, Explosives**	**TAL Metals**	**TAL Metals, Explosives**	**TAL Metals**	**TAL Metals, Explosives**
Metals (mg/kg)											
Aluminum	17700	8600	10300	8500	9110	7100	10400	9300	7200	11000	10400
Antimony	0.96	<0.52 U	0.2 J	<0.49 U	0.46	<0.41 U	0.19 J	<0.51 U	<0.33 U	<0.5 U	0.33
Arsenic	15.4	15	**18.2 ***	9.7	**16.9 ***	15	3.1	9.9	5.9	10	9.2
Barium	88.4	61	64.9	65	87.3	44	**135 ***	**92 ***	**90 ***	60	58.6
Beryllium	0.88	0.26 J	0.61	0.62	0.5	0.41 J	**1.8 ***	0.49	0.48	0.46	0.49
Cadmium	0	<0.088 U	<0.24 U	<0.084 U	**0.71 ***	<0.091 U	**0.23 ***	**2.9 ***	**0.36 ***	<0.091 U	<0.22 U
Calcium	15800	770	1380	2100	1230	1200	**113000 ***	4900	**75600 ***	1200	1780
Chromium	17.4	12	15	13	12.6	10	12	14	11.8	14	14.2
Cobalt	10.4	6.4	8.7	8.7	8.3	6.2	1.7	9.2	6.2	8.5	7.7
Copper	17.7	15	15.9	**20 ***	**24.3 ***	**19 ***	9.6	**18 ***	**25.2 ***	13	14.9
Iron	23100	16000	**25400 ***	21000	18200	19000	6140	16000	17300	20000	20200
Lead	26.1	12	**52.1 ***	**64 ***	**154 ***	**45 ***	**47 ***	**140 ***	**55 ***	18	**33.2 ***
Magnesium	3030	2000	2040	1900	1630	1800	**9600 ***	2000	2470	2000	1990
Manganese	1450	690	596	630	707	390	1360	830	493	640	451
Mercury	0.036	**0.063 ***	**0.054 ***	0.1 *	**0.06 ***	**0.073 ***	0.017 J	**1.3 ***	**0.071 ***	**0.047 ***	**0.23 ***
Nickel	21.1	13	15.6	16	13.7	15	5.7	15	16.6	16	13.9
Potassium	927	890	**954 ***	670	756	620	903	700	**1110 ***	790	771
Selenium	1.4	0.45 J	<1.2 U	0.54 J	<1.1 U	0.63 J	<1.1 U	0.45 J	<1 U	<0.46 U	<1.1 U
Sodium	123	**1200 ***	**192 ***	<92 U	**128 ***	<99 U	**279 ***	<100 U	**137 ***	<99 U	**177 ***
Vanadium	31.1	13	21.7	15	17.9	12	6.9	16	13.9	19	20.2
Zinc	61.8	45	**86 ***	**100 ***	**228 ***	**100 ***	46.6	**200 ***	**94.1 ***	**62 ***	**72.6 ***
Explosives (mg/kg)											
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Nitroguanidine	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
RDX	None	NR	<0.1 U	NR	<0.1 U	NR	<0.1 U	NR	<0.1 U	NR	<0.099 U
SVOCs (mg/kg)											
2-Methylnaphthalene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Acenaphthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Acenaphthylene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(*ghi*)perylene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Chrysene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dibenz(a,h)anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dibenzofuran	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Fluorene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Naphthalene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Phenanthrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 4–2. Analytes Detected in Phase I RI Discrete Surface Soil Samples (continued)

Station		**LL9ss-010**	**LL9ss-012**	**LL9ss-013**	**LL9ss-014**	**LL9ss-014**	**LL9ss-015**	**LL9ss-016**	**LL9ss-016**	**LL9ss-018**	**LL9ss-019**
Sample ID		**LL9ss-010-0001-SO**	**LL9ss-012-0001-SO**	**LL9ss-013-0001-SO**	**LL9ss-014-0001-FD**	**LL9ss-014-0001-SO**	**LL9ss-015-0001-SO**	**LL9ss-016-0001-FD**	**LL9ss-016-0001-SO**	**LL9ss-018-0001-SO**	**LL9ss-019-0001-SO**
Date		**12/08/03**	**12/10/03**	**12/10/03**	**12/11/03**	**12/11/03**	**12/11/03**	**12/11/03**	**12/11/03**	**12/10/03**	**12/11/03**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed		**TAL Metals**	**TAL Metals**	**TAL Metals**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**RVAAP Full-suite analytes**
Analyte	**Background Criteria**										
					Metals (mg/kg)						
Aluminum	17700	7200	9000	6000	6800	7900	17000	9100	9900	11000	14000
Antimony	0.96	<0.46 U	0.95	<0.47 U	<0.45 U	<0.46 U	0.7 J	<0.45 U	<0.49 U	0.54 J	<0.52 U
Arsenic	15.4	15	15	11	14	15	**24 ***	14	11	10	**17 ***
Barium	88.4	27	71	29	35	39	62	67	82	**95 ***	**170 ***
Beryllium	0.88	0.27 J	0.5	0.31 J	0.23 J	0.22 J	0.51	0.54	0.72	0.49	0.41 J
Cadmium	0	**0.11 J***	**0.51 ***	<0.08 U	<0.08 U	<0.083 U	<0.093 U	**0.14 J***	**0.17 J***	**0.16 J***	<0.085 U
Calcium	15800	1100	**22000 ***	2500	1200	1100	2200	12000	**20000 ***	1200	900
Chromium	17.4	10	13	8.4	8.9	11	**23 ***	12	10	14	17
Cobalt	10.4	6	7.1	7.9	5.7	7.2	8.3	6.1	7	10	8
Copper	17.7	**21 ***	**25 ***	**22 ***	**20 ***	**22 ***	**24 ***	**18 ***	**19 ***	12	**19 ***
Iron	23100	21000	22000	**24000 ***	19000	19000	**31000 ***	17000	18000	19000	**27000 ***
Lead	26.1	11	**44 ***	15	15	**43 ***	18	**35 ***	**38 ***	**40 ***	20
Magnesium	3030	1800	3000	2400	1700	2000	**3500 ***	**3300 ***	**3500 ***	2000	2600
Manganese	1450	280	600	370	340	410	180	790	1100	920	210
Mercury	0.036	**0.042 ***	**0.053 ***	0.024	0.024	**0.044 ***	**0.061 ***	**0.11 ***	**0.096 ***	**0.09 ***	**0.36 ***
Nickel	21.1	15	17	16	13	16	**23 ***	15	17	16	17
Potassium	927	790	**1100 ***	610	560	620	**1500 ***	**970 ***	**1000 ***	700	**1000 ***
Selenium	1.4	0.47 J	<0.45 U	<0.4 U	0.31 J	0.42 J	0.56 J	0.67 J	0.66 J	<0.45 U	0.43 J
Sodium	123	<92 U	<97 U	<87 U	<87 U	<90 U	<100 U	100	**170 ***	<98 U	<93 U
Vanadium	31.1	12	16	11	12	13	28	13	12	19	22
Zinc	61.8	**78 ***	**140 ***	**74 ***	**64 ***	**72 ***	**64 ***	**72 ***	**70 ***	**69 ***	51
					Explosives (mg/kg)						
Nitrocellulose	None	NR	NR	NR	**1.3 J***	**1.6 J***	NR	NR	NR	NR	**1.8 J***
Nitroguanidine	None	NR	NR	NR	<0.25 U	<0.25 U	NR	NR	NR	NR	<0.25 U
RDX	None	NR	NR	NR	<0.057 U	<0.058 U	NR	NR	NR	NR	<0.058 U
					SVOCs (mg/kg)						
2-Methylnaphthalene	None	NR	NR	NR	<0.0017 U	<0.0017 U	NR	NR	NR	NR	<0.0019 U
Acenaphthene	None	NR	NR	NR	<0.0016 U	<0.0015 U	NR	NR	NR	NR	<0.0017 U
Acenaphthylene	None	NR	NR	NR	<0.001 U	<0.001 U	NR	NR	NR	NR	<0.0011 U
Anthracene	None	NR	NR	NR	<0.00095 U	<0.00095 U	NR	NR	NR	NR	<0.0011 U
Benz(a)anthracene	None	NR	NR	NR	<0.0012 U	<0.0012 U	NR	NR	NR	NR	**0.0072 J***
Benzo(a)pyrene	None	NR	NR	NR	<0.0024 U	<0.0024 U	NR	NR	NR	NR	**0.0068 J***
Benzo(b)fluoranthene	None	NR	NR	NR	<0.0023 U	<0.0023 U	NR	NR	NR	NR	**0.0073 J***
Benzo(*ghi*)perylene	None	NR	NR	NR	<0.0021 U	<0.0021 U	NR	NR	NR	NR	**0.0053 J***
Benzo(k)fluoranthene	None	NR	NR	NR	<0.0031 U	<0.0031 U	NR	NR	NR	NR	**0.0049 J***
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	**0.047 J***	**0.15 J***	NR	NR	NR	NR	**0.061 J***
Chrysene	None	NR	NR	NR	<0.002 U	<0.002 U	NR	NR	NR	NR	**0.0052 J***
Dibenz(a,h)anthracene	None	NR	NR	NR	<0.0024 U	<0.0024 U	NR	NR	NR	NR	<0.0027 U
Dibenzofuran	None	NR	NR	NR	<0.003 U	<0.003 U	NR	NR	NR	NR	<0.0033 U
Fluoranthene	None	NR	NR	NR	<0.0012 U	<0.0012 U	NR	NR	NR	NR	**0.01 J***
Fluorene	None	NR	NR	NR	<0.0018 U	<0.0018 U	NR	NR	NR	NR	<0.002 U
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	<0.0023 U	<0.0023 U	NR	NR	NR	NR	<0.0026 U
Naphthalene	None	NR	NR	NR	<0.0019 U	<0.0019 U	NR	NR	NR	NR	<0.0021 U
Phenanthrene	None	NR	NR	NR	<0.0011 U	<0.0011 U	NR	NR	NR	NR	**0.0051 J***
Pyrene	None	NR	NR	NR	<0.0022 U	<0.0022 U	NR	NR	NR	NR	**0.01 J***

Table 4–2. Analytes Detected in Phase I RI Discrete Surface Soil Samples (continued)

Station		**LL9ss-020**	**LL9ss-021**	**LL9ss-022**	**LL9ss-022**	**LL9ss-023**	**LL9ss-024**	**LL9ss-026**	**LL9ss-035**	**LL9ss-037**	**LL9ss-038**
Sample ID		**LL9ss-020-0001-SO**	**LL9ss-021-0001-SO**	**LL9ss-022-0001-FD**	**LL9ss-022-0001-SO**	**LL9ss-023-0001-SO**	**LL9ss-024-0001-SO**	**LL9ss-026-0001-SO**	**LL9ss-035-0001-SO**	**LL9ss-037-0001-SO**	**LL9ss-038-0001-SO**
Date		**12/08/03**	**12/08/03**	**12/10/03**	**12/10/03**	**12/08/03**	**12/10/03**	**12/10/03**	**11/11/03**	**11/11/03**	**11/11/03**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed											
Analyte	**Background Criteria**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals**
Metals (mg/kg)											
Aluminum	17700	7900	13000	9600	8800	**20000 ***	8000	13000	7900	12000	13000
Antimony	0.96	<0.48 U	<0.5 U	<0.52 U	<0.49 U	<0.55 U	0.85	**1.2 ***	<0.47 U	<0.5 U	<0.54 U
Arsenic	15.4	13	**16 ***	12	13	**21 ***	10	8.3	10	9.4	7.5
Barium	88.4	47	55	55	38	66	49	**100 ***	38	**97 ***	81
Beryllium	0.88	0.32 J	0.37 J	0.49	0.36 J	0.43 J	0.31 J	0.6	0.41 J	0.58	0.59
Cadmium	0	**0.71 ***	**0.5 ***	<0.09 U	<0.086 U	**0.11 J***	**0.42 ***	<0.095 U	<0.092 U	<0.092 U	<0.11 U
Calcium	15800	1600	2700	4300	1300	5300	1100	1200	4100	610	210
Chromium	17.4	11	**18 ***	12	12	**21 ***	**110 ***	17	13	16	15
Cobalt	10.4	7	6	6.9	8.6	6.5	6.6	**11 ***	7.5	**17 ***	**14 ***
Copper	17.7	**31 ***	**19 ***	**21 ***	17	**23 ***	13	12	14	9.2	11
Iron	23100	16000	**27000 ***	22000	20000	**26000 ***	14000	23000	22000	17000	19000
Lead	26.1	**33 ***	**35 ***	**48 ***	20	**50 ***	**320 ***	**28 ***	21	21	21
Magnesium	3030	1800	2200	2300	1900	**3200 ***	1500	2300	2100	1800	1700
Manganese	1450	460	260	480	150	230	500	860	350	970	1000
Mercury	0.036	**0.74 ***	**0.045 ***	**0.2 ***	**0.11 ***	**0.25 ***	**0.057 ***	**0.045 ***	0.033	0.03	**0.072 ***
Nickel	21.1	14	13	15	15	16	9.9	16	14	15	14
Potassium	927	660	**1000 ***	750	750	**1500 ***	560	860	820	680	720
Selenium	1.4	0.52 J	<0.44 U	<0.45 U	<0.43 U	0.89 J	<0.5 U	<0.48 U	0.84 J	0.99 J	1.1 J
Sodium	123	<92 U	<94 U	<98 U	<93 U	<110 U	<110 U	<100 U	**1100 ***	**1100 ***	**1300 ***
Vanadium	31.1	14	22	15	15	28	15	23	14	21	22
Zinc	61.8	**85 ***	**72 ***	**69 ***	48	57	**210 ***	**71 ***	**66 ***	**65 ***	**69 ***
Explosives (mg/kg)											
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Nitroguanidine	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
RDX	None	NR	NR	NR	NR	NR	NR	NR	<0.058 U	<0.059 U	NR
SVOCs (mg/kg)											
2-Methylnaphthalene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Acenaphthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Acenaphthylene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(*ghi*)perylene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Chrysene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dibenz(a,h)anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dibenzofuran	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Fluorene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Naphthalene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Phenanthrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 4–2. Analytes Detected in Phase I RI Discrete Surface Soil Samples (continued)

Station	Background Criteria	LL9ss-042	LL9ss-043	LL9ss-044	LL9ss-045	LL9ss-046	LL9sb-048	LL9sb-049	LL9sb-050	LL9sb-051	LL9sb-052
Sample ID		**LL9ss-042-0001-SO**	**LL9ss-043-0001-SO**	**LL9ss-044-0001-SO**	**LL9ss-045-0001-SO**	**LL9ss-046-0001-SO**	**LL9sb-048-0001-SO**	**LL9sb-049-0001-SO**	**LL9sb-050-0001-SO**	**LL9sb-051-0001-SO**	**LL9sb-052-0001-SO**
Date		**11/06/03**	**11/06/03**	**11/06/03**	**11/06/03**	**11/06/03**	**12/10/03**	**12/10/03**	**12/10/03**	**12/08/03**	**12/08/03**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed		**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**RVAAP Full-suite analytes**	**TAL Metals**	**TAL Metals**
Analyte											
						Metals (mg/kg)					
Aluminum	17700	7200	10000	12000	13000	8900	8400	12000	12000	11000	16000
Antimony	0.96	<0.41 U	<0.49 U	<0.47 U	<0.49 U	0.54 J	<0.47 U	<0.49 U	<0.51 U	<0.51 U	<0.52 U
Arsenic	15.4	4	9.2	**18 ***	**17 ***	**18 ***	11	12	10	**18 ***	**16 ***
Barium	88.4	41	57	85	40	53	51	**150 ***	56	64	66
Beryllium	0.88	0.47	0.47	0.27 J	0.48	0.42 J	0.4 J	0.47	0.33 J	0.55	0.55
Cadmium	0	<0.078 U	<0.086 U	<0.09 U	<0.082 U	<0.09 U	<0.085 U	<0.089 U	<0.092 U	**0.11 J***	<0.089 U
Calcium	15800	470	630	2800	750	890	5100	990	970	6800	850
Chromium	17.4	10	13	16	17	13	12	**24 ***	16	15	**21 ***
Cobalt	10.4	9.2	9.3	4.2	8.6	**11 ***	9	9.2	6.8	9.6	7.4
Copper	17.7	11	13	9.7	**25 ***	**21 ***	**20 ***	**21 ***	11	**21 ***	**22 ***
Iron	23100	18000	20000	17000	**31000 ***	**25000 ***	21000	**27000 ***	23000	**24000 ***	**29000 ***
Lead	26.1	9.2	14	10	16	13	**41 ***	**64 ***	15	13	9.3
Magnesium	3030	1700	2400	2200	2900	3000	2500	2500	2200	**3100 ***	**3600 ***
Manganese	1450	610	440	150	240	370	590	530	370	350	190
Mercury	0.036	0.0076 J	0.026	0.0057 J	0.0081 J	0.016 J	**0.34 ***	0.036	0.027	0.027	0.017 J
Nickel	21.1	13	17	19	21	**24 ***	18	21	13	**22 ***	20
Potassium	927	710	860	770	**1200 ***	900	850	**1100 ***	**1000 ***	**1400 ***	**1600 ***
Selenium	1.4	0.39 J	0.62 J	<0.45 U	<0.41 U	<0.45 U	<0.43 U	<0.44 U	<0.46 U	<0.44 U	<0.44 U
Sodium	123	**930 ***	**1100 ***	**1200 ***	**1100 ***	**1300 ***	<92 U	<96 U	<100 U	<95 U	120
Vanadium	31.1	13	17	13	20	14	14	20	22	19	25
Zinc	61.8	46	50	40	**62 ***	**63 ***	**82 ***	**290 ***	40	59	53
						Explosives (mg/kg)					
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	NR	**4.3 J***	NR	NR
Nitroguanidine	None	NR	NR	NR	NR	NR	NR	NR	<0.25 U	NR	NR
RDX	None	NR	NR	NR	NR	NR	NR	NR	<0.059 U	NR	NR
						SVOCs (mg/kg)					
2-Methylnaphthalene	None	NR	NR	NR	NR	NR	NR	NR	<0.0018 U	NR	NR
Acenaphthene	None	NR	NR	NR	NR	NR	NR	NR	**0.019 J***	NR	NR
Acenaphthylene	None	NR	NR	NR	NR	NR	NR	NR	<0.0011 U	NR	NR
Anthracene	None	NR	NR	NR	NR	NR	NR	NR	**0.03 J***	NR	NR
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR	NR	**0.041 ***	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.042 ***	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	**0.038 J***	NR	NR
Benzo(*ghi*)perylene	None	NR	NR	NR	NR	NR	NR	NR	**0.033 J***	NR	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	**0.032 J***	NR	NR
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR	NR	NR	<0.011 U	NR	NR
Chrysene	None	NR	NR	NR	NR	NR	NR	NR	**0.042 ***	NR	NR
Dibenz(a,h)anthracene	None	NR	NR	NR	NR	NR	NR	NR	**0.043 ***	NR	NR
Dibenzofuran	None	NR	NR	NR	NR	NR	NR	NR	**0.0079 J***	NR	NR
Fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	**0.13 ***	NR	NR
Fluorene	None	NR	NR	NR	NR	NR	NR	NR	**0.015 J***	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.044 ***	NR	NR
Naphthalene	None	NR	NR	NR	NR	NR	NR	NR	<0.002 U	NR	NR
Phenanthrene	None	NR	NR	NR	NR	NR	NR	NR	**0.1 ***	NR	NR
Pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.1 ***	NR	NR

Table 4–2. Analytes Detected in Phase I RI Discrete Surface Soil Samples (continued)

Station		**LL9sb-053**	**LL9sb-053**	**LL9ss-011**	**LL9ss-017**	**LL9ss-025**	**LL9ss-027**	**LL9ss-028**	**LL9ss-028**	**LL9ss-029**	**LL9ss-030**
Sample ID		**LL9sb-053-0001-FD**	**LL9sb-053-0001-SO**	**LL9ss-011-0001-SO**	**LL9ss-017-0001-SO**	**LL9ss-025-0001-SO**	**LL9ss-027-0001-SO**	**LL9ss-028-0001-FD**	**LL9ss-028-0001-SO**	**LL9ss-029-0001-SO**	**LL9ss-030-0001-SO**
Date		**12/11/03**	**12/11/03**	**03/11/02**	**12/04/03**	**12/10/03**	**12/04/03**	**12/04/03**	**12/04/03**	**12/04/03**	**12/04/03**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed		**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals**	**RVAAP Full-suite analytes**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**
Analyte	**Background Criteria**										
Metals (mg/kg)											
Aluminum	17700	6900	7400	8700	10000	12000	10000	10000	10000	9400	6800
Antimony	0.96	<0.45 U	<0.46 U	**1.4 ***	<0.46 U	<0.54 U	<0.55 U	<0.53 U	<0.62 U	<0.54 U	<0.52 U
Arsenic	15.4	9.4	11	**16.9 ***	11	8.4	11	9.4	15	7.4	4.2
Barium	88.4	54	57	40.2	65	57	81	52	64	80	52
Beryllium	0.88	0.19 J	0.24 J	0.34 J	0.69	0.35 J	0.84	0.51	0.57 J	0.75	0.61
Cadmium	0	<0.08 U	<0.09 U	**0.14 J***	<0.09 U	<0.096 U	<0.1 U	<0.09 U	<0.12 U	<0.1 U	<0.096 U
Calcium	15800	1300	790	5090	650	1100	430	730	1100	530	530
Chromium	17.4	8.1	8.8	16.1	14	16	11	12	12	11	9.2
Cobalt	10.4	5.4	6.2	9.8	8	8	**18 ***	5.1	5.3	8.1	5.6
Copper	17.7	11	12	**1240 ***	12	9.9	7.1	6.4	7.2	8.9	8.1
Iron	23100	13000	15000	**42000 ***	23000	**24000 ***	**25000 ***	23000	21000	16000	20000
Lead	26.1	10	12	**1330 ***	16	25	16	13	13	17	13
Magnesium	3030	1400	1500	2230	1800	2300	1300	1300	1400	1600	1200
Manganese	1450	500	550	557	690	420	**3800 ***	330	460	870	650
Mercury	0.036	0.023	0.024	**882 ***	**0.037 ***	0.032	**0.041 ***	**0.2 ***	**0.24 ***	**0.088 ***	0.034
Nickel	21.1	11	13	17.3	14	12	12	7.9	8.9	13	10
Potassium	927	670	700	815	660	790	540	570	580	600	450
Selenium	1.4	0.46 J	0.41 J	<0.91 U	<0.45 U	<0.48 U	0.71 J	0.51 J	0.92 J	0.79 J	<0.48 U
Sodium	123	<86 U	<97 U	94.3	<97 U	<100 U	<110 U	<98 U	<130 U	<110 U	<100 U
Vanadium	31.1	14	13	12.6	21	23	23	22	21	16	14
Zinc	61.8	47	45	**711 ***	52	46	47	36	43	56	48
Explosives (mg/kg)											
Nitrocellulose	None	NR	NR	NR	NR	**1.6 J***	NR	NR	NR	NR	NR
Nitroguanidine	None	NR	NR	NR	NR	<0.25 U	NR	NR	NR	NR	NR
RDX	None	<0.058 U	**0.11 ***	<0.098 U	NR	<0.058 U	NR	NR	NR	NR	NR
SVOCs (mg/kg)											
2-Methylnaphthalene	None	NR	NR	NR	NR	<0.0018 U	NR	NR	NR	NR	NR
Acenaphthene	None	NR	NR	NR	NR	<0.0017 U	NR	NR	NR	NR	NR
Acenaphthylene	None	NR	NR	NR	NR	<0.0011 U	NR	NR	NR	NR	NR
Anthracene	None	NR	NR	NR	NR	<0.0011 U	NR	NR	NR	NR	NR
Benz(a)anthracene	None	NR	NR	NR	NR	**0.012 J***	NR	NR	NR	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	**0.012 J***	NR	NR	NR	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	**0.011 J***	NR	NR	NR	NR	NR
Benzo(*ghi*)perylene	None	NR	NR	NR	NR	**0.011 J***	NR	NR	NR	NR	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	**0.01 J***	NR	NR	NR	NR	NR
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	<0.012 U	NR	NR	NR	NR	NR
Chrysene	None	NR	NR	NR	NR	**0.012 J***	NR	NR	NR	NR	NR
Dibenz(a,h)anthracene	None	NR	NR	NR	NR	**0.03 J***	NR	NR	NR	NR	NR
Dibenzofuran	None	NR	NR	NR	NR	<0.0033 U	NR	NR	NR	NR	NR
Fluoranthene	None	NR	NR	NR	NR	**0.019 J***	NR	NR	NR	NR	NR
Fluorene	None	NR	NR	NR	NR	<0.002 U	NR	NR	NR	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	**0.024 J***	NR	NR	NR	NR	NR
Naphthalene	None	NR	NR	NR	NR	<0.0021 U	NR	NR	NR	NR	NR
Phenanthrene	None	NR	NR	NR	NR	**0.01 J***	NR	NR	NR	NR	NR
Pyrene	None	NR	NR	NR	NR	**0.019 J***	NR	NR	NR	NR	NR

Table 4–2. Analytes Detected in Phase I RI Surface Soil Samples (continued)

Station		**LL9ss-031**	**LL9ss-032**	**LL9ss-034**	**LL9ss-034**	**LL9ss-036**	**LL9ss-036**	**LL9ss-039**	**LL9ss-039**	**LL9ss-068**	**LL9ss-033**
Sample ID		**LL9ss-031-0001-SO**	**LL9ss-032-0001-SO**	**LL9ss-034-0001-FD**	**LL9ss-034-0001-SO**	**LL9ss-036-0001-FD**	**LL9ss-036-0001-SO**	**LL9ss-039-0001-FD**	**LL9ss-039-0001-SO**	**LL9ss-068-0001-SO**	**LL9ss-033-0001-SO**
Date		**12/04/03**	**12/04/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/11/03**	**12/12/03**	**11/11/03**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed											
Analyte	**Background Criteria**	**TAL Metals**	**TAL Metals**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals**	**TAL Metals**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**
Metals (mg/kg)											
Aluminum	17700	6400	8200	7000	9300	8500	8500	5700	6000	8400	13000
Antimony	0.96	<0.48 U	<0.49 U	<0.49 U	<0.5 U	<0.52 U	<0.52 U	<0.48 U	<0.55 U	<0.79 U	<0.54 U
Arsenic	15.4	6.9	7.4	10	7.1	5.6	5.3	3.1	4.2	7.3	9.2
Barium	88.4	72	45	41	57	47	44	34	37	**110 ***	77
Beryllium	0.88	0.74	0.58	0.46	0.42 J	0.39 J	0.36 J	0.49	0.51	0.54 J	0.55
Cadmium	0	**0.31 ***	<0.088 U	<0.086 U	<0.087 U	<0.092 U	<0.09 U	<0.091 U	<0.099 U	**2.7 ***	<0.11 U
Calcium	15800	2600	600	900	1300	370	320	2000	1600	1900	990
Chromium	17.4	11	12	12	14	14	14	9.8	9.7	15	15
Cobalt	10.4	**13 ***	7.5	6.1	8.7	8.1	7	4.5	4.8	6.8	**11 ***
Copper	17.7	8.5	13	**33 ***	**34 ***	9.1	8.8	7.1	7.8	**170 ***	9.3
Iron	23100	**76000 ***	22000	**32000 ***	21000	20000	19000	**25000 ***	**25000 ***	20000	23000
Lead	26.1	**28 ***	12	**38 ***	**43 ***	13	13	19	22	**150 ***	25
Magnesium	3030	1300	1700	1500	1900	1500	1600	1100	1100	1200	1900
Manganese	1450	**2000 ***	480	420	630	570	420	420	470	700	1200
Mercury	0.036	0.032	0.028	**17 ***	**12 ***	0.031	0.026	0.032	**0.039 ***	**0.21 ***	0.033
Nickel	21.1	18	13	16	15	12	12	9.4	10	15	12
Potassium	927	540	660	550	760	660	650	520	550	680	770
Selenium	1.4	<0.45 U	0.52 J	0.61 J	0.66 J	1.1 J	0.56 J	1.1 J	1.2 J	**1.8 J***	1 J
Sodium	123	<97 U	<95 U	**660 ***	**1000 ***	**970 ***	**970 ***	**850 ***	**940 ***	**170 J***	**1000 ***
Vanadium	31.1	19	15	15	17	15	15	11	12	16	25
Zinc	61.8	**75 ***	47	**79 ***	**71 ***	49	48	**69 ***	**76 ***	**780 ***	**86 ***
Explosives (mg/kg)											
Nitrocellulose	None	NR	NR	<2.5 U	**1.1 ***	NR	NR	NR	NR	**3.2 J***	**1.4 ***
Nitroguanidine	None	NR	NR	<0.25 U	**0.089 J***	NR	NR	NR	NR	<0.25 U	<0.25 U
RDX	None	NR	NR	<0.058 U	<0.058 U	NR	NR	<0.059 U	<0.059 U	<0.059 U	<0.058 U
SVOCs (mg/kg)											
2-Methylnaphthalene	None	NR	NR	<0.0018 U	<0.0018 U	NR	NR	NR	NR	**0.015 J***	<0.002 U
Acenaphthene	None	NR	NR	**0.011 J***	<0.0017 U	NR	NR	NR	NR	**0.011 J***	<0.0019 U
Acenaphthylene	None	NR	NR	<0.0011 U	<0.0011 U	NR	NR	NR	NR	**0.05 J***	<0.0012 U
Anthracene	None	NR	NR	**0.022 J***	<0.001 U	NR	NR	NR	NR	**0.048 J***	<0.0012 U
Benz(a)anthracene	None	NR	NR	**0.079 ***	**0.026 J***	NR	NR	NR	NR	**0.23 ***	**0.017 J***
Benzo(a)pyrene	None	NR	NR	**0.073 ***	**0.023 J***	NR	NR	NR	NR	**0.24 ***	**0.025 J***
Benzo(b)fluoranthene	None	NR	NR	**0.098 ***	**0.032 J***	NR	NR	NR	NR	**0.24 ***	**0.031 J***
Benzo(*ghi*)perylene	None	NR	NR	**0.056 ***	**0.017 J***	NR	NR	NR	NR	**0.17 ***	**0.02 J***
Benzo(k)fluoranthene	None	NR	NR	**0.058 ***	**0.025 J***	NR	NR	NR	NR	**0.2 ***	**0.018 J***
Bis(2-ethylhexyl)phthalate	None	NR	NR	**0.014 J***	<0.011 U	NR	NR	NR	NR	**0.03 J***	<0.013 U
Chrysene	None	NR	NR	**0.12 ***	**0.03 J***	NR	NR	NR	NR	**0.25 ***	**0.025 J***
Dibenz(a,h)anthracene	None	NR	NR	**0.027 J***	<0.0026 U	NR	NR	NR	NR	**0.13 ***	**0.01 J***
Dibenzofuran	None	NR	NR	<0.0032 U	<0.0032 U	NR	NR	NR	NR	**0.013 J***	<0.0036 U
Fluoranthene	None	NR	NR	**0.2 ***	**0.058 ***	NR	NR	NR	NR	**0.36 ***	**0.035 J***
Fluorene	None	NR	NR	**0.0085 J***	<0.0019 U	NR	NR	NR	NR	**0.025 J***	<0.0022 U
Indeno(1,2,3-cd)pyrene	None	NR	NR	**0.056 ***	<0.0025 U	NR	NR	NR	NR	**0.17 ***	**0.018 J***

Table 4–2. Analytes Detected in Phase I RI Surface Soil Samples (continued)

Station		**LL9ss-031**	**LL9ss-032**	**LL9ss-034**	**LL9ss-034**	**LL9ss-036**	**LL9ss-036**	**LL9ss-039**	**LL9ss-039**	**LL9ss-068**	**LL9ss-033**
Sample ID		**LL9ss-031-0001-SO**	**LL9ss-032-0001-SO**	**LL9ss-034-0001-FD**	**LL9ss-034-0001-SO**	**LL9ss-036-0001-FD**	**LL9ss-036-0001-SO**	**LL9ss-039-0001-FD**	**LL9ss-039-0001-SO**	**LL9ss-068-0001-SO**	**LL9ss-033-0001-SO**
Date		**12/04/03**	**12/04/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/11/03**	**11/11/03**	**12/12/03**	**11/11/03**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed **Analyte**	**Background Criteria**	**TAL Metals**	**TAL Metals**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals**	**TAL Metals**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**
Naphthalene	None	NR	NR	<0.002 U	<0.002 U	NR	NR	NR	NR	**0.019 J***	<0.0023 U
Phenanthrene	None	NR	NR	**0.1 ***	**0.021 J***	NR	NR	NR	NR	**0.28 ***	**0.02 J***
Pyrene	None	NR	NR	**0.16 ***	**0.045 ***	NR	NR	NR	NR	**0.4 ***	**0.039 J***

ft = Feet.
ID = Identification.
mg/kg = Milligrams per kilogram.
NR = Not reported/not analyzed.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
TAL = Target analyte list.
U = Not detected.
*** = Result exceeds background criteria or no background criteria was available.**
< = Less than.

Table 4–3. Analytes Detected in Phase I RI Subsurface Soil Samples

Station		**LL9sb-047**	**LL9sb-065**	**LL9sb-066**	**LL9sb-001**	**LL9sb-002**	**LL9sb-003**	**LL9sb-004**	**LL9sb-005**	**LL9sb-005**	**LL9sb-006**
Sample ID		**LL9sb-047-0001-SO**	**LL9sb-065-0001-SO**	**LL9sb-066-0001-SO**	**LL9sb-001-0001-SO**	**LL9sb-002-0001-SO**	**LL9sb-003-0001-SO**	**LL9sb-004-0001-SO**	**LL9sb-005-0001-FD**	**LL9sb-005-0001-SO**	**LL9sb-006-0001-SO**
Date		**11/06/03**	**11/06/03**	**11/06/03**	**12/04/03**	**12/04/03**	**12/04/03**	**12/04/03**	**12/04/03**	**12/04/03**	**12/11/03**
Depth (ft)		**3.0 - 5.0**	**3.0 - 5.0**	**5.0 - 7.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 2.0**
Parameters Analyzed											
Analyte	**Background Criteria**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals, Explosives**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals**
Metals (mg/kg)											
Aluminum	19500	8600	10000	5300	7500	10000	6600	8200	11000	11000	7000
Antimony	0.96	<0.49 U	0.72 J	<0.45 U	<0.52 U	<0.48 U	<0.48 U	<0.5 U	<0.53 U	<0.48 U	<0.48 U
Arsenic	19.8	5.9	4.6	11	12	12	9.8	8.5	9	7.7	9.9
Barium	124	61	83	38	30	64	26	50	80	70	66
Beryllium	0.88	0.16 J	0.43 J	0.44	0.33 J	0.44 J	0.38 J	0.43	0.8	0.63	0.31 J
Cadmium	0	<0.082 U	<0.11 U	<0.086 U	<0.091 U	<0.092 U	<0.085 U	<0.084 U	<0.091 U	<0.09 U	**2 ***
Calcium	35500	1000	1100	1200	800	4300	530	1100	360	330	2700
Chromium	27.2	11	12	9.8	10	16	8.4	10	13	13	11
Cobalt	23.2	1.6	5.8	10	6.8	8	5.5	3.8	11	11	6.2
Copper	32.3	8.7	8.7	18	27	19	17	6.5	9.3	9.1	15
Iron	35200	9600	14000	19000	23000	23000	16000	18000	17000	15000	14000
Lead	19.1	5.2	**51 ***	10	9.2	**24 ***	10	9.9	12	11	**54 ***
Magnesium	8790	1300	2100	1700	2100	2200	1600	1200	1700	1600	1500
Manganese	3030	92	140	340	400	600	310	200	1300	1100	520
Mercury	0.044	0.03	**9.7 ***	0.016 J	0.021	**0.076 ***	0.022	0.019 J	0.039	0.034	**0.94 ***
Nickel	60.7	9.6	15	22	18	17	13	7.1	16	14	12
Potassium	3350	740	790	1000	630	660	480	490	560	550	550
Selenium	1.5	<0.41 U	0.58 J	<0.43 U	<0.45 U	0.77 J	<0.43 U	<0.42 U	0.91 J	0.69 J	0.38 J
Sodium	145	**1200 ***	**1300 ***	**1100 ***	<98 U	<99 U	<93 U	<91 U	<99 U	<97 U	<95 U
Thallium	0.91	<1 U	<1.1 U	<0.97 U	<0.23 U	<0.21 U	<0.21 U	<0.22 U	<0.23 U	<0.21 U	<0.21 U
Vanadium	37.6	9.2	17	9.8	13	19	11	15	18	17	13
Zinc	93.3	50	72	54	60	68	48	37	49	45	**120 ***
Explosives (mg/kg)											
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	NR	**2.7 J***	**1.2 J***	NR
SVOCs (mg/kg)											
Acenaphthene	None	NR	NR	NR	NR	NR	NR	NR	<0.0017 U	<0.0017 U	NR
Anthracene	None	NR	NR	NR	NR	NR	NR	NR	<0.0011 U	<0.001 U	NR
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR	NR	<0.0014 U	<0.0013 U	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR	NR	<0.0027 U	<0.0026 U	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	<0.0026 U	<0.0025 U	NR
Benzo(*ghi*)perylene	None	NR	NR	NR	NR	NR	NR	NR	**0.0038 J***	<0.0023 U	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	<0.0034 U	<0.0033 U	NR
Chrysene	None	NR	NR	NR	NR	NR	NR	NR	<0.0022 U	<0.0021 U	NR
Di-n-butyl phthalate	None	NR	NR	NR	NR	NR	NR	NR	<0.025 U	<0.024 U	NR
Dibenz(a,h)anthracene	None	NR	NR	NR	NR	NR	NR	NR	<0.0027 U	<0.0026 U	NR
Fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	<0.0014 U	<0.0013 U	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.018 J***	**0.017 J***	NR
Phenanthrene	None	NR	NR	NR	NR	NR	NR	NR	<0.0012 U	<0.0012 U	NR
Pyrene	None	NR	NR	NR	NR	NR	NR	NR	<0.0025 U	<0.0024 U	NR

Table 4–3. Analytes Detected in Phase I RI Subsurface Soil Samples (continued)

Station		**LL9sb-007**	**LL9sb-008**	**LL9sb-009**	**LL9sb-010**	**LL9sb-012**	**LL9sb-013**	**LL9sb-014**	**LL9sb-015**	**LL9sb-016**	**LL9sb-018**
Sample ID		**LL9sb-007-0001-SO**	**LL9sb-008-0001-SO**	**LL9sb-009-0001-SO**	**LL9sb-010-0001-SO**	**LL9sb-012-0001-SO**	**LL9sb-013-0001-SO**	**LL9sb-014-0001-SO**	**LL9sb-015-0001-SO**	**LL9sb-016-0001-SO**	**LL9sb-018-0001-SO**
Date		**12/08/03**	**12/10/03**	**12/08/03**	**12/08/03**	**12/10/03**	**12/10/03**	**12/11/03**	**12/11/03**	**12/11/03**	**12/10/03**
Depth (ft)		**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 2.5**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Parameters Analyzed		**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**
Analyte	**Background Criteria**										
Metals (mg/kg)											
Aluminum	19500	12000	12000	12000	9700	9700	6700	7100	10000	8000	14000
Antimony	0.96	<0.5 U	<0.53 U	<0.47 U	<0.49 U	0.8	<0.46 U	<0.48 U	**1 ***	<0.47 U	0.82
Arsenic	19.8	14	12	**22 ***	**22 ***	19	11	18	18	11	15
Barium	124	75	71	51	57	55	29	34	60	47	58
Beryllium	0.88	0.55	0.58	0.52	0.55	0.34 J	0.25 J	0.23 J	0.54	0.43	0.53
Cadmium	0	**0.13 J***	<0.095 U	<0.091 U	**0.13 J***	<0.091 U	<0.084 U	<0.081 U	<0.079 U	<0.077 U	<0.09 U
Calcium	35500	1900	1100	420	4900	2600	4400	900	750	2200	580
Chromium	27.2	16	15	17	14	13	9	12	15	12	18
Cobalt	23.2	10	10	11	9.3	8.8	6	7.2	11	7.1	9.1
Copper	32.3	21	19	21	21	26	24	20	22	19	20
Iron	35200	23000	30000	28000	24000	25000	18000	18000	27000	24000	26000
Lead	19.1	19	14	13	19	**20 ***	11	15	14	17	12
Magnesium	8790	2700	2100	3000	3200	2500	2600	1800	3200	2100	3000
Manganese	3030	570	550	280	470	470	420	430	280	550	250
Mercury	0.044	0.025	0.037	0.014 J	**0.18 ***	0.033	0.016 J	0.02	0.015 J	0.029	0.035
Nickel	60.7	21	17	24	25	19	15	16	32	17	24
Potassium	3350	1100	780	1300	1200	900	640	620	1300	760	1200
Selenium	1.5	<0.46 U	<0.47 U	<0.46 U	<0.44 U	<0.46 U	<0.42 U	0.32 J	0.15 J	0.3 J	<0.45 U
Sodium	145	<100 U	<100 U	<99 U	<96 U	<99 U	<91 U	<87 U	<85 U	<83 U	<97 U
Thallium	0.91	<0.22 U	<0.23 U	<0.2 U	<0.21 U	<0.2 U	<0.2 U	<0.21 U	<0.19 U	<0.2 U	<0.21 U
Vanadium	37.6	21	22	18	14	17	11	12	17	15	19
Zinc	93.3	62	64	62	72	**110 ***	64	65	62	82	63
Explosives (mg/kg)											
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
SVOCs (mg/kg)											
Acenaphthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(*ghi*)perylene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Chrysene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Di-n-butyl phthalate	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dibenz(a,h)anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Phenanthrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 4–3. Analytes Detected in Phase I RI Subsurface Soil Samples (continued)

Station		**LL9sb-019**	**LL9sb-020**	**LL9sb-021**	**LL9sb-022**	**LL9sb-023**	**LL9sb-024**	**LL9sb-026**	**LL9sb-040**	**LL9sb-041**	**LL9sb-042**
Sample ID		**LL9sb-019-0001-SO**	**LL9sb-020-0001-SO**	**LL9sb-021-0001-SO**	**LL9sb-022-0001-SO**	**LL9sb-023-0001-SO**	**LL9sb-024-0001-SO**	**LL9sb-026-0001-SO**	**LL9sb-040-0001-SO**	**LL9sb-041-0001-SO**	**LL9sb-042-0001-SO**
Date		**12/11/03**	**12/08/03**	**12/08/03**	**12/10/03**	**12/08/03**	**12/10/03**	**12/10/03**	**10/27/03**	**10/27/03**	**11/06/03**
Depth (ft)		**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**6.0 - 7.0**	**6.5 - 7.5**	**8.0 - 10.0**
Parameters Analyzed											
Analyte	**Background Criteria**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals**
Metals (mg/kg)											
Aluminum	19500	11000	15000	12000	11000	11000	18000	13000	14000	8900	9100
Antimony	0.96	<0.49 U	0.85	0.52 J	<0.53 U	<0.49 U	**1 ***	0.56 J	<0.47 U	<0.49 U	<0.44 U
Arsenic	19.8	**32 ***	14	**26 ***	18	**24 ***	9.2	6.9	12	3.4	6.9
Barium	124	95	65	43	73	69	78	70	**140 ***	57	57
Beryllium	0.88	0.65	0.36 J	0.56	0.69	0.63	0.52	0.36 J	**1.1 ***	**1.2 ***	0.43 J
Cadmium	0	<0.092 U	**0.095 J***	<0.085 U	<0.094 U	<0.089 U	<0.099 U	<0.093 U	<0.083 U	<0.086 U	<0.087 U
Calcium	35500	870	1700	970	6700	1200	650	600	**36000 ***	6900	480
Chromium	27.2	16	19	17	15	16	**54 ***	15	17	18	14
Cobalt	23.2	12	6.4	11	10	13	14	8.1	6.1	19	8.7
Copper	32.3	25	20	22	25	21	24	8.1	15	20	13
Iron	35200	30000	24000	28000	24000	27000	28000	19000	**39000 ***	**51000 ***	23000
Lead	19.1	19	12	**22 ***	**23 ***	12	**86 ***	14	**51 ***	**31 ***	11
Magnesium	8790	3200	2500	2700	3600	3300	4700	2200	5000	3000	2200
Manganese	3030	270	420	290	500	350	440	470	2300	2100	420
Mercury	0.044	**0.18 ***	**0.18 ***	0.021	**0.087 ***	0.018 J	**0.079 ***	0.024	**0.26 ***	0.017 J	0.02
Nickel	60.7	29	15	23	25	29	31	14	11	37	17
Potassium	3350	1100	1200	1200	950	1300	1600	860	1200	1700	810
Selenium	1.5	0.3 J	<0.45 U	0.63 J	<0.47 U	<0.45 U	<0.5 U	<0.47 U	<0.42 U	<0.43 U	<0.43 U
Sodium	145	<100 U	<98 U	<93 U	<100 U	<97 U	<110 U	<100 U	**170 ***	<93 U	**1200 ***
Thallium	0.91	<0.21 U	<0.21 U	0.33	<0.23 U	<0.21 U	<0.24 U	<0.22 U	<0.2 U	<0.21 U	<0.95 U
Vanadium	37.6	17	26	19	15	18	29	23	17	16	15
Zinc	93.3	75	53	78	85	58	83	45	68	64	52
Explosives (mg/kg)											
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	NR	<2.3 U	<2.3 U	NR
SVOCs (mg/kg)											
Acenaphthene	None	NR	NR	NR	NR	NR	NR	NR	<0.0016 U	<0.0016 U	NR
Anthracene	None	NR	NR	NR	NR	NR	NR	NR	<0.00099 U	<0.00099 U	NR
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR	NR	**0.053 ***	<0.0013 U	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.052 ***	<0.0025 U	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	**0.062 ***	<0.0024 U	NR
Benzo(*ghi*)perylene	None	NR	NR	NR	NR	NR	NR	NR	**0.034 J***	<0.0022 U	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	**0.059 ***	<0.0032 U	NR
Chrysene	None	NR	NR	NR	NR	NR	NR	NR	**0.058 ***	<0.0021 U	NR
Di-n-butyl phthalate	None	NR	NR	NR	NR	NR	NR	NR	**0.14 J***	**0.087 J***	NR
Dibenz(a,h)anthracene	None	NR	NR	NR	NR	NR	NR	NR	**0.018 J***	<0.0025 U	NR
Fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	**0.17 ***	<0.0013 U	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.034 J***	<0.0024 U	NR
Phenanthrene	None	NR	NR	NR	NR	NR	NR	NR	**0.061 ***	<0.0012 U	NR
Pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.12 ***	<0.0023 U	NR

Table 4–3. Analytes Detected in Phase I RI Subsurface Soil Samples (continued)

Station		LL9sb-028	LL9sb-029	LL9sb-030	LL9sb-031	LL9sb-032	LL9sb-055	LL9sb-056	LL9sb-059	LL9sb-061
Sample ID		LL9sb-028-0001-SO	LL9sb-029-0001-SO	LL9sb-030-0001-SO	LL9sb-031-0001-SO	LL9sb-032-0001-SO	LL9sb-055-0001-SO	LL9sb-056-0001-SO	LL9sb-059-0001-SO	LL9sb-061-0001-SO
Date		12/04/03	12/04/03	12/04/03	12/04/03	12/04/03	11/05/03	11/05/03	11/05/03	11/05/03
Depth (ft)		1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.0 - 3.0	1.5 - 3.5	2.0 - 4.0	3.0 - 5.0	1.0 - 3.0
Parameters Analyzed		TAL Metals	TAL Metals	TAL Metals	TAL Metals, Explosives	RVAAP Full-suite analytes	Misc., SVOCs, VOCs	Misc., SVOCs, VOCs	Misc., SVOCs, VOCs	Misc., SVOCs, VOCs
Analyte	Background Criteria									
Metals(mg/kg)										
Aluminum	19500	9600	9400	10000	6400	11000	NR	NR	NR	NR
Antimony	0.96	<0.47 U	<0.46 U	<0.46 U	<0.47 U	<0.46 U	NR	NR	NR	NR
Arsenic	19.8	5.1	11	6	7.4	7.4	NR	NR	NR	NR
Barium	124	37	62	43	28	100	NR	NR	NR	NR
Beryllium	0.88	0.33 J	0.58	0.55	0.4 J	0.84	NR	NR	NR	NR
Cadmium	0	<0.092 U	<0.08 U	<0.094 U	<0.087 U	<0.086 U	NR	NR	NR	NR
Calcium	35500	600	320	500	470	760	NR	NR	NR	NR
Chromium	27.2	11	14	13	9.9	13	NR	NR	NR	NR
Cobalt	23.2	2.4	8.7	5.9	5.5	11	NR	NR	NR	NR
Copper	32.3	5.2	9.1	11	6.3	12	NR	NR	NR	NR
Iron	35200	11000	24000	21000	16000	19000	NR	NR	NR	NR
Lead	19.1	5.5	11	8.8	6.5	15	NR	NR	NR	NR
Magnesium	8790	1200	1700	1700	1400	1600	NR	NR	NR	NR
Manganese	3030	50	660	380	390	970	NR	NR	NR	NR
Mercury	0.044	0.032	0.038	0.038	0.016 J	0.015 J	NR	NR	NR	NR
Nickel	60.7	6.6	12	13	10	13	NR	NR	NR	NR
Potassium	3350	610	530	560	440	510	NR	NR	NR	NR
Selenium	1.5	<0.46 U	0.65 J	0.58 J	<0.43 U	<0.43 U	NR	NR	NR	NR
Sodium	145	<100 U	<87 U	<100 U	<94 U	<93 U	NR	NR	NR	NR
Thallium	0.91	<0.2 U	<0.99 U	<0.2 U	<1 U	<0.2 U	NR	NR	NR	NR
Vanadium	37.6	18	19	20	12	21	NR	NR	NR	NR
Zinc	93.3	27	42	45	38	44	NR	NR	NR	NR
Explosives (mg/kg)										
Nitrocellulose	None	NR	NR	NR	NR	**1.3 J***	NR	NR	NR	NR
SVOCs (mg/kg)										
Acenaphthene	None	NR	NR	NR	NR	<0.0017 U	<0.0017 U	<0.0016 U	**0.006 J***	<0.0016 U
Anthracene	None	NR	NR	NR	NR	<0.001 U	<0.0011 U	<0.00099 U	**0.0063 J***	<0.00099 U
Benz(a)anthracene	None	NR	NR	NR	NR	**0.0031 J***	<0.0013 U	**0.0066 J***	**0.029 J***	**0.0066 J***
Benzo(a)pyrene	None	NR	NR	NR	NR	<0.0027 U	<0.0027 U	**0.0061 J***	**0.027 J***	**0.0071 J***
Benzo(b)fluoranthene	None	NR	NR	NR	NR	**0.0045 J***	<0.0026 U	**0.0072 J***	**0.032 J***	**0.01 J***
Benzo(*ghi*)perylene	None	NR	NR	NR	NR	**0.0033 J***	<0.0023 U	**0.0054 J***	**0.012 J***	<0.0022 U
Benzo(k)fluoranthene	None	NR	NR	NR	NR	<0.0034 U	<0.0034 U	**0.0078 J***	**0.03 J***	**0.0065 J***
Chrysene	None	NR	NR	NR	NR	**0.0031 J***	<0.0022 U	**0.007 J***	**0.026 J***	**0.0071 J***
Di-n-butyl phthalate	None	NR	NR	NR	NR	<0.024 U	<0.024 U	<0.023 U	<0.023 U	<0.023 U
Dibenz(a,h)anthracene	None	NR	NR	NR	NR	**0.026 J***	<0.0027 U	<0.0025 U	**0.0064 J***	<0.0025 U
Fluoranthene	None	NR	NR	NR	NR	**0.0064 J***	<0.0013 U	**0.015 J***	**0.071 ***	**0.013 J***
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	**0.018 J***	<0.0026 U	**0.0039 J***	**0.014 J***	**0.0041 J***
Phenanthrene	None	NR	NR	NR	NR	<0.0012 U	<0.0012 U	**0.0065 J***	**0.036 J***	**0.0049 J***
Pyrene	None	NR	NR	NR	NR	**0.004 J***	<0.0024 U	**0.0096 J***	**0.044 ***	**0.0079 J***

ft = Feet.
ID = Identification.
Mg/kg – Milligrams per kilogram.
NR = Not Reported/Not Analyzed.
SVOC = Semi-volatile organic compound.

TAL = Target analyte list.
U = Not detected.
VOC = Volatile organic compound.
*** = Result exceeds background criteria or no background criteria was available.**
< = Less than.

Table 4–4. Analytes Detected in Phase I RI Surface Water Samples

Station		**LL9sw-001**	**LL9sw-003**	**LL9sw-004**	**LL9sw-005**	**LL9sw-012**	**LL9sw-012**	**LL9sw-002**
Sample ID		**LL9sw-001-0001-SW**	**LL9sw-003-0001-SW**	**LL9sw-004-0001-SW**	**LL9sw-005-0001-SW**	**LL9sw-012-0001-FD**	**LL9sw-012-0001-SW**	**LL9sw-002-0001-SW**
Date		**03/12/02**	**12/05/03**	**12/05/03**	**03/13/02**	**12/09/03**	**12/09/03**	**12/05/03**
Depth (ft)		**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals, Explosives**
Parameters Analyzed								
Analyte	**Background Criteria**	**LL9sw-001**	**LL9sw-003**	**LL9sw-004**	**LL9sw-005**	**LL9sw-012**	**LL9sw-012**	**LL9sw-002**
				Metals (mg/L)				
Aluminum	3.37	0.339	**12 ***	3.2	**17.8 ***	0.44	0.43	1.8
Arsenic	0.0032	<0.002 U	**0.0099 ***	0.0019 J	**0.008 ***	<0.00073 U	<0.00073 U	**0.0043 ***
Barium	0.0475	0.0214	**0.13 ***	0.043	**0.145 ***	0.028	0.028	**0.06 ***
Beryllium	0	<0.004 U	**0.0003 J***	<0.00017 U	**0.0007 J***	<0.00017 U	<0.00017 U	**0.00026 J***
Cadmium	0	<0.002 U	<0.00044 U	<0.00044 U	**0.0011 J***	<0.00044 U	<0.00044 U	<0.00044 U
Calcium	41.4	9.83	**61 ***	12	13.9	18	18	9.9
Chromium	0	<0.01 U	**0.014 ***	**0.0038 J***	**0.0202 ***	<0.0015 U	<0.0015 U	**0.0033 J***
Cobalt	0	<0.005 U	**0.008 ***	**0.0012 J***	**0.006 ***	<0.001 U	<0.001 U	**0.0046 J***
Copper	0.0079	<0.01 U	**0.02 ***	0.0044 J	**0.0186 ***	<0.0016 U	<0.0016 U	0.0058 J
Iron	2.56	0.249	**17 ***	**3.2 ***	**18.9 ***	0.44	0.54	**20 ***
Lead	0	<0.002 U	**0.07 ***	**0.0087 ***	**0.0629 ***	**0.0012 J***	**0.0014 J***	**0.0089 ***
Magnesium	10.8	2.11	9.6	3	5.36	4.3	4.5	3
Manganese	0.391	0.0101	**1.4 ***	**0.47 ***	**0.633 ***	0.11	0.12	**1.2 ***
Mercury	0	<0.0002 U	**0.00039 ***	**0.00012 J***	**0.00037 ***	**0.0017 ***	**0.0003 ***	**0.00007 J***
Nickel	0	<0.01 U	**0.015 ***	**0.004 J***	**0.0201 ***	**0.0048 J***	**0.0053 J***	**0.011 ***
Potassium	3.17	0.798	**5.2 ***	1.4	**3.9 ***	1.2	1.2	1.7
Sodium	21.3	0.966 J	4.3	2	1.35	2.3	2.4	2
Vanadium	0	<0.005 U	**0.019 ***	**0.0049 J***	**0.0319 ***	<0.0021 U	<0.0021 U	<0.0021 U
Zinc	0.042	0.0324	**0.19 ***	0.039	**0.228 ***	0.019	0.02	0.041
				Explosives (mg/L)				
Nitrocellulose	None	NR	NR	NR	NR	**0.1 J***	**0.12 J***	NR

ft = Feet.
ID = Identification.
mg/L = Milligrams per liter.
NR = Not reported/not analyzed.
RVAAP = Ravenna Army Ammunition Plant.
TAL = Target analyte list.
U = Not detected.
*** = Result exceeds background criteria or no background criteria was available.**
< = Less than.

Table 4–5. Analytes Detected in Phase I RI Sediment Samples

Station	**Background Criteria**	**LL9sd-001**	**LL9sd-001**	**LL9sd-001**	**LL9sd-003**	**LL9sd-004**	**LL9sd-005**	**LL9sd-006**	**LL9sd-013**	**LL9sd-014**	**LL9sd-015**
Sample ID		**LL9sd-001-0001-SD**	**LL9sd-001-D24S-FD**	**LL9sd-001-W24S-FD**	**LL9sd-003-0001-SD**	**LL9sd-004-0001-SD**	**LL9sd-005-0001-SD**	**LL9sd-006-0001-SD**	**LL9sd-013-0001-SD**	**LL9sd-014-0001-SD**	**LL9sd-015-0001-FD**
Date		**03/12/02**	**03/15/02**	**03/15/02**	**03/13/02**	**12/05/03**	**03/13/02**	**12/05/03**	**12/05/03**	**12/05/03**	**12/09/03**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 1.0**	**0.0 - 0.5**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 0.5**
Parameters Analyzed		**TAL Metals, Explosives**	**Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals**	**TAL Metals, Explosives**	**TAL Metals**	**TAL Metals**	**TAL Metals**	**RVAAP Full-suite analytes**
Analyte											
Metals (mg/kg)											
Aluminum	13900	10800	NR	10900	**15600 ***	**14000 ***	**14500 ***	11000	12000	11000	12000
Antimony	0	**0.49 ***	NR	<0.44 U	<0.32 U	<0.8 U	<0.39 U	<0.69 U	<0.88 U	<0.99 U	<0.78 U
Arsenic	19.5	9.4	NR	10.8	17.3	11	14.4	10	15	10	10
Barium	123	77.2	NR	74.4	62.7	89	71.6	64	65	96	92
Beryllium	0.38	**0.99 ***	NR	**0.88 ***	0.67 *	**0.76 ***	**0.62 ***	0.31 J	**0.52 J***	**0.63 J***	**0.59 J***
Cadmium	0	**0.47 ***	NR	**0.23 J***	<0.21 U	**0.77 ***	<0.21 U	**0.2 J***	**0.5 ***	**0.35 J***	**0.71 ***
Calcium	5510	1660	NR	1610	1670	3000	988	1700	2100	2700	1900
Chromium	18.1	14.1	NR	13.7	**20.6 ***	17	**18.9 ***	14	18	15	16
Cobalt	9.1	7.6	NR	6.1	8.9	9.1	6.8	5.2	7.2	7	7.9
Copper	27.6	14.6	NR	13.2	23	16	17.3	11	18	16	14
Iron	28200	22700	NR	18400	**31900 ***	26000	26500	18000	26000	19000	20000
Lead	27.4	**47.2 ***	NR	**49.6 ***	**37.8 ***	**31 ***	**34.1 ***	**36 ***	**100 ***	**35 ***	**77 ***
Magnesium	2760	1720	NR	1660	**3450 ***	2400	2680	1800	2300	2200	1900
Manganese	1950	563	NR	448	300	1200	395	250	200	880	670
Mercury	0.059	**0.15 ***	NR	**0.15 ***	**0.35 ***	**0.1 ***	**0.13 ***	**0.072 ***	**0.18 ***	**0.33 ***	**0.13 ***
Nickel	17.7	**22.4 ***	NR	**20.9 ***	**21.2 ***	**18 ***	16	11	17	**18 ***	**18 ***
Potassium	1950	831	NR	846	1820	1100	1170	860	1000	1100	950
Selenium	1.7	1.1 J	NR	<1.2 U	<1 U	**2.1 ***	<1.1 U	0.7 J	1.6	**1.8 J***	1.2 J
Sodium	112	**136 J***	NR	**120 J***	**213 ***	<140 U	**204 ***	<130 U	<140 U	<210 U	<160 U
Explosives (mg/kg)											
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**4.2 J***
SVOCs (mg/kg)											
2-Methylnaphthalene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	<0.0028 U
Acenaphthylene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	<0.0017 U
Anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	<0.0016 U
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.016 J***
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.021 J***
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.02 J***
Benzo(*ghi*)perylene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.013 J***
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.019 J***
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.55 ***
Butyl benzyl phthalate	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	<0.0077 U
Chrysene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.023 J***
Di-n-butyl phthalate	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	<0.037 U
Dibenz(a,h)anthracene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.043 J***
Fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.037 J***
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.037 J***
Phenanthrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.02 J***
Pyrene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	**0.028 J***

ft = Feet.
ID = Identification.
mg/kg = Milligrams per kilogram.
NR = Not Reported/Not Analyzed.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
TAL = Target analyte list.
U = Not detected.
*** = Result exceeds background criteria or no background criteria was available.**
< = Less than.

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Table 4–6. Human Health COPCs per the Phase 1 RI

Surface and Subsurface Soil	Sediment	Surface Water	Groundwater
Aluminum Arsenic Chromium Manganese Mercury Benzo(a)pyrene Dibenz(a,h)anthracene	Aluminum Mercury Vanadium	Aluminum Arsenic Chromium Lead Manganese Mercury Vanadium	Antimony Manganese

Information from the *Phase I Remedial Investigation for Load Line 9* (MKM 2007).
RI = Remedial Investigation.

Table 4–7. Summary of Ecological Risk Calculation Results per the Phase I RI

Terrestrial Plants and Soil Invertebrates	Benthic Invertebrates	Aquatic Organisms	Terrestrial Wildlife−Insectivores /Herbivores	Terrestrial Wildlife−Carnivores
Copper Lead Mercury Zinc	Mercury	Aluminum Copper Iron Lead Zinc	No COPCs retained.	No COPCs retained.

Information from the *Phase I Remedial Investigation for Load Line 9* (MKM 2007).
COPC = Chemical of Potential Concern.
RI = Remedial Investigation.

Table 4–8. Chemicals Detected at Concentrations above Screening Criteria in Previous Investigations

Surface Soil	Subsurface Soil	Sediment	Surface Water
Aluminum Arsenic Chromium Cobalt Copper Lead Manganese Mercury Benz(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenz(a,h)anthracene	Arsenic Chromium Mercury Thallium Benzo(a)pyrene Dibenz(a,h)anthracene	Aluminum Chromium Mercury Benzo(a)pyrene Dibenz(a,h)anthracene	Aluminum Arsenic Chromium Lead Manganese Mercury

Information from the *Performance-based Acquisition 2008 Supplemental Investigation Sampling and Analysis Plan Addendum No. 1* (SAIC 2008).
RI = Remedial Investigation.

Table 4–9. PBA08 RI Surface Soil Samples and Rationales

PBA08 RI Location	Targeted Area	Purpose	Analyses Performed				
			Metals	Explosives	VOCs	Pesticides/ PCBs	SVOC
LL9ss-095	Near LL9ss-031	Delineate lateral extent of previously identified surface soil contamination. Sample collected in NPA, adjacent to AOC entrance.	Y	Y	N	N	PAH
LL9ss-096	Buildings DT-28 and DT-52	Characterize an area within FPA (Change House and Dining Facility during WWII) not previously sampled.	Y	Y	N	N	PAH
		QA/QC.	Y	Y	N	N	PAH
			Y	Y	N	N	PAH
LL9ss-097	Building DT-28	Characterize FPA (Change House during WWII) not previously sampled.	Y	Y	N	N	PAH
LL9ss-098	Near LL9ss-045 and LL9ss-021	Delineate lateral extent of previously identified surface soil contamination at Building DT-22 (Loading Building during WWII). Analyzed for RVAAP full-suite analytes.	Y	Y	Y	Y	Y
LL9ss-099	Near LL9ss-045	Delineate lateral extent of previously identified surface soil contamination at Building DT-29 (Change House during WWII).	Y	Y	N	N	PAH
LL9ss-102	Near LL9sb-051	Delineate lateral extent of previously identified surface soil contamination at Building DT-18A (Detonator Testing during WWII).	Y	Y	N	N	PAH
LL9ss-103	Building DT-13	Characterize an area (Final Inspection, Packing, & Shipping building during WWII) within FPA not previously sampled.	Y	Y	N	N	PAH
LL9ss-104	Building DT-12	Characterize an area (Saw Dust Storage during WWII) within FPA not previously sampled. Analyzed for RVAAP full-suite analytes.	Y	Y	Y	Y	Y
		QA/QC. Analyzed for RVAAP full-suite analytes.	Y	Y	Y	Y	Y
			Y	Y	Y	Y	Y
LL9ss-105	Near LL9ss-015	Delineate lateral extent of previously identified surface soil contamination at Building DT-3 (Fulminate Dry House during WWII).	Y	Y	N	N	PAH
LL9ss-106	LL9ss-015	Define lateral extent of previously identified surface soil contamination at Building DT-2 (Fulminate Mix House during WWII). Adjacent concrete settling tank for settling out explosive contamination from wastewater.	Y	Y	N	N	PAH

Table 4–9. PBA08 RI Surface Soil Samples and Rationales (continued)

PBA08 RI Location	Targeted Area	Purpose	Analyses Performed				
			Metals	Explosives	VOCs	Pesticides/ PCBs	SVOC
LL9ss-107	LL9ss-001	Delineate lateral extent of previously identified surface soil contamination at Buildings DT-6 and DT-54 (Azide Dry Houses during WWII).	Y	Y	N	N	PAH
LL9ss-108	LL9ss-003	Delineate lateral extent of previously identified surface soil contamination at Buildings DT-8 and DT-55 (Azide Dry Houses during WWII).	Y	Y	N	N	PAH
LL9ss-110	LL9ss-027	Delineate lateral extent of previously identified surface soil contamination. Sample collected just north of the AOC fence.	Y	Y	N	N	PAH
LL9ss-112	LL9ss-023	Confirm presence of contamination in an area previously sampled (Building DT-20 - Loading Building during WWII). Analyzed for all SVOCs. *Originally no ditch or pond was found. A ditch was located 10 ft from the original location but it was dry. A surface soil sample was collected instead.*	Y	Y	N	N	Y
LL9ss-131	LL9ss-011	Delineate lateral extent of previously identified surface soil contamination (mercury) at former Building DT-34 (Detonator Destroying House during WWII). (Collected in April 2011).	Hg	N	N	N	N
LL9ss-132			Hg	N	N	N	N
LL9ss-133			Hg	N	N	N	N
LL9ss-134			Hg	N	N	N	N
LL9ss-135			Hg	N	N	N	N

AOC = Area of concern.
FPA = Former production area.
Hg = Mercury
NPA = Non-production area.
PAH = Polycyclic aromatic hydrocarbon.
PBA08 RI = Performance-Based Acquisition 2008 Remedial Investigation.
PCB = Polychlorinated biphenyl.
QA/QC = Quality assurance/quality control.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
VOC = Volatile organic compound.
WWII = World War II.

Table 4–10. Chromium Speciation Samples under PBA08 RI

PBA08 RI Location	Rationale for Sample Selection
LL9ss-100	Discrete sample collected to assess chromium speciation. Previous chromium result represents near background chromium concentration (LL9ss-021 at 18 mg/kg). (Building DT-21 - Loading Building)
LL9ss-101	Discrete sample collected to assess chromium speciation. Previous chromium result represents elevated chromium concentration. (LL9ss-024 at 110 mg/kg) (near WW-32 - Elevated Water Tank)
LL9ss-101	Recollected for total and hexavalent chromium to replace data collected on 3/1/2010. (near WW-32 - Elevated Water Tank)
LL9ss-109	Discrete sample collected to assess chromium speciation. Previous chromium result represents elevated chromium concentration. (LL9ss-049 at 54 mg/kg) (Building DT-8 - Azide Dry House)

mg/kg = Milligrams per kilogram.
PBA08 RI = Performance-Based Acquisition 2008 Remedial Investigation.

Table 4–11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples

Station	**Background Criteria**	**LL9sb-093**	**LL9sb-087**	**LL9sb-088**	**LL9sb-089**	**LL9sb-091**	**LL9sb-092**	**LL9sb-092**	**LL9ss-096**	**LL9ss-096**	**LL9ss-097**
Sample ID		**LL9sb-093-5461-SO**	**LL9sb-087-5437-SO**	**LL9sb-088-5441-SO**	**LL9sb-089-5445-SO**	**LL9sb-091-5453-SO**	**LL9sb-092-6156-FD**	**LL9sb-092-5457-SO**	**LL9ss-096-6149-FD**	**LL9ss-096-5474-SO**	**LL9ss-097-5475-SO**
Date		**03/09/10**	**03/08/10**	**03/08/10**	**03/08/10**	**03/09/10**	**03/09/10**	**03/09/10**	**03/01/10**	**03/01/10**	**03/01/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed **Analyte**		**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**
Metals (mg/kg)											
Aluminum	17700	12200 J	11600 J	11000 J	9370 J	6080 J	8790 J	9730 J	11900	12300	16300
Antimony	0.96	<0.65 UJ	0.14 J	0.14 J	0.1 J	0.15 J	0.12 J	0.12 J	0.17 J	0.15 J	0.23 J
Arsenic	15.4	10.8 J	11.5 J	**17.8 J***	14.5 J	9.2 J	8.5 J	7.6 J	7.5	6	8
Barium	88.4	67.5 J	**90.7 J***	58.5 J	56.2 J	30.8	49.2 J	48 J	**196 ***	**180 ***	**177 ***
Beryllium	0.88	0.55 J	**0.96 J***	0.74 J	0.65 J	0.41 J	0.55 J	0.55 J	**1.3 ***	**1.3 ***	**1.9 ***
Cadmium	0	<0.047 UJ	**0.29 ***	**0.11 J***	**0.22 J***	**0.077 J***	**0.099 J***	**0.11 J***	**0.61 ***	**0.36 ***	**0.54 ***
Calcium	15800	911	**54400 J***	2550 J	4660 J	726	880	908	**101000 ***	**98300 ***	**56000 ***
Chromium	17.4	14	14.7 J	16.4 J	12.3 J	9.3	12.8	13	15	**19.6 ***	13.5
Chromium, hexavalent	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Cobalt	10.4	8	7.9	**14.4 ***	10.2	7.8	**13.5 ***	8.4	3.5	2.9	10.1
Copper	17.7	8.4 J	13.4 J	**23.5 J***	**18.6 J***	6.4 J	12.8 J	10.6 J	**21.5 ***	**18.2 ***	**28.8 ***
Iron	23100	**24400 ***	18500	**26900 ***	20000	**24100 ***	**26300 ***	**25000 ***	11800	9920	19500
Lead	26.1	14.5	**34.7 ***	23.9	22.1	10.9	17.2	14.3	**115 J***	**64.8 J***	**104 J***
Magnesium	3030	2120 J	**4070 J***	**3290 J***	**3110 J***	1350 J	2020 J	1910 J	**7900 ***	**7650 ***	**7650 ***
Manganese	1450	934	1120	309	448	488	748	649	**1580 ***	**1690 ***	**3240 ***
Mercury	0.036	**2.5 ***	**0.46 ***	0.035 J	**0.53 ***	**0.037 J***	0.033 J	<0.12 U	**0.29 ***	**0.3 ***	**0.17 ***
Nickel	21.1	15	15.2 J	**25.1 J***	20.8 J	11.2	16.7	15	10.5	12.6	10.9
Potassium	927	**942 ***	768 J	**937 J***	832 J	369	635	758	**1000 ***	**1020 ***	**1070 ***
Selenium	1.4	0.82 J	0.85 J	1.1 J	0.88 J	0.72 J	0.86 J	0.94 J	1.3	1.2	**1.4 ***
Silver	0	<0.03 UJ	<0.024 UJ	<0.016 UJ	**0.019 J***	**0.014 J***	<0.026 UJ	<0.026 UJ	**0.015 J***	**0.023 J***	**0.024 J***
Sodium	123	30.7 J	106 J	48.5 J	51.4 J	<127 U	23.7 J	27.3 J	**254 ***	**259 ***	**298 ***
Thallium	0	**0.14 J***	**0.15 J***	**0.14 J***	**0.12 J***	**0.13 J***	**0.13 J***	**0.14 J***	**0.068 J***	<0.25 U	**0.13 J***
Vanadium	31.1	21.3	17.4 J	18.1 J	14.5 J	14.8	17.3	18.4	13.2 J	11.9 J	18.6 J
Zinc	61.8	55.1 J	**64.1 ***	**64 ***	**85.4 ***	45.5 J	53.3 J	58.3 J	**147 J***	**93.3 J***	**155 J***
Explosives (mg/kg)											
2,6-Dinitrotoluene	None	<0.25 UJ	<0.25 U	<0.24 UJ	<0.25 UJ	<0.27 UJ	<0.24 U	<0.25 UJ	**0.03 J***	<0.24 U	<0.24 U
SVOCs (mg/kg)											
2-Methylnaphthalene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Acenaphthene	None	<0.0086 U	**0.0095 ***	<0.0086 U	<0.008 U	**0.014 J***	<0.0085 U	<0.0083 U	**1.2 ***	**4.1 ***	**0.082 ***
Acenaphthylene	None	<0.0086 U	<0.0079 U	<0.0086 U	<0.008 U	<0.0085 UJ	<0.0085 U	<0.0083 U	<0.16 U	**0.55 ***	**0.1 ***
Anthracene	None	<0.0086 U	**0.024 ***	**0.014 ***	<0.008 U	**0.03 J***	<0.0085 U	<0.0083 U	**4.3 ***	**12 ***	**0.44 ***
Benz(a)anthracene	None	<0.0086 U	**0.095 ***	**0.055 ***	**0.021 ***	**0.1 J***	**0.011 ***	**0.0097 ***	**10 ***	**17 ***	**1 ***
Benzo(a)pyrene	None	<0.0086 U	**0.094 ***	**0.054 ***	**0.021 ***	**0.087 J***	**0.01 ***	**0.0097 ***	**8.5 ***	**15 ***	**1.7 ***
Benzo(b)fluoranthene	None	<0.0086 U	**0.14 ***	**0.073 ***	**0.032 ***	**0.11 J***	**0.016 ***	**0.015 ***	**12 ***	**20 ***	**2.4 ***
Benzo(*ghi*)perylene	None	<0.0086 U	**0.06 ***	**0.035 ***	**0.015 ***	**0.063 J***	<0.0085 U	<0.0083 U	**5.5 ***	**9.2 ***	**1.2 ***
Benzo(k)fluoranthene	None	<0.0086 U	**0.045 ***	**0.03 ***	**0.01 ***	**0.046 J***	<0.0085 U	<0.0083 U	**4.1 ***	**7.1 ***	**1 ***
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Chrysene	None	<0.0086 U	**0.11 ***	**0.057 ***	**0.019 ***	**0.11 J***	**0.011 ***	**0.011 ***	**8.8 ***	**17 ***	**1.5 ***
Dibenz(a,h)anthracene	None	<0.0086 U	**0.014 ***	<0.0086 U	<0.008 U	**0.018 J***	<0.0085 U	<0.0083 U	**1.5 ***	**2.2 ***	**0.36 ***
Fluoranthene	None	<0.0086 U	**0.23 ***	**0.12 ***	**0.042 ***	**0.23 J***	**0.023 ***	**0.02 ***	**24 ***	**48 ***	**1.7 ***
Fluorene	None	<0.0086 U	<0.0079 U	<0.0086 U	<0.008 U	**0.012 J***	<0.0085 U	<0.0083 U	**1.4 ***	**5.3 ***	**0.11 ***
Indeno(1,2,3-cd)pyrene	None	<0.0086 U	**0.051 ***	**0.03 ***	**0.012 ***	**0.055 J***	<0.0085 U	<0.0083 U	**5 ***	**8.5 ***	**1.1 ***
Naphthalene	None	<0.0086 U	**0.021 ***	<0.0086 U	<0.008 U	<0.0085 UJ	<0.0085 U	<0.0083 U	**0.19 ***	**0.92 ***	**0.046 ***
Phenanthrene	None	<0.0086 U	**0.11 ***	**0.052 ***	**0.014 ***	**0.13 J***	**0.011 ***	<0.0083 U	**18 ***	**43 ***	**1 ***
Pyrene	None	<0.0086 U	**0.17 ***	**0.092 ***	**0.035 ***	**0.19 J***	**0.019 ***	**0.016 ***	**18 ***	**34 ***	**1.4 ***
VOCs (mg/kg)											
Toluene	None	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 4–11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Station		LL9ss-098	LL9ss-099	LL9ss-100	LL9ss-101	LL9ss-102	LL9ss-103	LL9ss-104	LL9ss-104	LL9ss-105	LL9ss-106
Sample ID		**LL9ss-098-5476-SO**	**LL9ss-099-5477-SO**	**LL9ss-100-5478-SO**	**LL9ss-101-5807-SO**	**LL9ss-102-5480-SO**	**LL9ss-103-5481-SO**	**LL9ss-104-6151-FD**	**LL9ss-104-5482-SO**	**LL9ss-105-5483-SO**	**LL9ss-106-5484-SO**
Date		**03/01/10**	**03/02/10**	**03/01/10**	**10/18/10**	**03/02/10**	**03/02/10**	**03/02/10**	**03/02/10**	**03/02/10**	**03/02/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed		**RVAAP Full-suite analytes**	**TAL Metals, Explosives, SVOCs**	**Chromium Speciation**	**Chromium Speciation**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**
Analyte	**Background Criteria**										
Metals (mg/kg)											
Aluminum	17700	1850	9780	NR	NR	8420	12400	7280	6400	15900	**17900 ***
Antimony	0.96	<0.56 UJ	0.13 J	NR	NR	0.15 J	0.12 J	0.083 J	0.11 J	0.085 J	0.089 J
Arsenic	15.4	3.8	12.7	NR	NR	7.7	11.2	10.7	12.3	12	14
Barium	88.4	80.4	51.7	NR	NR	58.7	76.4	24.9	24.6	58.6	56.8
Beryllium	0.88	0.27	0.45	NR	NR	0.65	0.66	0.31	0.38	0.51	0.61
Cadmium	0	**0.12 J***	**0.23 J***	NR	NR	**0.17 J***	**0.2 J***	**0.098 J***	**0.11 J***	<0.026 UJ	**0.047 J***
Calcium	15800	**250000 ***	4820	NR	NR	2740	1030	517	740	1320	912
Chromium	17.4	7.1	12.1	**18 ***	**21.4 ***	13.1	16.2	8.2	7.7	**19.4 ***	**20.7 ***
Chromium, hexavalent	None	NR	NR	<1 U	**0.74 J***	NR	NR	NR	NR	NR	NR
Cobalt	10.4	2.4	**11.6 ***	NR	NR	10.3	**13.2 ***	5.3	5.2	6.9	9
Copper	17.7	6.6	**20.6 ***	NR	NR	**29.2 ***	15.7	13.9	15.4	13.8	**21.9 ***
Iron	23100	7770	22800	NR	NR	17900	23100	16300	21300	**27400 ***	**29200 ***
Lead	26.1	7.6 J	22.3 J	NR	NR	**40.1 J***	**29.9 J***	10.7 J	17.5 J	11.6 J	14.2 J
Magnesium	3030	2150	**3040 ***	NR	NR	1750	2110	1530	1440	3030	**3790 ***
Manganese	1450	566	530	NR	NR	387	1180	266	284	206	177
Mercury	0.036	**0.33 ***	<0.058 UJ	NR	NR	<0.049 UJ	<0.051 UJ	<0.035 UJ	<0.054 UJ	<0.027 UJ	<0.043 UJ
Nickel	21.1	11	20.5	NR	NR	19.8	15.3	11.5	11.9	17.7	**23.2 ***
Potassium	927	395	**930 ***	NR	NR	835	617	485	431	898	**1320 ***
Selenium	1.4	0.3 J	0.86	NR	NR	1.1	0.98	0.72	0.69	0.74	0.91
Silver	0	<0.0087 UJ	<0.01 UJ	NR	NR	<0.024 UJ	**0.032 J***	<0.0087 UJ	<0.015 UJ	<0.023 UJ	<0.02 UJ
Sodium	123	74.9 J	40.2 J	NR	NR	32.4 J	29.6 J	19.9 J	25 J	70.5 J	44.9 J
Thallium	0	<0.22 U	**0.12 J***	NR	NR	**0.13 J***	**0.16 J***	**0.11 J***	**0.11 J***	**0.17 J***	**0.2 J***
Vanadium	31.1	5.4 J	14.5 J	NR	NR	14.6 J	25 J	12.2 J	10.9 J	25.7 J	25.1 J
Zinc	61.8	23.3 J	**79.9 J***	NR	NR	**69 J***	60.7 J	47.1 J	52.7 J	49.2 J	61.1 J
Explosives											
2,6-Dinitrotoluene	None	<0.25 U	<0.25 U	NR	NR	<0.25 U	<0.24 U	<0.24 U	<0.25 U	<0.24 U	<0.24 U
SVOCs											
2-Methylnaphthalene	None	**0.02 J***	NR	NR	NR	NR	NR	<0.37 U	<0.38 U	NR	NR
Acenaphthene	None	<0.056 U	<0.0087 U	NR	NR	<0.0088 U	<0.0087 U	<0.056 U	<0.057 U	<0.0085 U	<0.0086 U
Acenaphthylene	None	<0.056 U	<0.0087 U	NR	NR	<0.0088 U	<0.0087 U	<0.056 U	<0.057 U	<0.0085 U	<0.0086 U
Anthracene	None	**0.014 J***	**0.024 ***	NR	NR	<0.0088 U	<0.0087 U	<0.056 U	<0.057 U	<0.0085 U	<0.0086 U
Benz(a)anthracene	None	**0.071 ***	**0.081 ***	NR	NR	<0.0088 U	**0.029 ***	**0.0087 J***	<0.057 U	**0.013 ***	**0.013 ***
Benzo(a)pyrene	None	**0.07 ***	**0.069 ***	NR	NR	<0.0088 U	**0.028 ***	<0.056 U	<0.057 U	**0.013 ***	**0.013 ***
Benzo(b)fluoranthene	None	**0.1 ***	**0.097 ***	NR	NR	<0.0088 U	**0.042 ***	**0.0097 J***	**0.0092 J***	**0.027 ***	**0.018 ***
Benzo(*ghi*)perylene	None	**0.058 ***	**0.048 ***	NR	NR	<0.0088 U	**0.021 ***	<0.056 U	<0.057 U	**0.012 ***	**0.01 ***
Benzo(k)fluoranthene	None	**0.03 J***	**0.04 ***	NR	NR	<0.0088 U	**0.014 ***	<0.056 U	<0.057 U	**0.012 ***	<0.0086 U
Bis(2-ethylhexyl)phthalate	None	**0.027 J***	NR	NR	NR	NR	NR	**0.023 J***	<0.38 U	NR	NR
Chrysene	None	**0.065 ***	**0.079 ***	NR	NR	<0.0088 U	**0.028 ***	**0.0084 J***	<0.057 U	**0.02 ***	**0.013 ***
Dibenz(a,h)anthracene	None	**0.014 J***	**0.011 ***	NR	NR	<0.0088 U	<0.0087 U	<0.056 U	<0.057 U	<0.0085 U	<0.0086 U
Fluoranthene	None	**0.12 ***	**0.17 ***	NR	NR	**0.011 ***	**0.062 ***	**0.017 J***	**0.014 J***	**0.031 ***	**0.025 ***
Fluorene	None	<0.056 U	**0.0095 ***	NR	NR	<0.0088 U	<0.0087 U	<0.056 U	<0.057 U	<0.0085 U	<0.0086 U
Indeno(1,2,3-cd)pyrene	None	**0.046 J***	**0.044 ***	NR	NR	<0.0088 U	**0.019 ***	<0.056 U	<0.057 U	**0.011 ***	**0.0091 ***
Naphthalene	None	**0.013 J***	<0.0087 U	NR	NR	<0.0088 U	<0.0087 U	<0.056 U	<0.057 U	<0.0085 U	<0.0086 U
Phenanthrene	None	**0.06 ***	**0.096 ***	NR	NR	<0.0088 U	**0.029 ***	**0.009 J***	<0.057 U	**0.015 ***	**0.012 ***
Pyrene	None	**0.1 ***	**0.13 ***	NR	NR	<0.0088 U	**0.048 ***	**0.013 J***	**0.01 J***	**0.023 ***	**0.019 ***
VOCs											
Toluene	None	**0.00036 J***	NR	NR	NR	NR	NR	**0.0003 J***	**0.00037 J***	NR	NR

Table 4–11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Station		**LL9ss-107**	**LL9ss-108**	**LL9ss-109**	**LL9ss-112**	**LL9sb-090**	**LL9sb-094**	**LL9ss-095**	**LL9ss-110**	**LL9ss-107**
Sample ID		**LL9ss-107-5485-SO**	**LL9ss-108-5486-SO**	**LL9ss-109-5487-SO**	**LL9ss-112-5470-SO**	**LL9sb-090-5449-SO**	**LL9sb-094-5465-SO**	**LL9ss-095-5473-SO**	**LL9ss-110-5488-SO**	**LL9ss-107-5485-SO**
Date		**03/02/10**	**03/02/10**	**03/01/10**	**03/09/10**	**03/09/10**	**03/09/10**	**03/02/10**	**03/02/10**	**03/02/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed		**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**Chromium Speciation**	**TAL Metals, Explosives, SVOCs**	**RVAAP Full-suite analytes**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**
Analyte	**Background Criteria**									
Metals (mg/kg)										
Aluminum	17700	9530	10900	NR	12800 J	7240 J	5920 J	11300	10200	9530
Antimony	0.96	0.091 J	0.1 J	NR	0.13 J	0.4 J	0.12 J	0.11 J	<0.64 UJ	0.091 J
Arsenic	15.4	9.3	11.3	NR	10.9 J	9.2 J	3.8 J	12.3	10.2	9.3
Barium	88.4	49.5	41.1	NR	53.8 J	53.4 J	26.5 J	51.4	51.5	49.5
Beryllium	0.88	0.44	0.44	NR	0.46 J	0.47 J	0.35 J	0.58	0.49	0.44
Cadmium	0	**0.11 J***	**0.28 ***	NR	**0.069 J***	**0.25 J***	**0.083 J***	**0.12 J***	**0.082 J***	**0.11 J***
Calcium	15800	971	679	NR	4920	2910 J	257 J	1940	511	971
Chromium	17.4	12	12.9	10.2	14.5	10.2 J	8.3	15.4	12	12
Chromium, hexavalent	None	NR	NR	<1 U	NR	NR	NR	NR	NR	NR
Cobalt	10.4	8.1	8.9	NR	6.9	7.4	6	**10.5 ***	5.7	8.1
Copper	17.7	11.6	16	NR	13.3 J	**23 J***	5.3 J	17.5	6.3	11.6
Iron	23100	19300	21300	NR	21800	16000	13800	**26500 ***	20700	19300
Lead	26.1	15.9 J	**26.9 J***	NR	16.2	**40.3 ***	14.4	17.7 J	11 J	15.9 J
Magnesium	3030	1950	2110	NR	2290 J	1520 J	539 J	2810	1490	1950
Manganese	1450	446	381	NR	421	608	335	454	718	446
Mercury	0.036	**0.24 ***	<0.04 UJ	NR	**0.062 J***	**4.8 ***	**0.095 J***	<0.056 UJ	<0.036 UJ	**0.24 ***
Nickel	21.1	14	14.3	NR	13.7	13.9 J	5.8	**23.9 ***	10.4	14
Potassium	927	506	726	NR	**935 ***	538 J	250	837	471	506
Selenium	1.4	0.72	0.81	NR	0.8 J	0.7 J	0.63 J	0.81	0.73	0.72
Silver	0	**0.024 J***	<0.017 UJ	NR	<0.017 UJ	**0.034 J***	<0.054 UJ	**0.011 J***	<0.027 UJ	**0.024 J***
Sodium	123	26.2 J	27.2 J	NR	35.3 J	26.9 J	20.1 J	32.9 J	32.7 J	26.2 J
Thallium	0	**0.13 J***	**0.15 J***	NR	**0.17 J***	**0.12 J***	**0.14 J***	**0.14 J***	**0.13 J***	**0.13 J***
Vanadium	31.1	17 J	17.4 J	NR	22.5	14.7 J	12.3	18.2 J	21.2 J	17 J
Zinc	61.8	48.3 J	**63.3 J***	NR	47.9 J	53.5	26.7 J	**75.8 J***	**93 J***	48.3 J
Explosives (mg/kg)										
2,6-Dinitrotoluene	None	<0.25 U	<0.24 U	NR	<0.25 UJ	<0.25 UJ	<0.27 UJ	<0.24 U	<0.25 U	<0.25 U
SVOCs (mg/kg)										
2-Methylnaphthalene	None	NR	NR	NR	<0.41 U	**0.021 J***	NR	NR	NR	NR
Acenaphthene	None	<0.0082 U	<0.0084 U	NR	<0.063 U	<0.068 U	<0.0093 UJ	**0.013 ***	<0.0085 U	<0.0082 U
Acenaphthylene	None	<0.0082 U	<0.0084 U	NR	<0.063 U	<0.068 U	<0.0093 UJ	<0.0087 U	<0.0085 U	<0.0082 U
Anthracene	None	<0.0082 U	<0.0084 U	NR	<0.063 U	<0.068 U	<0.0093 UJ	**0.031 ***	<0.0085 U	<0.0082 U
Benz(a)anthracene	None	**0.0084 ***	**0.012 ***	NR	**0.0095 J***	**0.038 J***	**0.012 J***	**0.13 ***	<0.0085 U	**0.0084 ***
Benzo(a)pyrene	None	<0.0082 U	**0.013 ***	NR	**0.0088 J***	**0.039 J***	**0.0098 J***	**0.13 ***	<0.0085 U	<0.0082 U
Benzo(b)fluoranthene	None	**0.013 ***	**0.077 ***	NR	**0.011 J***	**0.046 J***	<0.0093 UJ	**0.17 ***	<0.0085 U	**0.013 ***
Benzo(*ghi*)perylene	None	<0.0082 U	**0.027 ***	NR	<0.063 U	**0.031 J***	<0.0093 UJ	**0.091 ***	<0.0085 U	<0.0082 U
Benzo(k)fluoranthene	None	<0.0082 U	**0.026 ***	NR	<0.063 U	**0.031 J***	<0.0093 UJ	**0.086 ***	<0.0085 U	<0.0082 U
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	<0.41 UJ	<0.45 UJ	NR	NR	NR	NR
Chrysene	None	**0.0089 ***	**0.042 ***	NR	<0.063 U	**0.045 J***	<0.0093 UJ	**0.13 ***	<0.0085 U	**0.0089 ***
Dibenz(a,h)anthracene	None	<0.0082 U	**0.0085 ***	NR	<0.063 U	<0.068 U	<0.0093 UJ	<0.0087 U	<0.0085 U	<0.0082 U
Fluoranthene	None	**0.017 ***	**0.017 ***	NR	**0.02 J***	**0.086 ***	**0.016 J***	**0.31 ***	<0.0085 U	**0.017 ***
Fluorene	None	<0.0082 U	<0.0084 U	NR	<0.063 U	<0.068 U	<0.0093 UJ	<0.0087 U	<0.0085 U	<0.0082 U
Indeno(1,2,3-cd)pyrene	None	<0.0082 U	**0.03 ***	NR	<0.063 U	**0.025 J***	<0.0093 UJ	**0.082 ***	<0.0085 U	<0.0082 U
Naphthalene	None	<0.0082 U	**0.014 ***	NR	<0.063 U	**0.015 J***	<0.0093 UJ	<0.0087 U	<0.0085 U	<0.0082 U
Phenanthrene	None	**0.0083 ***	<0.0084 U	NR	**0.01 J***	**0.036 J***	<0.0093 UJ	**0.12 ***	<0.0085 U	**0.0083 ***
Pyrene	None	**0.013 ***	**0.015 ***	NR	**0.015 J***	**0.069 ***	**0.012 J***	**0.24 ***	<0.0085 U	**0.013 ***
Toluene	None	NR	NR	NR	NR	<0.0068 UJ	NR	NR	NR	NR

Table 4–11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Station		**LL9ss-131**	**LL9ss-132**	**LL9ss-133**	**LL9ss-134**	**LL9ss-134**	**LL9ss-135**
Sample ID		**LL9ss-131-5865-SO**	**LL9ss-132-5866-SO**	**LL9ss-133-5867-SO**	**LL9ss-134-6247-FD**	**LL9ss-134-5868-SO**	**LL9ss-135-5869-SO**
Date		**04/26/11**	**04/26/11**	**04/26/11**	**04/26/11**	**04/26/11**	**04/26/11**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed							
Analyte	**Background Criteria**	**Mercury**	**Mercury**	**Mercury**	**Mercury**	**Mercury**	**Mercury**
Metals (mg/kg)							
Aluminum	17700	NR	NR	NR	NR	NR	NR
Antimony	0.96	NR	NR	NR	NR	NR	NR
Arsenic	15.4	NR	NR	NR	NR	NR	NR
Barium	88.4	NR	NR	NR	NR	NR	NR
Beryllium	0.88	NR	NR	NR	NR	NR	NR
Cadmium	0	NR	NR	NR	NR	NR	NR
Calcium	15800	NR	NR	NR	NR	NR	NR
Chromium	17.4	NR	NR	NR	NR	NR	NR
Chromium, hexavalent	None	NR	NR	NR	NR	NR	NR
Cobalt	10.4	NR	NR	NR	NR	NR	NR
Copper	17.7	NR	NR	NR	NR	NR	NR
Iron	23100	NR	NR	NR	NR	NR	NR
Lead	26.1	NR	NR	NR	NR	NR	NR
Magnesium	3030	NR	NR	NR	NR	NR	NR
Manganese	1450	NR	NR	NR	NR	NR	NR
Mercury	0.036	**65 ***	**280 ***	**520 ***	**5.9 ***	**5.2 ***	**11.9 ***
Nickel	21.1	NR	NR	NR	NR	NR	NR
Potassium	927	NR	NR	NR	NR	NR	NR
Selenium	1.4	NR	NR	NR	NR	NR	NR
Silver	0	NR	NR	NR	NR	NR	NR
Sodium	123	NR	NR	NR	NR	NR	NR
Thallium	0	NR	NR	NR	NR	NR	NR
Vanadium	31.1	NR	NR	NR	NR	NR	NR
Zinc	61.8	NR	NR	NR	NR	NR	NR
Explosives (mg/kg)							
2,6-Dinitrotoluene	None	NR	NR	NR	NR	NR	NR
SVOCs (mg/kg)							
2-Methylnaphthalene	None	NR	NR	NR	NR	NR	NR
Acenaphthene	None	NR	NR	NR	NR	NR	NR
Acenaphthylene	None	NR	NR	NR	NR	NR	NR
Anthracene	None	NR	NR	NR	NR	NR	NR
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR
Benzo(*ghi*)perylene	None	NR	NR	NR	NR	NR	NR
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR	NR
Chrysene	None	NR	NR	NR	NR	NR	NR
Dibenz(a,h)anthracene	None	NR	NR	NR	NR	NR	NR
Fluoranthene	None	NR	NR	NR	NR	NR	NR
Fluorene	None	NR	NR	NR	NR	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	NR	NR
Naphthalene	None	NR	NR	NR	NR	NR	NR

Table 4–11. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Station		**LL9ss-131**	**LL9ss-132**	**LL9ss-133**	**LL9ss-134**	**LL9ss-134**	**LL9ss-135**
Sample ID		**LL9ss-131-5865-SO**	**LL9ss-132-5866-SO**	**LL9ss-133-5867-SO**	**LL9ss-134-6247-FD**	**LL9ss-134-5868-SO**	**LL9ss-135-5869-SO**
Date		**04/26/11**	**04/26/11**	**04/26/11**	**04/26/11**	**04/26/11**	**04/26/11**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed							
Analyte	**Background Criteria**	**Mercury**	**Mercury**	**Mercury**	**Mercury**	**Mercury**	**Mercury**
			Metals (mg/kg)				
Phenanthrene	None	NR	NR	NR	NR	NR	NR
Pyrene	None	NR	NR	NR	NR	NR	NR
			VOCs (mg/kg)				
Toluene	None	NR	NR	NR	NR	NR	NR

[a] Only detected analytes are presented in the table.

[b] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b).

ft = Feet.
ID = Identification.
J = Estimated value less than reporting limits.
mg/kg = Milligrams per kilogram.
bgs = Below ground surface.
NR = Not reported/not analyzed.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
TAL = Target Analyte List.
U = Non-detectable concentration.
UJ = Non-detectable concentration and reporting limit estimated.
VOC = Volatile organic compound.
*** = Result exceeds background concentration.**
< = Less than.

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Table 4–12. PBA08 RI Subsurface Soil Rationale and Analyses

PBA08 RI Location	Comments/Rationale	Sample Type	Depth ft (bgs)	Analyses Performed				
				Metals	Explosives	VOCs	Pesticides/ PCBs	SVOC
LL9sb-087	Further evaluate screening criteria exceedances at Building DT-21 (Loading Building during WWII). Bedrock encountered at 8 ft.	Discrete	0-1	Y	Y	N	N	PAH
		Discrete	1-4	Y	Y	N	N	PAH
		Discrete	4-7	Y	Y	N	N	PAH
		NA	7-8	N	N	N	N	N
LL9sb-088	Further evaluate screening criteria exceedances at Building DT-20 (Loading Building during WWII). Bedrock encountered at 6 ft.	Discrete	0-1	Y	Y	N	N	PAH
		Discrete	1-4	Y	Y	N	N	PAH
		Discrete	4-6	Y	Y	N	N	PAH
		NS	7-13	N	N	N	N	N
LL9sb-089	Further evaluate screening criteria exceedances at Building DT-22 (Loading Building during WWII). Bedrock encountered at 8 ft.	Discrete	0-1	Y	Y	N	N	PAH
		Discrete	1-4	Y	Y	N	N	PAH
		Discrete	4-7	Y	Y	N	N	PAH
		Discrete[a]	7-8	Y	Y	N	N	PAH
LL9sb-090	Define vertical and lateral extent of previously identified contamination at Building DT-34 (Detonator Destroying House during WWII). Bedrock encountered 3.5 ft. Analyzed for RVAAP full-suite analytes.	Discrete	0-1	Y	Y	Y	Y	Y
		Discrete	1-3.5	Y	Y	Y	Y	Y
		NS	4-7	N	N	N	N	N
		NS	7-13	N	N	N	N	N
LL9sb-091	Define lateral extent of previously identified contamination at Building DT-2 (fulminate mix house). Bedrock encountered at 6 ft.	Discrete	0-1	Y	Y	N	N	PAH
		Discrete	1-4	Y	Y	N	N	PAH
		Discrete	4-6	Y	Y	N	N	PAH
		NS	7-13	N	N	N	N	N
LL9sb-092	Define lateral extent of previously identified contamination at Building DT-5 (Azide Mix House during WWII). Bedrock encountered at 6 ft.	Discrete	0-1	Y	Y	N	N	PAH
		Discrete	1-4	Y	Y	N	N	PAH
		Discrete	4-6	Y	Y	N	N	PAH
		NS	7-13	N	N	N	N	N
	QA/QC.	Discrete	0-1	Y	Y	N	N	PAH
		Discrete	1-4	Y	Y	N	N	PAH

Table 4-12. PBA08 RI Subsurface Soil Rationale and Analyses (continued)

PBA08 RI Location	Comments/Rationale	Sample Type	Depth ft (bgs)	Analyses Performed				
				Metals	Explosives	VOCs	Pesticides/ PCBs	SVOC
LL9sb-092	QA/QC.	Discrete	4-6	Y	Y	N	N	PAH
		Discrete	0-1	Y	Y	N	N	PAH
		Discrete	1-4	Y	Y	N	N	PAH
		Discrete	4-6	Y	Y	N	N	PAH
LL9sb-093	Define lateral extent of previously identified contamination associated with the DWA. Bedrock encountered at 4.8 ft. Analyzed for RVAAP full-suite analytes (1-4 ft bgs interval only).	Discrete	0-1	Y	Y	N	N	PAH
		Discrete	1-4	Y	Y	Y	Y	Y
		Discrete	4-4.8	Y	Y	N	N	PAH
		NS	7-13	N	N	N	N	N
LL9sb-094	Define vertical and lateral extent of previously identified contamination in the northwest portion of the NPA. Bedrock encountered at 1 ft.	Discrete	0-1	Y	Y	N	N	PAH
		NS	1-4	N	N	N	N	N
		NS	4-7	N	N	N	N	N
		NS	7-13	N	N	N	N	N

[a] One sample (10%) from 7-8 ft was submitted for laboratory analysis to characterize subsurface soil to 8 ft bgs.
bgs = Below ground surface.
DWA = Dry well area.
Ft = Feet.
NA = Sample not analyzed by the laboratory based on preliminary screening criteria of the 4-7 ft sample interval.
NPA = Non-production area.
NS = Not sampled due to refusal.
PAH = Polycyclic aromatic hydrocarbon.
PBA08 RI = Performance-Based Acquisition 2008 Remedial Investigation.
PCB = Polychlorinated biphenyl.
QA/QC = Quality assurance/quality control.
RVAAP = Ravenna Army and Ammunition Plant.
SVOC = Semi-volatile organic compound.
VOC = Volatile organic compound.
WWII = World War II.

Table 4–13. Analytes Detected in PBA08 RI Subsurface Soil Samples

Station		**LL9sb-093**	**LL9sb-093**	**LL9sb-087**	**LL9sb-087**	**LL9sb-088**	**LL9sb-088**	**LL9sb-089**	**LL9sb-089**	**LL9sb-089**	**LL9sb-091**
Sample ID		**LL9sb-093-5462-SO**	**LL9sb-093-5463-SO**	**LL9sb-087-5438-SO**	**LL9sb-087-5439-SO**	**LL9sb-088-5442-SO**	**LL9sb-088-5443-SO**	**LL9sb-089-5446-SO**	**LL9sb-089-5447-SO**	**LL9sb-089-5448-SO**	**LL9sb-091-5454-SO**
Date		**03/09/10**	**03/09/10**	**03/08/10**	**03/08/10**	**03/08/10**	**03/08/10**	**03/08/10**	**03/08/10**	**03/08/10**	**03/09/10**
Depth (ft)		**1.0 - 4.0**	**4.0 - 4.8**	**1.0 - 4.0**	**4.0 - 7.0**	**1.0 - 4.0**	**4.0 - 6.0**	**1.0 - 4.0**	**4.0 - 7.0**	**7.0 - 13.0**	**1.0 - 4.0**
Parameters Analyzed		**RVAAP Full-suite analytes**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**
Analyte	**Background Criteria**										
Metals (mg/kg)											
Aluminum	19500	5970 J	5140 J	10700 J	7590	8910 J	8670 J	7680 J	6910	6360 J	3800 J
Antimony	0.96	0.08 J	0.12 J	0.1 J	0.085 J	0.082 J	0.079 J	0.086 J	0.084 J	0.1 J	<0.57 UJ
Arsenic	19.8	12.7 J	16.1 J	13.9 J	16.9	17.8 J	16 J	11 J	16.5	**21.3 J***	2.4 J
Barium	124	33.4 J	29.1 J	43.6 J	31	46.6 J	31.8 J	57.4 J	28	31.9 J	15.3 J
Beryllium	0.88	0.33 J	0.4 J	0.58 J	0.38	0.55 J	0.48 J	0.42 J	0.37	0.52 J	0.31 J
Cadmium	0	<0.046 UJ	**0.083 J***	**0.05 J***	**0.025 J***	**0.055 J***	**0.054 J***	**0.14 J***	**0.055 J***	**0.15 J***	**0.051 J***
Calcium	35500	614	754	2520 J	472	1280 J	6560 J	6180 J	3760	1060 J	369
Chromium	27.2	9.6	10.2	14.3 J	10.8	13.2 J	13.5 J	14 J	11.6	10.2 J	7
Cobalt	23.2	7.9	8.8	7	7.5	10.6	10.2	8.3	10.2	13.2	5
Copper	32.3	15.4 J	15.6 J	20 J	17.6	28.3 J	18.5 J	17.1 J	20.3	15.3 J	4.7 J
Iron	35200	19400	22700	24400	21800	25400	24000	19000	24000	22200	20800
Lead	19.1	10.5	12.6	12.6	12	11	10.3	**42 ***	11.7	10.5	5.8
Magnesium	8790	1820 J	1640 J	2710 J	2020	3470 J	4390 J	3510 J	3210	1840 J	998 J
Manganese	3030	452	534	241	234	354	325	414	449	1050	471
Mercury	0.044	**0.12 ***	**0.28 ***	0.044 J	<0.11 U	<0.12 U	<0.12 U	**1.3 ***	0.035 J	<0.12 U	<0.11 U
Nickel	60.7	18.8	22.2	17.3 J	15.3	30.2 J	23.3 J	19.7 J	23.1	31.1 J	7.3
Potassium	3350	771	830	840 J	697	964 J	1130 J	789 J	1040	903 J	437
Selenium	1.5	0.6 J	0.63 J	0.56 J	0.76	0.77 J	0.61 J	0.66 J	0.94	0.74 J	0.48 J
Silver	0	<0.0031 UJ	<0.009 UJ	<0.011 UJ	**0.0061 J***	**0.0082 J***	**0.022 J***	**0.014 J***	**0.014 J***	**0.011 J***	<0.57 U
Sodium	145	30 J	34.2 J	37.9 J	28.6 J	45.7 J	63.8 J	41.6 J	42.6 J	33.2 J	<114 U
Thallium	0.91	0.11 J	0.11 J	0.14 J	0.12 J	0.14 J	0.12 J	0.098 J	0.12 J	0.16 J	<0.23 U
Vanadium	37.6	9.8	9.9	19 J	13.1	14.8 J	13.9 J	13.6 J	12.2	11.1 J	10.5
Zinc	93.3	52.1 J	56.8 J	48.5	50.6	53.6	58.7	61.6	62.2	**98.8 ***	48.7 J
Explosives (mg/kg)											
Tetryl	None	<0.24 UJ	<0.24 UJ	<0.23 UJ	<0.24 U	<0.26 UJ	<0.24 UJ	**0.011 J***	<0.24 U	<0.25 UJ	<0.25 U
SVOCs (mg/kg)											
Acenaphthene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.014 ***	<0.0077 U	<0.0077 U	<0.0076 U
Anthracene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.043 ***	<0.0077 U	<0.0077 U	<0.0076 U
Benz(a)anthracene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.11 ***	<0.0077 U	<0.0077 U	<0.0076 U
Benzo(a)pyrene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.11 ***	<0.0077 U	<0.0077 U	<0.0076 U
Benzo(b)fluoranthene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.16 ***	<0.0077 U	<0.0077 U	<0.0076 U
Benzo(*ghi*)perylene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.11 ***	<0.0077 U	<0.0077 U	<0.0076 U
Benzo(k)fluoranthene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.059 ***	<0.0077 U	<0.0077 U	<0.0076 U
Chrysene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.12 ***	<0.0077 U	<0.0077 U	<0.0076 U
Dibenz(a,h)anthracene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.025 ***	<0.0077 U	<0.0077 U	<0.0076 U
Fluoranthene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.27 ***	<0.0077 U	<0.0077 U	<0.0076 U
Fluorene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.019 ***	<0.0077 U	<0.0077 U	<0.0076 U
Indeno(1,2,3-cd)pyrene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.094 ***	<0.0077 U	<0.0077 U	<0.0076 U
Phenanthrene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.18 ***	<0.0077 U	<0.0077 U	<0.0076 U
Pyrene	None	<0.06 U	<0.008 U	<0.008 U	<0.0077 U	<0.0078 U	<0.0078 U	**0.21 ***	<0.0077 U	<0.0077 U	<0.0076 U

Table 4-13. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Station	**Background Criteria**	**LL9sb-091**	**LL9sb-092**	**LL9sb-092**	**LL9sb-092**	**LL9sb-092**	**LL9sb-090**
Sample ID		**LL9sb-091-5455-SO**	**LL9sb-092-6157-FD**	**LL9sb-092-5458-SO**	**LL9sb-092-6158-FD**	**LL9sb-092-5459-SO**	**LL9sb-090-5450-SO**
Date		**03/09/10**	**03/09/10**	**03/09/10**	**03/09/10**	**03/09/10**	**03/09/10**
Depth (ft)		**4.0 - 6.0**	**1.0 - 4.0**	**1.0 - 4.0**	**4.0 - 6.0**	**4.0 - 6.0**	**1.0 - 3.5**
Parameters Analyzed		**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**RVAAP Full-suite analytes**
Analyte							
Metals (mg/kg)							
Aluminum	19500	3050 J	10400 J	12600 J	3400 J	3260	4860 J
Antimony	0.96	<0.55 UJ	0.1 J	0.1 J	0.082 J	<0.55 U	0.094 J
Arsenic	19.8	1.7 J	10 J	8.7 J	6.4 J	4.1	4.2 J
Barium	124	17.1 J	51.2 J	60.2 J	20.4 J	18.4	29.8 J
Beryllium	0.88	0.4 J	0.65 J	0.82 J	0.55 J	0.5	0.32 J
Cadmium	0	**0.059 J***	<0.055 UJ	<0.032 UJ	<0.061 UJ	**0.07 J***	**0.065 J***
Calcium	35500	386	447	410	287	397	738
Chromium	27.2	6	14.3	16.8	8.1	7.5	7.5
Cobalt	23.2	5.2	11.3	14.5	5.4	8.7	5.2
Copper	32.3	4.6 J	17.9 J	20.8 J	10.4 J	7.4	8 J
Iron	35200	28200	28900	27800	**37400 ***	**37700 ***	17900
Lead	19.1	4.7	13	13.1	16.8	12.3	12.6
Magnesium	8790	855 J	2820 J	3380 J	918 J	1100	1210 J
Manganese	3030	741	407	396	336	547	409
Mercury	0.044	**1.5 ***	0.033 J	0.018 J	<0.11 U	0.038 J	**0.76 ***
Nickel	60.7	7.2	19.2	22.6	9.3	12.6	9.2
Potassium	3350	412	826	1080	396	460	405
Selenium	1.5	0.47 J	0.95 J	1.1 J	0.59 J	0.85	0.5 J
Silver	0	<0.55 U	<0.014 UJ	<0.019 UJ	<0.028 UJ	**0.013 J***	<0.0066 UJ
Sodium	145	17 J	27.6 J	31.6 J	<110 U	<110 U	<113 U
Thallium	0.91	<0.22 U	0.15 J	0.17 J	0.12 J	0.098 J	0.076 J
Vanadium	37.6	9.4	18.7	18.9	13.8	9.9	10.1
Zinc	93.3	47.2 J	52.2 J	60.6 J	49.1 J	56.4	38.6 J
Explosives (mg/kg)							
Tetryl	None	<0.25 U	<0.24 UJ	<0.26 UJ	<0.25 U	<0.24 U	<0.24 UJ
SVOCs (mg/kg)							
Acenaphthene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	<0.056 U
Anthracene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	<0.056 U
Benz(a)anthracene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	**0.024 J***
Benzo(a)pyrene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	**0.021 J***
Benzo(b)fluoranthene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	**0.027 J***
Benzo(*ghi*)perylene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	**0.018 J***
Benzo(k)fluoranthene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	**0.016 J***
Chrysene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	**0.024 J***
Dibenz(a,h)anthracene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	<0.056 U
Fluoranthene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	**0.055 J***
Fluorene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	<0.056 U
Indeno(1,2,3-cd)pyrene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	**0.013 J***
Phenanthrene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	**0.037 J***
Pyrene	None	<0.0074 U	<0.0079 U	<0.008 U	<0.0073 U	<0.0074 U	**0.046 J***

[a] Only detected analytes are presented in the table.

[b] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b).

ft = Feet.

ID = Identification.

J = Estimated value less than reporting limits.

mg/kg = Milligrams per kilogram.

R = Rejected result.

RVAAP = Ravenna Army Ammunition Plant.

SVOC = Semi-volatile organic compound.

TAL = Target Analyte List.

U= Non-detectable concentration.

*** = Result exceeds background concentration.**

< = Less than.

Table 4–14. PBA08 RI Surface Water and Sediment Samples and Rationales

PBA08 RI Location	Targeted Area	Comments/Rationale	Sample Type	Depth ft (bgs)	Analyses Performed				
					Metals	Explosives	VOCs	Pesticides/ PCBs	SVOC
LL9sw-111	LL9sd/sw-001	Characterize current conditions of previously sampled area in northern portion of NPA.	Discrete	N/A	Y	Y	Y	Y	Y
LL9sd-111			Composite	0-0.5	Y	Y	N	N	PAH
LL9sw-113	LL9sw-004	Characterize current conditions of previously sampled area in western portion of NPA. Surface water was only available to sample after snowmelt and rain.	Discrete	N/A	Y	Y	Y	Y	Y
LL9sd-113		Sediment analyzed for RVAAP full-suite analytes.	Composite	0-0.5	Y	Y	Y	Y	Y
		QA/QC. Analyzed for RVAAP full-suite analytes.	Composite	0-0.5	Y	Y	Y	Y	Y
			Composite	0-0.5	Y	Y	Y	Y	Y
LL9sw-114	LL9sd/sw-003	Confirm presence of contamination in previously sampled area in southern portion of NPA. Surface water was only available to sample after snowmelt and rain.	Discrete	N/A	Y	Y	Y	Y	Y
LL9sd-114			Composite	0-0.5	Y	Y	N	N	PAH

bgs = Below ground surface.
ft = Feet.
NA = Not Applicable.
NPA = Non-production area.
PAH = Polycyclic aromatic hydrocarbon.
PBA08 RI =
PCB = Polychlorinated biphenyl.
QA/QC = Quality assurance/quality control.
RVAAP = Ravenna Army Ammunition Plant.
SVOC= Semi-volatile organic compound.
VOC = Volatile organic compound.
.

Table 4–15. Analytes Detected in PBA08 RI Surface Water Samples

Sample location		**LL9sw-111**	**LL9sw-113**	**LL9sw-114**
Sample ID		**LL9sw-111-5489-SW**	**LL9sw-113-5491-SW**	**LL9sw-114-5492-SW**
Date		**02/18/10**	**03/09/10**	**03/09/10**
Parameters Analyzed[a]	**Background Criteria**[b]	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**
Analyte				
Metals (mg/L)				
Aluminum	3.37	0.153 J	2.57	0.92
Arsenic	0.0032	<0.005 U	0.0014 J	0.00086 J
Barium	0.0475	0.0169	0.0295	0.0211
Beryllium	0	<0.001 U	**0.00012 J***	<0.001 U
Cadmium	0	**0.00004 J***	<0.00011 UJ	<0.00003 UJ
Calcium	41.4	10.9	25.2	32.2
Chromium	0	<0.005 U	**0.0028 J***	**0.0013 J***
Cobalt	0	**0.00007 J***	**0.0007 J***	**0.00033 J***
Copper	0.0079	<0.005 U	0.0046 J	0.0038 J
Iron	2.56	0.167	**2.64 ***	0.997
Lead	0	**0.00022 J***	**0.0035 ***	**0.0013 J***
Magnesium	10.8	1.94	3.51	3.47
Manganese	0.391	0.0208	0.109	0.0322
Mercury	0	<0.0002 U	**0.002 ***	<0.0002 U
Nickel	0	**0.0015 J***	**0.0028 J***	**0.0017 J***
Potassium	3.17	0.971 J	2.17	3
Sodium	21.3	1.03	0.753 J	1.43
Vanadium	0	**0.00081 J***	**0.0045 J***	**0.0018 J***
Zinc	0.042	0.0211 J	**0.107 ***	<0.0337 UJ

[a] Only detected analytes are presented in the table.

[b] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b).

ID = Identification.

J = Estimated value less than reporting limits.

mg/L = Milligrams per liter.

PBA08 RI = Performance Based Acquisition 2008 Remedial Investigation.

RVAAP = Ravenna Army Ammunition Plant.

*** = Result exceeds background criteria or no background criteria was available.**

Table 4–16. Analytes Detected in PBA08 RI Sediment Samples

Sample location		**LL9sd-111**	**LL9sd-113**	**LL9sd-113**	**LL9sd-114**
Sample ID		**LL9sd-111-5469-SD**	**LL9sd-113-6147-FD**	**LL9sd-113-5471-SD**	**LL9sd-114-5472-SD**
Date		**02/18/10**	**02/18/10**	**02/18/10**	**02/18/10**
Depth (ft)		**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**
Parameters Analyzed[a]	**Background Criteria**[b]	**TAL Metals, Explosives, SVOCs**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals, Explosives, SVOCs**
Analyte					
Metals (mg/kg)					
Aluminum	13900	8100	12600	13700	11400
Antimony	0	**0.14 J***	**0.16 J***	**0.16 J***	**0.16 J***
Arsenic	19.5	7.5	12.8	12.2	10.1
Barium	123	69.4	102	86.3	57.7
Beryllium	0.38	**0.76 J***	**0.98 J***	**0.89 J***	**0.57 J***
Cadmium	0	**0.42 ***	**0.55 ***	**0.72 ***	**0.37 ***
Calcium	5510	1760 J	2540 J	2350 J	2130 J
Chromium	18.1	9.9	15.8	16.9	14.8
Cobalt	9.1	**9.6 J***	**14.1 J***	**10 J***	6.7 J
Copper	27.6	11.1	15.8	15.2	15.9
Iron	28200	18500	26700	28000	19800
Lead	27.4	26 J	**32.7 J***	**31.1 J***	**30.8 J***
Magnesium	2760	1390	2200	2520	2120
Manganese	1950	1130	**2570 ***	1130	422
Mercury	0.059	**0.086 J***	**0.14 J***	**0.17 ***	**0.37 ***
Nickel	17.7	17.6	**18.7 ***	**19.3 ***	15.9
Potassium	1950	519	783	909	901
Selenium	1.7	1	1.4	1.3	1.1
Silver	0	**0.056 J***	**0.059 J***	**0.066 J***	**0.056 J***
Sodium	112	32.1 J	38.7 J	43.6 J	41.5 J
Thallium	0.89	0.16 J	0.22 J	0.24 J	0.2 J
Vanadium	26.1	16.7	24	24.8	20.2
Zinc	532	160	213	348	158
Explosives and Propellants (mg/kg)					
HMX	None	<0.25 U	**0.026 J***	<0.25 U	<0.24 U
Nitroguanidine	None	NR	**1.4 ***	**1.2 ***	NR
PETN	None	<0.5 U	<0.5 U	<0.5 U	**0.13 J***
SVOCs (mg/kg)					
2-Methylnaphthalene	None	<0.53 U	<0.55 U	<0.53 U	**0.014 J***
Benz(a)anthracene	None	<0.08 U	**0.025 J***	**0.025 J***	**0.036 J***
Benzenemethanol	None	<0.53 U	<0.55 U	**0.036 J***	**0.035 J***
Benzo(a)pyrene	None	<0.08 U	**0.026 J***	**0.026 J***	**0.039 J***
Benzo(b)fluoranthene	None	**0.013 J***	**0.045 J***	**0.042 J***	**0.058 J***
Benzo(*ghi*)perylene	None	<0.08 U	**0.021 J***	**0.022 J***	**0.027 J***
Benzo(k)fluoranthene	None	<0.08 U	**0.017 J***	<0.08 U	**0.019 J***

Table 4-16. Analytes Detected in PBA08 RI Sediment Samples (continued)

Sample location	Background Criteria[b]	LL9sd-111	LL9sd-113	LL9sd-113	LL9sd-114
Sample ID		**LL9sd-111-5469-SD**	**LL9sd-113-6147-FD**	**LL9sd-113-5471-SD**	**LL9sd-114-5472-SD**
Date		**02/18/10**	**02/18/10**	**02/18/10**	**02/18/10**
Depth (ft)		**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**
Parameters Analyzed[a]		**TAL Metals, Explosives, SVOCs**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**TAL Metals, Explosives, SVOCs**
Analyte					
SVOCs, continued (mg/kg)					
Chrysene	None	<0.08 U	**0.028 J***	**0.031 J***	**0.04 J***
Fluoranthene	None	**0.018 J***	**0.057 J***	**0.057 J***	**0.095 ***
Indeno(1,2,3-cd)pyrene	None	<0.08 U	**0.018 J***	**0.019 J***	**0.024 J***
Naphthalene	None	<0.08 U	<0.084 U	<0.08 U	**0.0092 J***
Phenanthrene	None	<0.08 U	**0.019 J***	**0.022 J***	**0.039 J***
Pyrene	None	**0.014 J***	**0.041 J***	**0.044 J***	**0.067 J***
VOCs (mg/kg)					
Toluene	None	NR	<0.0084 U	**0.00044 J***	NR

[a] Only detected analytes are presented in the table.

[b] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b).

ft = Feet.
HMX = Octahydor-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.
ID = Identification.
J = Estimated value less than reporting limits.
mg/kg = Milligrams per kilogram.
PETN = Pentaerythritol tetranitrate.
TAL = Target analyte list.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
U= Not detected.
UJ = Not detected, reporting limit estimated.
VOC = Volatile organic compound.
* = Result exceeds background criteria or no background criteria was available.
< = Less than.

Table 4–17. Changes from the PBA08 Sample and Analysis Plan

Station	Affected Sample	Date Sampled	Change/Rationale
LL9sb-091	LL9SB-091-5453-SO	3/9/2010	Sample location was relocated due to slope being too steep to set up the equipment. The station was re-located ~14 ft northeast of the original location.
	LL9SB-091-5454-SO	3/9/2010	
	LL9SB-091-5455-SO	3/9/2010	
LL9sb-093	LL9SB-093-5461-SO	3/9/2010	Sample location was relocated ~6 ft northwest to the bottom of the ditch.
	LL9SB-093-5462-SO	3/9/2010	
	LL9SB-093-5463-SO	3/9/2010	
LL9sw-112	LL9SW-112-5490-SW	N/A	Originally no ditch or pond was found. A ditch was located 10 ft from the original location but it was dry. No surface water or sediment samples were collected. A surface soil sample (LL9SS-112-5470-SO) was collected instead.
LL9sd-112	LL9SD-112-5470-SD	N/A	
LL9sw-113	LL9SW-113-5491-SW	3/9/2010	Sample location was re-located to the bottom of the ditch. Ditch initially did not have enough water to collect a sample. Surface water had to be collected after heavy rain and snowmelt on a different date than the sediment sample.
LL9sd-113	LL9SD-113-5471-SD	2/18/2010	
	LL9SD-113-6147-FD	2/18/2010	
LL9sd-114	LL9SD-114-5472-SD	2/18/2010	Sample location initially did not have enough water to collect a sample. Surface water had to be collected after heavy rain and snowmelt on a different date than the sediment sample.
LL9sw-114	LL9SW-114-5492-SW	3/9/2010	

ft= Feet.
N/A = Not applicable.

Table 4–18. RVAAP Background Concentrations

Chemical	Surface Soil (mg/kg)	Subsurface soil (mg/kg)	Sediment (mg/kg)	Surface Water (mg/L)	Groundwater-Unconsolidated (mg/L)		Groundwater-Bedrock (mg/L)	
					Filtered	Unfiltered	Filtered	Unfiltered
Aluminum	17700	19500	13900	3.37	NA	48	NA	9.41
Antimony	0.96	0.96	0	0	0	0.0043	0	0
Arsenic	15.4	19.8	19.5	0.0032	0.0117	0.215	0	0.0191
Barium	88.4	124	123	0.0475	0.0821	0.327	0.256	0.241
Beryllium	0.88	0.88	0.38	0	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0
Calcium	15800	35500	5510	41.4	115	194	53.1	48.2
Chromium	17.4	27.2	18.1	0	0.0073	0.0852	0	0.0195
Cobalt	10.4	23.2	9.1	0	0	0.0463	0	0
Copper	17.7	32.3	27.6	0.0079	0	0.289	0	0.017
Cyanide	0	0	0	0	0	0	0	0
Iron	23100	35200	28200	2.56	0.279	195	1.43	21.5
Lead	26.1	19.1	27.4	0	0	0.183	0	0.023
Magnesium	3030	8790	2760	10.8	43.3	58.4	15	13.7
Manganese	1450	3030	1950	0.391	1.02	2.86	1.34	1.26
Mercury	0.036	0.044	0.059	0	0	0.00025	0	0
Nickel	21.1	60.7	17.7	0	0	0.117	0.0834	0.0853
Potassium	927	3350	1950	3.17	2.89	7.48	5.77	6.06
Selenium	1.4	1.5	1.7	0	0	0.0057	0	0
Silver	0	0	0	0	0	0	0	0
Sodium	123	145	112	21.3	45.7	44.7	51.4	49.7
Thallium	0	0.91	0.89	0	0	0.0024	0	0
Vanadium	31.1	37.6	26.1	0	0	0.0981	0	0.0155
Zinc	61.8	93.3	532	0.042	0.0609	0.888	0.0523	0.193

mg/kg = Milligrams per kilogram.
mg/L = Milligrams per liter.
NA = Not available. Aluminum results were rejected in validation.

Table 4–19. RDA/RDI Values

Essential Human Nutrient	USDA RDA/RDI[a] Value
Calcium	1000 mg/d
Chloride[b]	3400 mg/d
Iodine	150 µg/d
Iron	8 mg/d
Magnesium	400 mg/d
Potassium[b]	4700 mg/d
Phosphorous	700 mg/d
Sodium[b]	2300 mg/d

[a] Dietary reference intakes vary by gender and age, values present are for life stage group: Males 19-30 years.
[b] Adequate intake value.
mg/d = Milligram per day.
RDA = Recommended daily allowance.
RDI = Recommended daily intake.
µg/d = Micrograms per day.
USDA = U.S. Department of Agriculture.
Source= Values were obtained from http://fnic.nal.usda.gov charts.

Table 4–20. SRC Screening Summary for Former Production Area Surface Soil

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
Metals								
Aluminum	**7429-90-5**	**48/ 48**	**1850**	**20000**	**10500**	**17700**	**Yes**	**Exceeds background**
Antimony	**7440-36-0**	**26/ 48**	**0.085**	**1.2**	**0.277**	**0.96**	**Yes**	**Exceeds background**
Arsenic	**7440-38-2**	**48/ 48**	**3.1**	**24**	**11.9**	**15.4**	**Yes**	**Exceeds background**
Barium	**7440-39-3**	**48/ 48**	**24.6**	**180**	**69**	**88.4**	**Yes**	**Exceeds background**
Beryllium	**7440-41-7**	**48/ 48**	**0.22**	**1.9**	**0.557**	**0.88**	**Yes**	**Exceeds background**
Cadmium	**7440-43-9**	**28/ 48**	**0.047**	**2.9**	**0.228**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	48/ 48	210	250000	15900	15800	No	Essential Nutrient
Chromium	**7440-47-3**	**48/ 48**	**7.1**	**110**	**15.8**	**17.4**	**Yes**	**Exceeds background**
Cobalt	**7440-48-4**	**48/ 48**	**1.7**	**17**	**8.28**	**10.4**	**Yes**	**Exceeds background**
Copper	**7440-50-8**	**48/ 48**	**6.4**	**31**	**17.4**	**17.7**	**Yes**	**Exceeds background**
Iron	7439-89-6	48/ 48	6140	31000	20700	23100	No	Essential Nutrient
Lead	**7439-92-1**	**48/ 48**	**7.6**	**320**	**40.1**	**26.1**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	48/ 48	1350	9600	2700	3030	No	Essential Nutrient
Manganese	**7439-96-5**	**48/ 48**	**150**	**3240**	**610**	**1450**	**Yes**	**Exceeds background**
Mercury	**7439-97-6**	**40/ 48**	**0.0057**	**1.3**	**0.137**	**0.036**	**Yes**	**Exceeds background**
Nickel	**7440-02-0**	**48/ 48**	**5.7**	**25.1**	**15.8**	**21.1**	**Yes**	**Exceeds background**
Potassium	7440-09-7	48/ 48	369	1500	832	927	No	Essential Nutrient
Selenium	**7782-49-2**	**32/ 48**	**0.3**	**1.4**	**0.619**	**1.4**	**Yes**	**Exceeds background**
Silver	**7440-22-4**	**6/ 48**	**0.014**	**0.032**	**0.127**	**0**	**Yes**	**Exceeds background**
Sodium	7440-23-5	30/ 48	25	1300	256	123	No	Essential Nutrient
Thallium	**7440-28-0**	**15/ 48**	**0.11**	**0.2**	**0.144**	**0**	**Yes**	**Exceeds background**
Vanadium	7440-62-2	48/ 48	5.4	28	17.1	31.1	No	Below background
Zinc	**7440-66-6**	**48/ 48**	**23.3**	**228**	**77.8**	**61.8**	**Yes**	**Exceeds background**
Explosives and Propellants								
Nitrocellulose	**9004-70-0**	**2/ 4**	**1.6**	**1.8**	**1.67**	**None**	**Yes**	**Detected organic**

Table 4-20. SRC Screening Summary for Former Production Area Surface Soil (continued)

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
SVOCs								
2-Methylnaphthalene	**91-57-6**	**1/ 5**	**0.02**	**0.02**	**0.0834**	**None**	**Yes**	**Detected organic**
Acenaphthene	**83-32-9**	**4/ 19**	**0.0095**	**4.1**	**0.228**	**None**	**Yes**	**Detected organic**
Acenaphthylene[b]	**208-96-8**	**2/ 19**	**0.1**	**0.55**	**0.0416**	**None**	**Yes**	**Detected organic**
Anthracene	**120-12-7**	**7/ 19**	**0.014**	**12**	**0.665**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**56-55-3**	**16/ 19**	**0.0072**	**17**	**0.977**	**None**	**Yes**	**Detected organic**
Benzo(a)pyrene	**50-32-8**	**15/ 19**	**0.0068**	**15**	**0.907**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**205-99-2**	**17/ 19**	**0.0073**	**20**	**1.22**	**None**	**Yes**	**Detected organic**
Benzo(*ghi*)perylene[c]	**191-24-2**	**13/ 19**	**0.0053**	**9.2**	**0.57**	**None**	**Yes**	**Detected organic**
Benzo(k)fluoranthene	**207-08-9**	**12/ 19**	**0.0049**	**7.1**	**0.444**	**None**	**Yes**	**Detected organic**
Bis(2-ethylhexyl)phthalate	**117-81-7**	**3/ 5**	**0.027**	**0.15**	**0.127**	**None**	**Yes**	**Detected organic**
Chrysene	**218-01-9**	**15/ 19**	**0.0052**	**17**	**1.01**	**None**	**Yes**	**Detected organic**
Dibenz(a,h)anthracene	**53-70-3**	**7/ 19**	**0.0085**	**2.2**	**0.143**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**18/ 19**	**0.01**	**48**	**2.68**	**None**	**Yes**	**Detected organic**
Fluorene	**86-73-7**	**4/ 19**	**0.0095**	**5.3**	**0.293**	**None**	**Yes**	**Detected organic**
Indeno(1,2,3-cd)pyrene	**193-39-5**	**12/ 19**	**0.0091**	**8.5**	**0.525**	**None**	**Yes**	**Detected organic**
Naphthalene	**91-20-3**	**5/ 19**	**0.013**	**0.92**	**0.0589**	**None**	**Yes**	**Detected organic**
Phenanthrene[c]	**85-01-8**	**14/ 19**	**0.0051**	**43**	**2.35**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**17/ 19**	**0.01**	**34**	**1.91**	**None**	**Yes**	**Detected organic**
VOCs								
Toluene	**108-88-3**	**2/ 4**	**0.00036**	**0.00037**	**0.000508**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).

[b] Acenaphthene RSL used as a surrogate for Acenaphthylene.

[c] Pyrene RSL used as a surrogate for benzo(*ghi*)perylene and for phenanthrene.

CAS = Chemical Abstract Service.
mg/kg = Milligrams per kilogram.
RSL = Regional screening level.
SRC = Site-related contaminant.
SVOC = Semi-volatile organic compound.
VOC = Volatile organic compound.
Bold indicates analyte identified as an SRC.

Table 4–21. SRC Screening Summary for NPA Surface Soil

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
				Metals				
Aluminum	7429-90-5	17/ 17	5920	12000	8730	17700	No	Below background
Antimony	**7440-36-0**	**4/ 17**	**0.11**	**1.4**	**0.331**	**0.96**	**Yes**	**Exceeds background**
Arsenic	**7440-38-2**	**17/ 17**	**3.8**	**16.9**	**8.68**	**15.4**	**Yes**	**Exceeds background**
Barium	**7440-39-3**	**17/ 17**	**26.5**	**110**	**58.1**	**88.4**	**Yes**	**Exceeds background**
Beryllium	7440-41-7	17/ 17	0.34	0.84	0.541	0.88	No	Below background
Cadmium	**7440-43-9**	**7/ 17**	**0.082**	**2.7**	**0.245**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	17/ 17	257	5090	1370	15800	No	Essential Nutrient
Chromium	7440-47-3	17/ 17	8.3	16.1	12.4	17.4	No	Below background
Cobalt	**7440-48-4**	**17/ 17**	**4.8**	**18**	**8.25**	**10.4**	**Yes**	**Exceeds background**
Copper	**7440-50-8**	**17/ 17**	**5.3**	**1240**	**93.4**	**17.7**	**Yes**	**Exceeds background**
Iron	7439-89-6	17/ 17	13800	76000	25400	23100	No	Essential Nutrient
Lead	**7439-92-1**	**17/ 17**	**11**	**1330**	**105**	**26.1**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	17/ 17	539	2810	1590	3030	No	Essential Nutrient
Manganese	**7439-96-5**	**17/ 17**	**335**	**3800**	**839**	**1450**	**Yes**	**Exceeds background**
Mercury	**7439-97-6**	**20/ 22**	**0.026**	**882**	**81**	**0.036**	**Yes**	**Exceeds background**
Nickel	**7440-02-0**	**17/ 17**	**5.8**	**23.9**	**13.2**	**21.1**	**Yes**	**Exceeds background**
Potassium	7440-09-7	17/ 17	250	837	610	927	No	Essential Nutrient
Selenium	**7782-49-2**	**12/ 17**	**0.52**	**1.8**	**0.671**	**1.4**	**Yes**	**Exceeds background**
Silver	**7440-22-4**	**2/ 17**	**0.011**	**0.034**	**0.156**	**0**	**Yes**	**Exceeds background**
Sodium	7440-23-5	9/ 17	20.1	1000	218	123	No	Essential Nutrient
Thallium	**7440-28-0**	**4/ 17**	**0.12**	**0.14**	**0.193**	**0**	**Yes**	**Exceeds background**
Vanadium	7440-62-2	17/ 17	12	23	17.1	31.1	No	Below background
Zinc	**7440-66-6**	**17/ 17**	**26.7**	**780**	**138**	**61.8**	**Yes**	**Exceeds background**
				Explosives and Propellants				
Nitrocellulose	**9004-70-0**	**3/ 4**	**1.1**	**3.2**	**2.33**	**None**	**Yes**	**Detected organic**
Nitroguanidine	**556-88-7**	**1/ 4**	**0.089**	**0.089**	**0.116**	**None**	**Yes**	**Detected organic**

Table 4-21. SRC Screening Summary for NPA Surface Soil (continued)

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
SVOCs								
2-Methylnaphthalene	**91-57-6**	**2/ 4**	**0.015**	**0.021**	**0.00945**	**None**	**Yes**	**Detected organic**
Acenaphthene	**83-32-9**	**2/ 7**	**0.011**	**0.013**	**0.0098**	**None**	**Yes**	**Detected organic**
Acenaphthylene[b]	**208-96-8**	**1/ 7**	**0.05**	**0.05**	**0.0141**	**None**	**Yes**	**Detected organic**
Anthracene	**120-12-7**	**2/ 7**	**0.031**	**0.048**	**0.0176**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**56-55-3**	**6/ 7**	**0.012**	**0.23**	**0.0646**	**None**	**Yes**	**Detected organic**
Benzo(a)pyrene	**50-32-8**	**6/ 7**	**0.0098**	**0.24**	**0.0654**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**205-99-2**	**5/ 7**	**0.011**	**0.24**	**0.0726**	**None**	**Yes**	**Detected organic**
Benzo(*ghi*)perylene[c]	**191-24-2**	**5/ 7**	**0.011**	**0.17**	**0.047**	**None**	**Yes**	**Detected organic**
Benzo(k)fluoranthene	**207-08-9**	**5/ 7**	**0.01**	**0.2**	**0.0516**	**None**	**Yes**	**Detected organic**
Bis(2-ethylhexyl)phthalate	**117-81-7**	**1/ 4**	**0.03**	**0.03**	**0.0666**	**None**	**Yes**	**Detected organic**
Chrysene	**218-01-9**	**5/ 7**	**0.012**	**0.25**	**0.068**	**None**	**Yes**	**Detected organic**
Dibenz(a,h)anthracene	**53-70-3**	**2/ 7**	**0.03**	**0.13**	**0.0298**	**None**	**Yes**	**Detected organic**
Dibenzofuran	**132-64-9**	**1/ 4**	**0.013**	**0.013**	**0.0603**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**6/ 7**	**0.016**	**0.36**	**0.122**	**None**	**Yes**	**Detected organic**
Fluorene	**86-73-7**	**1/ 7**	**0.025**	**0.025**	**0.0106**	**None**	**Yes**	**Detected organic**
Indeno(1,2,3-cd)pyrene	**193-39-5**	**4/ 7**	**0.024**	**0.17**	**0.0445**	**None**	**Yes**	**Detected organic**
Naphthalene	**91-20-3**	**2/ 7**	**0.015**	**0.019**	**0.00704**	**None**	**Yes**	**Detected organic**
Phenanthrene[c]	**85-01-8**	**5/ 7**	**0.01**	**0.28**	**0.068**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**6/ 7**	**0.012**	**0.4**	**0.113**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).

[b] Acenaphthene RSL used as a surrogate for Acenaphthylene.

[c] Pyrene RSL used as a surrogate for benzo(*ghi*)perylene and for phenanthrene.

CAS = Chemical Abstract Service.

mg/kg = Milligrams per kilogram.

RSL = Regional screening level.

SRC = Site-related contaminant.

SVOC = Semi-volatile organic compound.

Bold indicates analyte identified as an SRC.

Table 4–22. SRC Screening Summary for DWA Surface Soil

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
Metals								
Aluminum	7429-90-5	2/ 2	8600	12200	10400	17700	No	Below background
Arsenic	7440-38-2	2/ 2	10.8	15	12.9	15.4	No	Below background
Barium	7440-39-3	2/ 2	61	67.5	64.3	88.4	No	Below background
Beryllium	7440-41-7	2/ 2	0.26	0.55	0.405	0.88	No	Below background
Calcium	7440-70-2	2/ 2	770	911	841	15800	No	Essential Nutrient
Chromium	7440-47-3	2/ 2	12	14	13	17.4	No	Below background
Cobalt	7440-48-4	2/ 2	6.4	8	7.2	10.4	No	Below background
Copper	7440-50-8	2/ 2	8.4	15	11.7	17.7	No	Below background
Iron	7439-89-6	2/ 2	16000	24400	20200	23100	No	Essential Nutrient
Lead	7439-92-1	2/ 2	12	14.5	13.3	26.1	No	Below background
Magnesium	7439-95-4	2/ 2	2000	2120	2060	3030	No	Essential Nutrient
Manganese	7439-96-5	2/ 2	690	934	812	1450	No	Below background
Mercury	**7439-97-6**	**2/ 2**	**0.063**	**2.5**	**1.28**	**0.036**	**Yes**	**Exceeds background**
Nickel	7440-02-0	2/ 2	13	15	14	21.1	No	Below background
Potassium	7440-09-7	2/ 2	890	942	916	927	No	Essential Nutrient
Selenium	7782-49-2	2/ 2	0.45	0.82	0.635	1.4	No	Below background
Sodium	7440-23-5	2/ 2	30.7	1200	615	123	No	Essential Nutrient
Thallium	**7440-28-0**	**1/ 2**	**0.14**	**0.14**	**0.345**	**0**	**Yes**	**Exceeds background**
Vanadium	7440-62-2	2/ 2	13	21.3	17.2	31.1	No	Below background
Zinc	7440-66-6	2/ 2	45	55.1	50.1	61.8	No	Below background

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).

CAS = Chemical Abstract Service.

mg/kg = Milligrams per kilogram.

SRC = Site-related contaminant.

Bold indicates analyte identified as an SRC.

Table 4–23. SRC Screening Summary for Former Production Area Subsurface Soil

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
				Metals				
Aluminum[b]	7429-90-5	43/ 43	2900	18000	9150	19500	No	Below background
Antimony	**7440-36-0**	**17/ 43**	**0.079**	**1**	**0.318**	**0.96**	**Yes**	**Exceeds background**
Arsenic	**7440-38-2**	**43/ 43**	**1.7**	**32**	**13.3**	**19.8**	**Yes**	**Exceeds background**
Barium	**7440-39-3**	**43/ 43**	**13**	**140**	**49.9**	**124**	**Yes**	**Exceeds background**
Beryllium	**7440-41-7**	**43/ 43**	**0.16**	**1.2**	**0.483**	**0.88**	**Yes**	**Exceeds background**
Cadmium	**7440-43-9**	**14/ 43**	**0.025**	**2**	**0.1**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	43/ 43	330	36000	2660	35500	No	Essential Nutrient
Chromium	**7440-47-3**	**43/ 43**	**4.7**	**54**	**13.9**	**27.2**	**Yes**	**Exceeds background**
Cobalt[b]	7440-48-4	43/ 43	2.2	19	8.93	23.2	No	Below background
Copper[b]	7440-50-8	43/ 43	4.6	28.3	17.7	32.3	No	Below background
Iron	7439-89-6	43/ 43	9800	51000	24400	35200	No	Essential Nutrient
Lead	**7439-92-1**	**43/ 43**	**4.7**	**86**	**17.5**	**19.1**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	43/ 43	540	5000	2520	8790	No	Essential Nutrient
Manganese[b]	7439-96-5	43/ 43	42	2300	525	3030	No	Below background
Mercury	**7439-97-6**	**38/ 43**	**0.013**	**1.5**	**0.133**	**0.044**	**Yes**	**Exceeds background**
Nickel[b]	7440-02-0	43/ 43	4.3	37	19.3	60.7	No	Below background
Potassium	7440-09-7	43/ 43	370	1700	893	3350	No	Essential Nutrient
Selenium	7782-49-2	20/ 43	0.15	1.1	0.397	1.5	No	Below background
Silver	**7440-22-4**	**7/ 43**	**0.0061**	**0.022**	**0.142**	**0**	**Yes**	**Exceeds background**
Sodium	7440-23-5	15/ 43	17	1200	170	145	No	Essential Nutrient
Thallium[b]	**7440-28-0**	**11/ 43**	**0.098**	**1**	**0.174**	**0.91**	**Yes**	**Exceeds background**
Vanadium	7440-62-2	43/ 43	6.1	29	15.5	37.6	No	Below background
Zinc	**7440-66-6**	**43/ 43**	**37**	**120**	**63.7**	**93.3**	**Yes**	**Exceeds background**
				Explosives and Propellants				
Nitrocellulose	**9004-70-0**	**1/ 4**	**1.2**	**1.2**	**1.16**	**None**	**Yes**	**Detected organic**
Tetryl	**479-45-8**	**1/ 16**	**0.011**	**0.011**	**0.0843**	**None**	**Yes**	**Detected organic**

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Table 4-23. SRC Screening Summary for Former Production Area Subsurface Soil (continued)

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
				SVOCs				
Acenaphthene	**83-32-9**	**1/ 15**	**0.014**	**0.014**	**0.00372**	**None**	**Yes**	**Detected organic**
Anthracene	**120-12-7**	**1/ 15**	**0.043**	**0.043**	**0.00557**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**56-55-3**	**2/ 15**	**0.053**	**0.11**	**0.0136**	**None**	**Yes**	**Detected organic**
Benzo(a)pyrene	**50-32-8**	**2/ 15**	**0.052**	**0.11**	**0.0136**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**205-99-2**	**2/ 15**	**0.062**	**0.16**	**0.0176**	**None**	**Yes**	**Detected organic**
Benzo(*ghi*)perylene	**191-24-2**	**2/ 15**	**0.034**	**0.11**	**0.0124**	**None**	**Yes**	**Detected organic**
Benzo(k)fluoranthene	**207-08-9**	**2/ 15**	**0.059**	**0.059**	**0.0108**	**None**	**Yes**	**Detected organic**
Chrysene	**218-01-9**	**2/ 15**	**0.058**	**0.12**	**0.0146**	**None**	**Yes**	**Detected organic**
Di-n-butyl phthalate	**84-74-2**	**2/ 4**	**0.087**	**0.14**	**0.0625**	**None**	**Yes**	**Detected organic**
Dibenz(a,h)anthracene	**53-70-3**	**2/ 15**	**0.018**	**0.025**	**0.00569**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**2/ 15**	**0.17**	**0.27**	**0.032**	**None**	**Yes**	**Detected organic**
Fluorene	**86-73-7**	**1/ 15**	**0.019**	**0.019**	**0.00408**	**None**	**Yes**	**Detected organic**
Indeno(1,2,3-cd)pyrene	**193-39-5**	**3/ 15**	**0.017**	**0.094**	**0.0124**	**None**	**Yes**	**Detected organic**
Phenanthrene	**85-01-8**	**2/ 15**	**0.061**	**0.18**	**0.0188**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**2/ 15**	**0.12**	**0.21**	**0.0248**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).
[b] Inorganic analyte was identified as an SRC in corresponding surface soil interval; however, was not an SRC in the subsurface soil interval.
CAS = Chemical Abstract Service.
mg/kg = Milligrams per kilogram.
SRC = Site-related Contaminant.
SVOC = Semi-volatile organic compound.
Bold indicates analyte identified as an SRC.

Table 4–24. SRC Screening Summary for NPA Subsurface Soil

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
Metals								
Aluminum[b]	7429-90-5	9/ 9	4860	18000	9920	19500	No	Below background
Antimony	7440-36-0	3/ 9	0.094	0.85	0.34	0.96	No	Below background
Arsenic[b]	7440-38-2	9/ 9	4.2	18	9.34	19.8	No	Below background
Barium[b]	7440-39-3	9/ 9	28	100	52.2	124	No	Below background
Beryllium[b]	7440-41-7	9/ 9	0.32	0.84	0.526	0.88	No	Below background
Cadmium	**7440-43-9**	**1/ 9**	**0.065**	**0.065**	**0.0463**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	9/ 9	320	890	591	35500	No	Essential Nutrient
Chromium[b]	7440-47-3	9/ 9	7.5	23	13.2	27.2	No	Below background
Cobalt[b]	7440-48-4	9/ 9	2.4	11	6.73	23.2	No	Below background
Copper[b]	7440-50-8	9/ 9	5.2	23	10.9	32.3	No	Below background
Iron	7439-89-6	9/ 9	11000	32000	20400	35200	No	Essential Nutrient
Lead	**7439-92-1**	9/ 9	5.5	15	10.5	19.1	No	Below background
Magnesium	7439-95-4	9/ 9	1200	4000	1790	8790	No	Essential Nutrient
Manganese[b]	**7439-96-5**	9/ 9	50	970	468	3030	No	Below background
Mercury	**7439-97-6**	**9/ 9**	**0.0095**	**0.76**	**0.108**	**0.044**	**Yes**	**Exceeds background**
Nickel[b]	7440-02-0	9/ 9	6.6	25	12.8	60.7	No	Below background
Potassium[b]	7440-09-7	9/ 9	405	1600	655	3350	No	Essential Nutrient
Selenium	7782-49-2	4/ 9	0.5	0.67	0.39	1.5	No	Below background
Thallium[b]	7440-28-0	1/ 9	0.076	0.076	0.237	0.91	No	Below background
Vanadium	7440-62-2	9/ 9	10.1	29	18.7	37.6	No	Below background
Zinc	7440-66-6	9/ 9	27	61	42.1	93.3	No	Below background
Explosives and Propellants								
Nitrocellulose	**9004-70-0**	**1/ 2**	**1.3**	**1.3**	**2.05**	**None**	**Yes**	**Detected organic**

Table 4-24. SRC Screening Summary for NPA Subsurface Soil (continued)

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
SVOCs								
Acenaphthene	**83-32-9**	**1/ 6**	**0.006**	**0.006**	**0.00622**	**None**	**Yes**	**Detected organic**
Anthracene	**120-12-7**	**1/ 6**	**0.0063**	**0.0063**	**0.00606**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**56-55-3**	**5/ 6**	**0.0031**	**0.029**	**0.0117**	**None**	**Yes**	**Detected organic**
Benzo(a)pyrene	**50-32-8**	**4/ 6**	**0.0061**	**0.027**	**0.0107**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**205-99-2**	**5/ 6**	**0.0045**	**0.032**	**0.0137**	**None**	**Yes**	**Detected organic**
Benzo(*ghi*)perylene	**191-24-2**	**4/ 6**	**0.0033**	**0.018**	**0.00683**	**None**	**Yes**	**Detected organic**
Benzo(k)fluoranthene	**207-08-9**	**4/ 6**	**0.0065**	**0.03**	**0.0106**	**None**	**Yes**	**Detected organic**
Chrysene	**218-01-9**	**5/ 6**	**0.0031**	**0.026**	**0.0114**	**None**	**Yes**	**Detected organic**
Dibenz(a,h)anthracene	**53-70-3**	**2/ 6**	**0.0064**	**0.026**	**0.0107**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**5/ 6**	**0.0064**	**0.071**	**0.0268**	**None**	**Yes**	**Detected organic**
Indeno(1,2,3-cd)pyrene	**193-39-5**	**5/ 6**	**0.0039**	**0.018**	**0.00905**	**None**	**Yes**	**Detected organic**
Phenanthrene	**85-01-8**	**4/ 6**	**0.0049**	**0.037**	**0.0143**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**5/ 6**	**0.004**	**0.046**	**0.0188**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).
[b] Inorganic analyte was identified as an SRC in corresponding surface soil interval; however, was not an SRC in the subsurface soil interval.
CAS = Chemical Abstract Service.
mg/kg = Milligrams per kilogram.
SRC = Site-related Contaminant.
Bold indicates analyte identified as an SRC.

Table 4–25. SRC Screening Summary for DWA Subsurface Soil

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
Metals								
Aluminum	7429-90-5	5/ 5	5140	10000	7000	19500	No	Below background
Antimony	7440-36-0	3/ 5	0.08	0.72	0.278	0.96	No	Below background
Arsenic	7440-38-2	5/ 5	4.6	16.1	10.1	19.8	No	Below background
Barium[b]	7440-39-3	5/ 5	29.1	83	48.9	124	No	Below background
Beryllium	7440-41-7	5/ 5	0.16	0.44	0.352	0.88	No	Below background
Cadmium	**7440-43-9**	**1/ 5**	**0.083**	**0.083**	**0.049**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	5/ 5	614	1200	934	35500	No	Essential Nutrient
Chromium	7440-47-3	5/ 5	9.6	12	10.5	27.2	No	Below background
Cobalt	7440-48-4	5/ 5	1.6	10	6.82	23.2	No	Below background
Copper	7440-50-8	5/ 5	8.7	18	13.3	32.3	No	Below background
Iron	7439-89-6	5/ 5	9600	22700	16900	35200	No	Essential Nutrient
Lead	**7439-92-1**	**5/ 5**	**5.2**	**51**	**17.9**	**19.1**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	5/ 5	1300	2100	1710	8790	No	Essential Nutrient
Manganese[b]	**7439-96-5**	5/ 5	92	534	312	3030	No	Below background
Mercury	**7439-97-6**	**5/ 5**	**0.016**	**9.7**	**2.03**	**0.044**	**Yes**	**Exceeds background**
Nickel[b]	7440-02-0	5/ 5	9.6	22.2	17.5	60.7	No	Below background
Potassium	7440-09-7	5/ 5	740	1000	826	3350	No	Essential Nutrient
Selenium	7782-49-2	3/ 5	0.58	0.63	0.446	1.5	No	Below background
Sodium	7440-23-5	5/ 5	30	1300	733	145	No	Essential Nutrient
Thallium[b]	7440-28-0	2/ 5	0.11	0.11	0.351	0.91	No	Below background
Vanadium	7440-62-2	5/ 5	9.2	17	11.1	37.6	No	Below background
Zinc	7440-66-6	5/ 5	50	72	57	93.3	No	Below background

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).

[b] Inorganic analyte was identified as an SRC in corresponding surface soil interval; however, was not an SRC in the subsurface soil interval.

CAS = Chemical Abstract Service.

mg/kg = Milligrams per kilogram.

SRC = Site-related contaminant.

Bold indicates analyte identified as an SRC.

Table 4–26. SRC Screening for Drainage Ditches Discrete Sediment Samples

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
				Metals				
Aluminum	7429-90-5	3/ 3	8100	13700	11100	13900	No	Below background
Antimony	**7440-36-0**	**3/ 3**	**0.14**	**0.16**	**0.153**	**0**	**Yes**	**Exceeds background**
Arsenic	7440-38-2	3/ 3	7.5	12.2	9.93	19.5	No	Below background
Barium[b]	7440-39-3	3/ 3	57.7	86.3	71.1	123	No	Below background
Beryllium	**7440-41-7**	**3/ 3**	**0.57**	**0.89**	**0.74**	**0.38**	**Yes**	**Exceeds background**
Cadmium	**7440-43-9**	**3/ 3**	**0.37**	**0.72**	**0.503**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	3/ 3	1760	2350	2080	5510	No	Essential Nutrient
Chromium	7440-47-3	3/ 3	9.9	16.9	13.9	18.1	No	Below background
Cobalt	**7440-48-4**	**3/ 3**	**6.7**	**10**	**8.77**	**9.1**	**Yes**	**Exceeds background**
Copper	7440-50-8	3/ 3	11.1	15.9	14.1	27.6	No	Below background
Iron	7439-89-6	3/ 3	18500	28000	22100	28200	No	Essential Nutrient
Lead	**7439-92-1**	**3/ 3**	**26**	**31.1**	**29.3**	**27.4**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	3/ 3	1390	2520	2010	2760	No	Essential Nutrient
Manganese[b]	7439-96-5	3/ 3	422	1130	894	1950	No	Below background
Mercury	**7439-97-6**	**3/ 3**	**0.086**	**0.37**	**0.209**	**0.059**	**Yes**	**Exceeds background**
Nickel[b]	**7440-02-0**	**3/ 3**	**15.9**	**19.3**	**17.6**	**17.7**	**Yes**	**Exceeds background**
Potassium	7440-09-7	3/ 3	519	909	776	1950	No	Essential Nutrient
Selenium	7782-49-2	3/ 3	1	1.3	1.13	1.7	No	Below background
Silver	**7440-22-4**	**3/ 3**	**0.056**	**0.066**	**0.0593**	**0**	**Yes**	**Exceeds background**
Sodium	7440-23-5	3/ 3	32.1	43.6	39.1	112	No	Essential Nutrient
Thallium[b]	7440-28-0	3/ 3	0.16	0.24	0.2	0.89	No	Below background
Vanadium	7440-62-2	3/ 3	16.7	24.8	20.6	26.1	No	Below background
Zinc	7440-66-6	3/ 3	158	348	222	532	No	Below background
				Explosives and Propellants				
Nitroguanidine	**556-88-7**	**1/ 1**	**1.2**	**1.2**	**1.2**	**None**	**Yes**	**Detected organic**
PETN	**78-11-5**	**1/ 3**	**0.13**	**0.13**	**0.21**	**None**	**Yes**	**Detected organic**

Table 4-26. SRC Screening for Drainage Ditches Discrete Sediment Samples (continued)

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
SVOCs								
2-Methylnaphthalene	**91-57-6**	**1/ 3**	**0.014**	**0.014**	**0.181**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**56-55-3**	**2/ 3**	**0.025**	**0.036**	**0.0337**	**None**	**Yes**	**Detected organic**
Benzenemethanol	**100-51-6**	**2/ 3**	**0.035**	**0.036**	**0.112**	**None**	**Yes**	**Detected organic**
Benzo(a)pyrene	**50-32-8**	**2/ 3**	**0.026**	**0.039**	**0.035**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**205-99-2**	**3/ 3**	**0.013**	**0.058**	**0.0377**	**None**	**Yes**	**Detected organic**
Benzo(*ghi*)perylene[b]	**191-24-2**	**2/ 3**	**0.022**	**0.027**	**0.0297**	**None**	**Yes**	**Detected organic**
Benzo(k)fluoranthene	**207-08-9**	**1/ 3**	**0.019**	**0.019**	**0.033**	**None**	**Yes**	**Detected organic**
Chrysene	**218-01-9**	**2/ 3**	**0.031**	**0.04**	**0.037**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**3/ 3**	**0.018**	**0.095**	**0.0567**	**None**	**Yes**	**Detected organic**
Indeno(1,2,3-cd)pyrene	**193-39-5**	**2/ 3**	**0.019**	**0.024**	**0.0277**	**None**	**Yes**	**Detected organic**
Naphthalene	**91-20-3**	**1/ 3**	**0.0092**	**0.0092**	**0.0297**	**None**	**Yes**	**Detected organic**
Phenanthrene[b]	**85-01-8**	**2/ 3**	**0.022**	**0.039**	**0.0337**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**3/ 3**	**0.014**	**0.067**	**0.0417**	**None**	**Yes**	**Detected organic**
VOCs								
Toluene	**108-88-3**	**1/ 1**	**0.00044**	**0.00044**	**0.00044**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).

[b] Pyrene RSL used as a surrogate for benzo(*ghi*)perylene and for phenanthrene.

CAS = Chemical Abstract Service.
mg/kg = Milligrams per kilogram.
PETN = Pentaerythritol tetranitrate.
RSL = Regional screening level.
SRC = Site-related contaminant.
Bold indicates analyte identified as an SRC.

Table 4–27. SRC Screening for DWA Discrete Sediment Samples

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Average Result (mg/kg)	Background Criteria[a] (mg/kg)	SRC? (yes/no)	SRC Justification
Metals								
Aluminum	7429-90-5	1/ 1	12000	12000	12000	13900	No	Below background
Arsenic	7440-38-2	1/ 1	14	14	14	19.5	No	Below background
Barium	7440-39-3	1/ 1	100	100	100	123	No	Below background
Beryllium	**7440-41-7**	**1/ 1**	**0.86**	**0.86**	**0.86**	**0.38**	**Yes**	**Exceeds background**
Calcium	7440-70-2	1/ 1	1200	1200	1200	5510	No	Essential Nutrient
Chromium	7440-47-3	1/ 1	14	14	14	18.1	No	Below background
Cobalt	7440-48-4	1/ 1	7.1	7.1	7.1	9.1	No	Below background
Copper	7440-50-8	1/ 1	7.6	7.6	7.6	27.6	No	Below background
Iron	7439-89-6	1/ 1	24000	24000	24000	28200	No	Essential Nutrient
Lead	7439-92-1	1/ 1	17	17	17	27.4	No	Below background
Magnesium	7439-95-4	1/ 1	1800	1800	1800	2760	No	Essential Nutrient
Manganese	7439-96-5	1/ 1	1300	1300	1300	1950	No	Below background
Mercury	**7439-97-6**	1/ 1	**2.9**	**2.9**	**2.9**	**0.059**	**Yes**	**Exceeds background**
Nickel	**7440-02-0**	**1/ 1**	**19**	**19**	**19**	**17.7**	**Yes**	**Exceeds background**
Potassium	7440-09-7	1/ 1	1000	1000	1000	1950	No	Essential Nutrient
Selenium	7782-49-2	1/ 1	0.82	0.82	0.82	1.7	No	Below background
Thallium[b]	7440-28-0	1/ 1	0.31	0.31	0.31	0.89	No	Below background
Vanadium	7440-62-2	1/ 1	24	24	24	26.1	No	Below background
Zinc	7440-66-6	1/ 1	69	69	69	532	No	Below background

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).

CAS = Chemical Abstract Service.

mg/kg = Milligrams per kilogram.

SRC = Site-related contaminant.

Bold indicates analyte identified as an SRC.

Table 4–28. SRC Screening for Drainage Ditches Surface Water

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/L)	Maximum Detect (mg/L)	Average Result (mg/L)	Background Criteria[a] (mg/L)	SRC? (yes/no)	SRC Justification
				Metals				
Aluminum	7429-90-5	3/ 3	0.153	2.57	1.21	3.37	No	Below background
Arsenic	7440-38-2	2/ 3	0.00086	0.0014	0.00159	0.0032	No	Below background
Barium	7440-39-3	3/ 3	0.0169	0.0295	0.0225	0.0475	No	Below background
Beryllium	**7440-41-7**	**1/ 3**	**0.00012**	**0.00012**	**0.000373**	**0**	**Yes**	**Exceeds background**
Cadmium	**7440-43-9**	**1/ 3**	**0.000044**	**0.000044**	**0.0000383**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	3/ 3	10.9	32.2	22.8	41.4	No	Essential Nutrient
Chromium	**7440-47-3**	**2/ 3**	**0.0013**	**0.0028**	**0.0022**	**0**	**Yes**	**Exceeds background**
Cobalt	**7440-48-4**	**3/ 3**	**0.000074**	**0.0007**	**0.000368**	**0**	**Yes**	**Exceeds background**
Copper	7440-50-8	2/ 3	0.0038	0.0046	0.00363	0.0079	No	Below background
Iron	7439-89-6	3/ 3	0.167	2.64	1.27	2.56	No	Essential Nutrient
Lead	**7439-92-1**	**3/ 3**	**0.00022**	**0.0035**	**0.00167**	**0**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	3/ 3	1.94	3.51	2.97	10.8	No	Essential Nutrient
Manganese	7439-96-5	3/ 3	0.0208	0.109	0.054	0.391	No	Below background
Mercury	**7439-97-6**	**1/ 3**	**0.002**	**0.002**	**0.000733**	**0**	**Yes**	**Exceeds background**
Nickel	**7440-02-0**	**3/ 3**	**0.0015**	**0.0028**	**0.002**	**0**	**Yes**	**Exceeds background**
Potassium	7440-09-7	3/ 3	0.971	3	2.05	3.17	No	Essential Nutrient
Sodium	7440-23-5	3/ 3	0.753	1.43	1.07	21.3	No	Essential Nutrient
Vanadium	**7440-62-2**	**3/ 3**	**0.00081**	**0.0045**	**0.00237**	**0**	**Yes**	**Exceeds background**
Zinc	**7440-66-6**	**2/ 3**	**0.0211**	**0.107**	**0.0483**	**0.042**	**Yes**	**Exceeds background**

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).
CAS = Chemical Abstract Service.
mg/L = Milligrams per liter.
SRC = Site-related contaminant.
Bold indicates analyte identified as an SRC.

Table 4–29. SRC Screening for DWA Surface Water

Analyte	CAS Number	Freq of Detect	Minimum Detect (mg/L)	Maximum Detect (mg/L)	Average Result (mg/L)	Background Criteria[a] (mg/L)	SRC? (yes/no)	SRC Justification
Metals								
Aluminum	7429-90-5	1/ 1	0.43	0.43	0.43	3.37	No	Below background
Barium[b]	7440-39-3	1/ 1	0.028	0.028	0.028	0.0475	No	Below background
Calcium	7440-70-2	1/ 1	18	18	18	41.4	No	Essential Nutrient
Iron	7439-89-6	1/ 1	0.54	0.54	0.54	2.56	No	Essential Nutrient
Lead	**7439-92-1**	**1/ 1**	**0.0014**	**0.0014**	**0.0014**	**0**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	1/ 1	4.5	4.5	4.5	10.8	No	Essential Nutrient
Manganese[b]	7439-96-5	1/ 1	0.12	0.12	0.12	0.391	No	Below background
Mercury	**7439-97-6**	**1/ 1**	**0.0003**	**0.0003**	**0.0003**	**0**	**Yes**	**Exceeds background**
Nickel[b]	**7440-02-0**	**1/ 1**	**0.0053**	**0.0053**	**0.0053**	**0**	**Yes**	**Exceeds background**
Potassium	7440-09-7	1/ 1	1.2	1.2	1.2	3.17	No	Essential Nutrient
Sodium	7440-23-5	1/ 1	2.4	2.4	2.4	21.3	No	Essential Nutrient
Zinc	7440-66-6	1/ 1	0.02	0.02	0.02	0.042	No	Below background
Explosives								
Nitrocellulose	**9004-70-0**	**1/ 1**	**0.12**	**0.12**	**0.12**		**Yes**	**Detected organic**

[a] Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).

CAS = Chemical Abstract Service.
mg/L = Milligrams per liter.
SRC = Site-related contaminant.
Bold indicates analyte identified as an SRC.

Table 4–30. Data Summary and Designated Use for RI

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
Surface (0-1 ft) and Subsurface (>1 ft) Soil										
LL9sb-001-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-002-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-003-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-004-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-005-0001-FD	D	12/04/03	1–3	Phase I RI	X	--	--	--	--	Field duplicate
LL9sb-005-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-006-0001-SO	D	12/11/03	1–2	Phase I RI	--	X	X	X	--	
LL9sb-007-0001-SO	D	12/08/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-008-0001-SO	D	12/10/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-009-0001-SO	D	12/08/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-010-0001-SO	D	12/08/03	1–2.5	Phase I RI	--	X	X	X	--	
LL9sb-012-0001-SO	D	12/10/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-013-0001-SO	D	12/10/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-014-0001-SO	D	12/11/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-015-0001-SO	D	12/11/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-016-0001-SO	D	12/11/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-017-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-018-0001-SO	D	12/10/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-019-0001-SO	D	12/11/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-020-0001-SO	D	12/08/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-021-0001-SO	D	12/08/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-022-0001-SO	D	12/10/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-023-0001-SO	D	12/08/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-024-0001-SO	D	12/10/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-025-0001-SO	D	12/10/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-026-0001-SO	D	12/10/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-027-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-028-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-029-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-030-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-031-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-032-0001-SO	D	12/04/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-040-0001-SO	D	10/27/03	6–7	Phase I RI	--	X	X	X	--	
LL9sb-041-0001-SO	D	10/27/03	6.5–7.5	Phase I RI	--	X	X	X	--	
LL9sb-042-0001-SO	D	11/06/03	8–10	Phase I RI	--	X	X	X	--	
LL9sb-043-0001-FD	D	11/06/03	9–11	Phase I RI	X	--	--	--	--	Field Duplicate

Table 4–30. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
LL9sb-043-0001-SO	D	11/06/03	9–11	Phase I RI	--	X	X	X	--	
LL9sb-044-0001-SO	D	11/06/03	8–10	Phase I RI	--	X	X	X	--	
LL9sb-045-0001-SO	D	11/06/03	8–10	Phase I RI	--	X	X	X	--	
LL9sb-046-0001-SO	D	11/06/03	4–6	Phase I RI	--	X	X	X	--	
LL9sb-047-0001-SO	D	11/06/03	3–5	Phase I RI	--	X	X	X	--	
LL9sb-048-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	--	--	--	Sample taken under building that was subsequently demolished.
LL9sb-049-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	--	--	--	Sample taken under building that was subsequently demolished.
LL9sb-050-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	--	--	--	Sample taken under building that was subsequently demolished.
LL9sb-051-0001-SO	D	12/08/03	0–1	Phase I RI	--	X	--	--	--	Sample taken under building that was subsequently demolished.
LL9sb-052-0001-SO	D	12/08/03	0–1	Phase I RI	--	X	--	--	--	Sample taken under building that was subsequently demolished.
LL9sb-053-0001-FD	D	12/11/03	0–1	Phase I RI	X	--	--	--	--	Field duplicate.
LL9sb-053-0001-SO	D	12/11/03	0–1	Phase I RI	--	X	--	--	--	Sample taken under building that was subsequently demolished.
LL9sb-055-0001-SO	D	11/05/03	1.5–3.5	Phase I RI	--	X	X	X	--	
LL9sb-056-0001-SO	D	11/05/03	2–4	Phase I RI	--	X	X	X	--	
LL9sb-059-0001-SO	D	11/05/03	3–5	Phase I RI	--	X	X	X	--	
LL9sb-061-0001-SO	D	11/05/03	1–3	Phase I RI	--	X	X	X	--	
LL9sb-065-0001-SO	D	11/06/03	3–5	Phase I RI	--	X	X	X	--	
LL9sb-066-0001-SO	D	11/06/03	5–7	Phase I RI	--	X	X	X	--	
LL9sb-069-0001-SO	D	10/27/03	6.5–7.5	Phase I RI	--	X	X	X	--	
LL9sb-070-0001-SO	D	10/27/03	6–7	Phase I RI	--	X	X	X	--	
LL9sb-087-5437-SO	D	03/08/10	0–1	PBA08 RI	--	X	X	X	X	
LL9sb-087-5438-SO	D	03/08/10	1–4	PBA08 RI	--	X	X	X	--	
LL9sb-087-5439-SO	D	03/08/10	4–7	PBA08 RI	--	X	X	X	--	
LL9sb-088-5441-SO	D	03/08/10	0–1	PBA08 RI	--	X	X	X	X	
LL9sb-088-5442-SO	D	03/08/10	1–4	PBA08 RI	--	X	X	X	--	
LL9sb-088-5443-SO	D	03/08/10	4–6	PBA08 RI	--	X	X	X	--	
LL9sb-089-5445-SO	D	03/08/10	0–1	PBA08 RI	--	X	X	X	X	

Table 4–30. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
LL9sb-089-5446-SO	D	03/08/10	1–4	PBA08 RI	--	X	X	X	--	
LL9sb-089-5447-SO	D	03/08/10	4–7	PBA08 RI	--	X	X	X	--	
LL9sb-089-5448-SO	D	03/08/10	7–13	PBA08 RI	--	X	X	X	--	
LL9sb-090-5449-SO	D	03/09/10	0–1	PBA08 RI	--	X	X	X	X	
LL9sb-090-5450-SO	D	03/09/10	1–3.5	PBA08 RI	--	X	X	X	--	
LL9sb-091-5453-SO	D	03/09/10	0–1	PBA08 RI	--	X	X	X	X	
LL9sb-091-5454-SO	D	03/09/10	1–4	PBA08 RI	--	X	X	X	--	
LL9sb-091-5455-SO	D	03/09/10	4–6	PBA08 RI	--	X	X	X	--	
LL9sb-092-5457-SO	D	03/09/10	0–1	PBA08 RI	--	X	X	X	X	
LL9sb-092-5458-SO	D	03/09/10	1–4	PBA08 RI	--	X	X	X	--	
LL9sb-092-5459-SO	D	03/09/10	4–6	PBA08 RI	--	X	X	X	--	
LL9sb-092-6156-FD	D	03/09/10	0–1	PBA08 RI	X	--	--	--	--	Field duplicate.
LL9sb-092-6157-FD	D	03/09/10	1–4	PBA08 RI	X	--	--	--	--	Field duplicate.
LL9sb-092-6158-FD	D	03/09/10	4–6	PBA08 RI	X	--	--	--	--	Field duplicate.
LL9sb-093-5461-SO	D	03/09/10	0–1	PBA08 RI	--	X	X	X	X	
LL9sb-093-5462-SO	D	03/09/10	1–4	PBA08 RI	--	X	X	X	--	
LL9sb-093-5463-SO	D	03/09/10	4–4.8	PBA08 RI	--	X	X	X	--	
LL9sb-094-5465-SO	D	03/09/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-001-0001-SO	D	03/11/02	0–1	Phase I RI	--	X	X	X	X	Collected during lead azide screening event.
LL9ss-002-0001-SO	D	12/04/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-003-0001-SO	D	03/11/02	0–1	Phase I RI	--	X	X	X	X	Collected during lead azide screening event.
LL9ss-004-0001-SO	D	12/04/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-005-0001-SO	D	03/11/02	0–1	Phase I RI	--	X	X	X	X	Collected during lead azide screening event.
LL9ss-006-0001-SO	D	12/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-007-0001-SO	D	03/11/02	0–1	Phase I RI	--	X	X	X	X	Collected during lead azide screening event.
LL9ss-008-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-009-0001-SO	D	03/11/02	0–1	Phase I RI	--	X	X	X	X	Collected during lead azide screening event.
LL9ss-010-0001-SO	D	12/08/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-011-0001-SO	D	03/11/02	0–1	Phase I RI	--	X	X	X	X	Collected during lead azide screening event.
LL9ss-012-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-013-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-014-0001-FD	D	12/11/03	0–1	Phase I RI	X	--	--	--	--	Field duplicate.

Table 4–30. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
LL9ss-014-0001-SO	D	12/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-015-0001-SO	D	12/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-016-0001-FD	D	12/11/03	0–1	Phase I RI	X	--	--	--	--	Field duplicate.
LL9ss-016-0001-SO	D	12/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-017-0001-SO	D	12/04/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-018-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-019-0001-SO	D	12/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-020-0001-SO	D	12/08/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-021-0001-SO	D	12/08/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-022-0001-FD	D	12/10/03	0–1	Phase I RI	X	--	--	--	--	Field duplicate.
LL9ss-022-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-023-0001-SO	D	12/08/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-024-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-025-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-026-0001-SO	D	12/10/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-027-0001-SO	D	12/04/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-028-0001-FD	D	12/04/03	0–1	Phase I RI	X	--	--	--	--	Field duplicate.
LL9ss-028-0001-SO	D	12/04/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-029-0001-SO	D	12/04/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-030-0001-SO	D	12/04/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-031-0001-SO	D	12/04/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-032-0001-SO	D	12/04/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-033-0001-SO	D	11/11/03	0–1	Phase I RI	--	X	--	--	--	Sample taken outside the AOC.
LL9ss-034-0001-FD	D	11/11/03	0–1	Phase I RI	X	--	--	--	--	Field duplicate.
LL9ss-034-0001-SO	D	11/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-035-0001-SO	D	11/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-036-0001-FD	D	11/11/03	0–1	Phase I RI	X	--	--	--	--	Field duplicate.
LL9ss-036-0001-SO	D	11/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-037-0001-SO	D	11/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-038-0001-SO	D	11/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-039-0001-FD	D	11/11/03	0–1	Phase I RI	X	--	--	--	--	Field duplicate.
LL9ss-039-0001-SO	D	11/11/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-042-0001-SO	D	11/06/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-043-0001-SO	D	11/06/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-044-0001-SO	D	11/06/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-045-0001-SO	D	11/06/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-046-0001-SO	D	11/06/03	0–1	Phase I RI	--	X	X	X	X	

Table 4–30. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
LL9ss-047-0001-SO	D	11/06/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-068-0001-SO	D	12/12/03	0–1	Phase I RI	--	X	X	X	X	
LL9ss-095-5473-SO	D	03/02/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-096-5474-SO	D	03/01/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-096-6149-FD	D	03/01/10	0–1	PBA08 RI	X	--	--	--	--	Field duplicate.
LL9ss-097-5475-SO	D	03/01/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-098-5476-SO	D	03/01/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-099-5477-SO	D	03/02/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-100-5478-SO	D	03/01/10	0–1	PBA08 RI	--	X	--	X	--	Sample collected for chromium speciation analysis only.
LL9ss-101-5807-SO	D	10/18/10	0–1	PBA08 RI	--	X	--	X	--	Sample collected for chromium speciation analysis only.
LL9ss-102-5480-SO	D	03/02/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-103-5481-SO	D	03/02/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-104-5482-SO	D	03/02/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-104-6151-FD	D	03/02/10	0–1	PBA08 RI	X	--	--	--	--	Field duplicate.
LL9ss-105-5483-SO	D	03/02/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-106-5484-SO	D	03/02/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-107-5485-SO	D	03/02/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-108-5486-SO	D	03/02/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-109-5487-SO	D	03/01/10	0–1	PBA08 RI	--	X	--	X	--	Sample collected for chromium speciation analysis only.
LL9ss-110-5488-SO	D	03/02/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-112-5470-SO	D	03/09/10	0–1	PBA08 RI	--	X	X	X	X	
LL9ss-131-5865-SO	D	04/26/11	0–1	PBA08 RI	--	X	X	X	X	Analyzed for mercury only to delineate lateral extent of mercury near former Building DT-34 (sample LL9ss-011).
LL9ss-132-5866-SO	D	04/26/11	0–1	PBA08 RI	--	X	X	X	X	Analyzed for mercury only to delineate lateral extent of mercury near former Building DT-34 (sample LL9ss-011).
LL9ss-133-5867-SO	D	04/26/11	0–1	PBA08 RI	--	X	X	X	X	Analyzed for mercury only to delineate lateral extent of mercury near former Building DT-34 (sample LL9ss-011).

Table 4–30. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
LL9ss-134-5868-SO	D	04/26/11	0–1	PBA08 RI	--	X	X	X	X	Analyzed for mercury only to delineate lateral extent of mercury near former Building DT-34 (sample LL9ss-011).
LL9ss-134-6247-FD	D	04/26/11	0–1	PBA08 RI	X	--	--	--	--	Field duplicate.
LL9ss-135-5869-SO	D	04/26/11	0–1	PBA08 RI	--	X	X	X	X	Analyzed for mercury only to delineate lateral extent of mercury near former Building DT-34 (sample LL9ss-011).
RV-261A	D	10/30/96	0–0.5	1996 RRSE	--	--	--	--	--	Used for initial evaluation of site.
RV-261B	D	10/30/96	subsurface	1996 RRSE	--	--	--	--	--	Used for initial evaluation of site.
RV-421	D	10/27/98	0–0.5	1998 RRSE	--	--	--	--	--	Used for initial evaluation of site.
RV-422	D	10/27/98	0–0.5	1998 RRSE	--	--	--	--	--	Used for initial evaluation of site.
RV-423	D	10/27/98	0–0.5	1998 RRSE	--	--	--	--	--	Used for initial evaluation of site.
RV-424	D	10/27/98	0–0.5	1998 RRSE	--	--	--	--	--	Used for initial evaluation of site.
RV-425	D	10/27/98	0–0.5	1998 RRSE	--	--	--	--	--	Used for initial evaluation of site.
RV-426	D	10/27/98	0–0.5	1998 RRSE	--	--	--	--	--	Used for initial evaluation of site.
RV-427	D	10/27/98	0–0.5	1996 RRSE	--	--	--	--	--	Used for initial evaluation of site.
Sediment										
LL9sd-001-0001-SD	D	03/12/02	0–1	Phase I RI	--	X	--	--	--	Collected during lead azide screening event. Sample not used for HHRA and ERA because more recent sample was taken at the same location.
LL9sd-001-D24S-FD	D	03/15/02	0–1	Phase I RI	X	--	--	--	--	Collected during lead azide screening event. Field duplicate.
LL9sd-001-W24S-FD	D	03/15/02	0–1	Phase I RI	X	--	--	--	--	Collected during lead azide screening event. Field duplicate.

Table 4–30. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
LL9sd-002-0001-SD	D	12/05/03	0–0.5	Phase I RI	--	X	--	--	--	Sample represents drainage off AOC.
LL9sd-003-0001-SD	D	03/13/02	0–0.5	Phase I RI	--	X	--	--	--	Collected during lead azide screening event. Sample not used for HHRA and ERA because more recent sample was taken at the same location.
LL9sd-004-0001-SD	D	12/05/03	0–0.5	Phase I RI	--	X	--	--	--	Sample not used for HHRA and ERA because more recent sample was taken at the same location.
LL9sd-005-0001-SD	D	03/13/02	0–1	Phase I RI	--	X	--	--	--	Collected during lead azide screening event. Sample not used for HHRA and ERA because drainage changed in production area after demolition.
LL9sd-006-0001-SD	D	12/05/03	0–0.5	Phase I RI	--	X	--	--	--	Sample not used for HHRA and ERA because drainage changed in production area after demolition.
LL9sd-011-0001-SD	D	12/05/03	0–0.5	Phase I RI	--	X	--	--	--	Sample represents drainage off AOC.
LL9sd-012-0001-SD	D	12/09/03	0–1	Phase I RI	--	X	X	X	X	
LL9sd-013-0001-SD	D	12/05/03	0–1	Phase I RI	--	X	--	--	--	Sample not used for HHRA and ERA because drainage changed in production area after demolition.
LL9sd-014-0001-SD	D	12/05/03	0–1	Phase I RI	--	X	--	--	--	Sample not used for HHRA and ERA because drainage changed in production area after demolition.
LL9sd-015-0001-FD	D	12/09/03	0–0.5	Phase I RI	X	--	--	--	--	Field duplicate.
LL9sd-015-0001-SD	D	12/09/03	0–0.5	Phase I RI	--	X	--	--	--	Sample not used for HHRA and ERA because drainage changed in production area after demolition.
LL9sd-016-0001-FD	D	12/05/03	0–0.5	Phase I RI	X	--	--	--	--	Field duplicate.
LL9sd-016-0001-SD	D	12/05/03	0–0.5	Phase I RI	--	X	--	--	--	Sample not used for HHRA

Table 4–30. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
										and ERA because drainage changed in production area after demolition.
LL9sd-017-0001-SD	D	12/05/03	0–0.5	Phase I RI	--	X	--	--	--	Sample not used for HHRA and ERA because more recent sample was taken at the same location.
LL9sd-111-5469-SD	D	02/18/10	0–0.5	PBA08 RI	--	X	X	X	X	
LL9sd-113-5471-SD	D	02/18/10	0–0.5	PBA08 RI	--	X	X	X	X	
LL9sd-113-6147-FD	D	02/18/10	0–0.5	PBA08 RI	X	--	--	--	--	Field duplicate.
LL9sd-114-5472-SD	D	02/18/10	0–0.5	PBA08 RI	--	X	X	X	X	
Surface Water										
LL9sw-001-0001-SW	D	03/12/02	0–0.5	Phase I RI	--	X	--	--	--	Collected during lead azide screening event. Sample not used for HHRA and ERA because more recent sample was taken at the same location.
LL9sw-002-0001-SW	D	12/05/03	0–0.5	Phase I RI	--	X	--	--	--	Sample represents drainage off AOC.
LL9sw-003-0001-SW	D	12/05/03	0–0.5	Phase I RI	--	X	--	--	--	Sample not used for HHRA and ERA because more recent sample was taken at the same location.
LL9sw-004-0001-SW	D	12/05/03	0–0.5	Phase I RI	--	X	--	--	--	Sample not used for HHRA and ERA because more recent sample was taken at the same location.
LL9sw-005-0001-SW	D	03/13/02	0–0.5	Phase I RI	--	X	--	--	--	Collected during lead azide screening event. Sample not used for HHRA and ERA because drainage changed in production area after demolition.
LL9sw-007-0001-SW	D	03/12/02	0–0.5	Phase I RI	--	--	--	--	--	Collected during lead azide screening event. Excluded samples from sewers and sumps.
LL9sw-008-0001-FD	D	03/13/02	0–0.5	Phase I RI	--	--	--	--	--	Collected during lead azide screening event. Excluded

Table 4–30. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
										samples from sewers and sumps.
LL9sw-008-0001-SW	D	03/13/02	0–0.5	Phase I RI	--	--	--	--	--	Collected during lead azide screening event. Excluded samples from sewers and sumps.
LL9sw-009-0001-SW	D	12/09/03	0–0.5	Phase I RI	--	--	--	--	--	Excluded samples from sewers and sumps.
LL9sw-010-0001-SW	D	12/09/03	0–0.5	Phase I RI	--	--	--	--	--	Excluded samples from sewers and sumps.
LL9sw-012-0001-FD	D	12/09/03	0–1	Phase I RI	X	--	--	--	--	Field duplicate.
LL9sw-012-0001-SW	D	12/09/03	0–1	Phase I RI	--	X	X	X	X	
LL9sw-111-5489-SW	D	02/18/10	0–0	PBA08 RI	--	X	X	X	X	
LL9sw-113-5491-SW	D	03/09/10	0–0	PBA08 RI	--	X	X	X	X	
LL9sw-114-5492-SW	D	03/09/10	0–0	PBA08 RI	--	X	X	X	X	

AOC = Area of concern
bgs = Below ground surface.
D = Discrete.
ERA = Ecological risk assessment.
F&T = Fate and transport.
HHRA = Human health risk assessment.
ISM = Incremental sampling methodology.
N&E = Nature and extent.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
QC = Quality control.
RRSE = Relative risk site evaluation.
VOC = Volatile organic compound.

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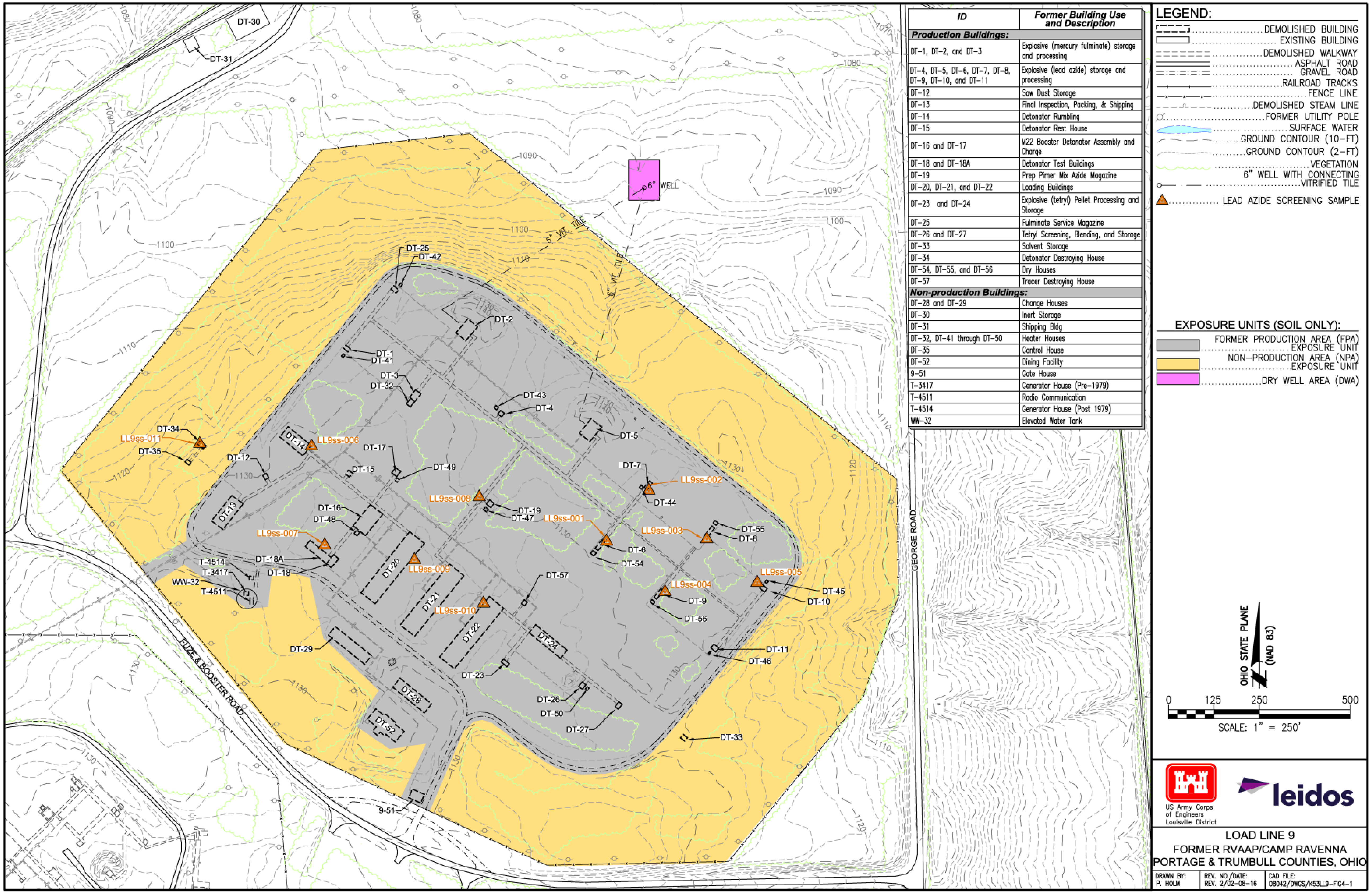
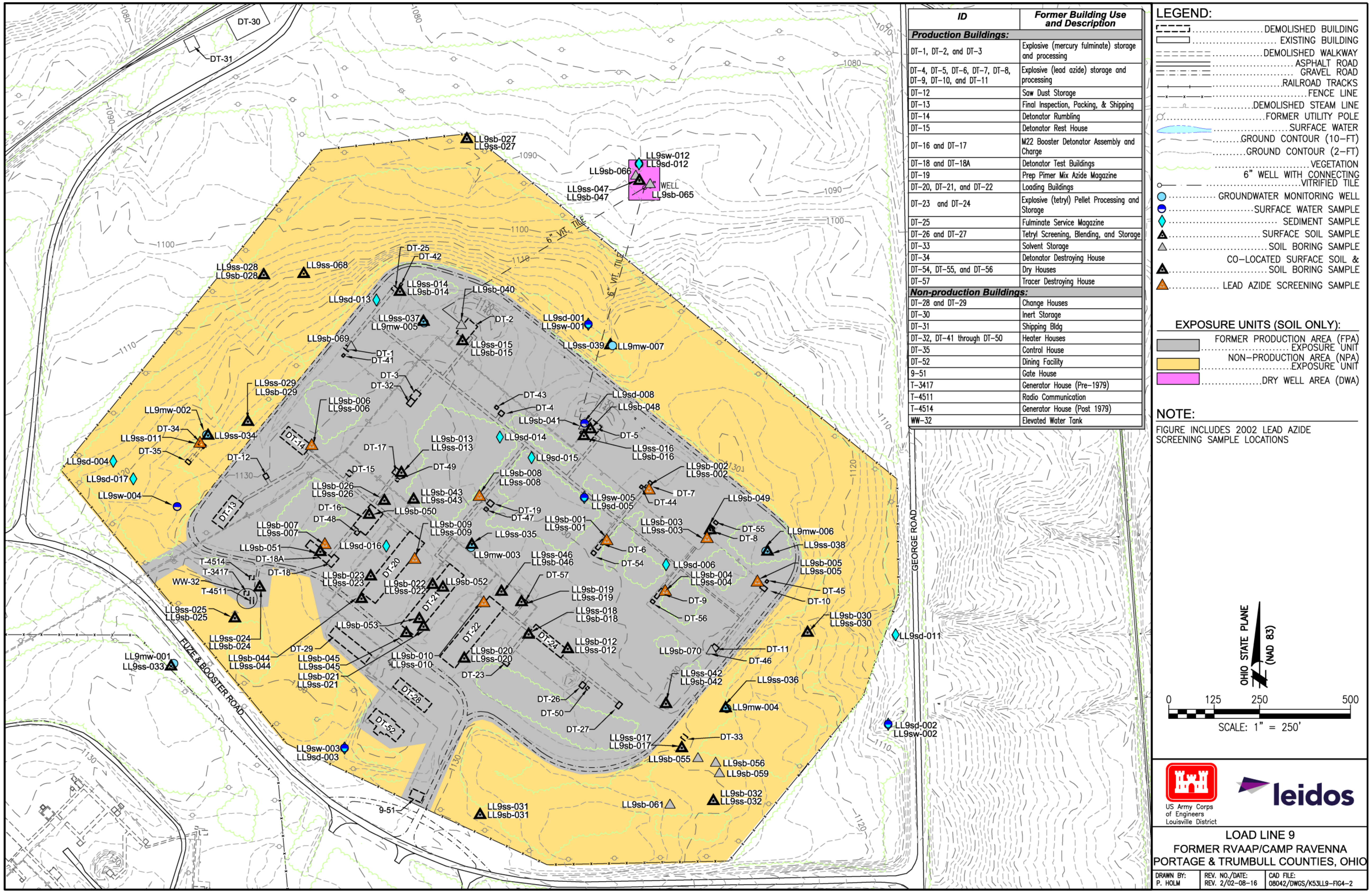


ID	Former Building Use and Description
Production Buildings:	
DT–1, DT–2, and DT–3	Explosive (mercury fulminate) storage and processing
DT–4, DT–5, DT–6, DT–7, DT–8, DT–9, DT–10, and DT–11	Explosive (lead azide) storage and processing
DT–12	Saw Dust Storage
DT–13	Final Inspection, Packing, & Shipping
DT–14	Detonator Rumbling
DT–15	Detonator Rest House
DT–16 and DT–17	M22 Booster Detonator Assembly and Charge
DT–18 and DT–18A	Detonator Test Buildings
DT–19	Prep Pimer Mix Azide Magazine
DT–20, DT–21, and DT–22	Loading Buildings
DT–23 and DT–24	Explosive (tetryl) Pellet Processing and Storage
DT–25	Fulminate Service Magazine
DT–26 and DT–27	Tetryl Screening, Blending, and Storage
DT–33	Solvent Storage
DT–34	Detonator Destroying House
DT–54, DT–55, and DT–56	Dry Houses
DT–57	Tracer Destroying House
Non-production Buildings:	
DT–28 and DT–29	Change Houses
DT–30	Inert Storage
DT–31	Shipping Bldg
DT–32, DT–41 through DT–50	Heater Houses
DT–35	Control House
DT–52	Dining Facility
9–51	Gate House
T–3417	Generator House (Pre–1979)
T–4511	Radio Communication
T–4514	Generator House (Post 1979)
WW–32	Elevated Water Tank

Figure 4-1. 2002 Lead Azide Screening Sample Locations



ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

Figure 4-2. Phase I RI Sample Locations at Load Line 9

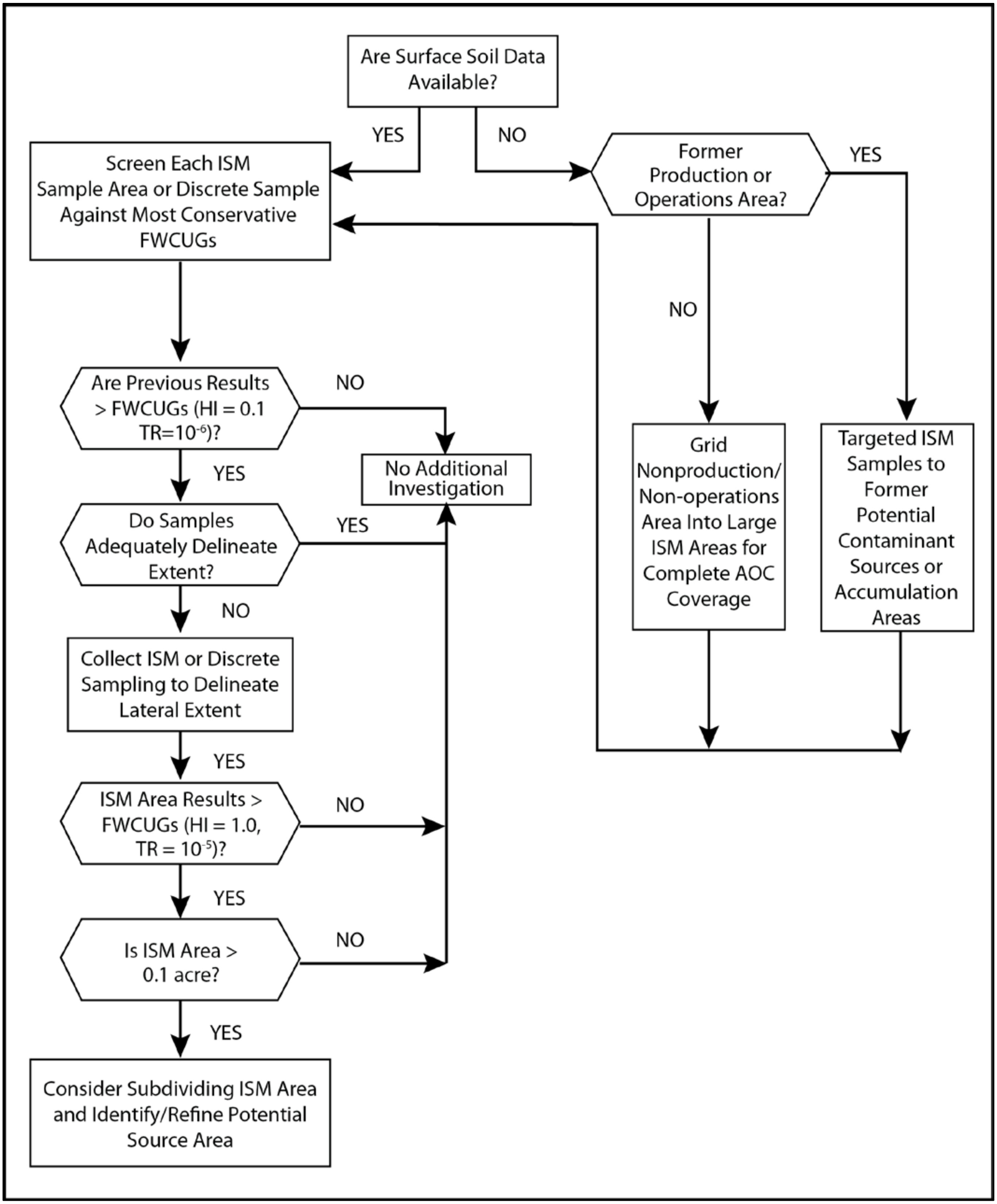


Figure 4-3. PBA08 RI Surface Soil Sampling

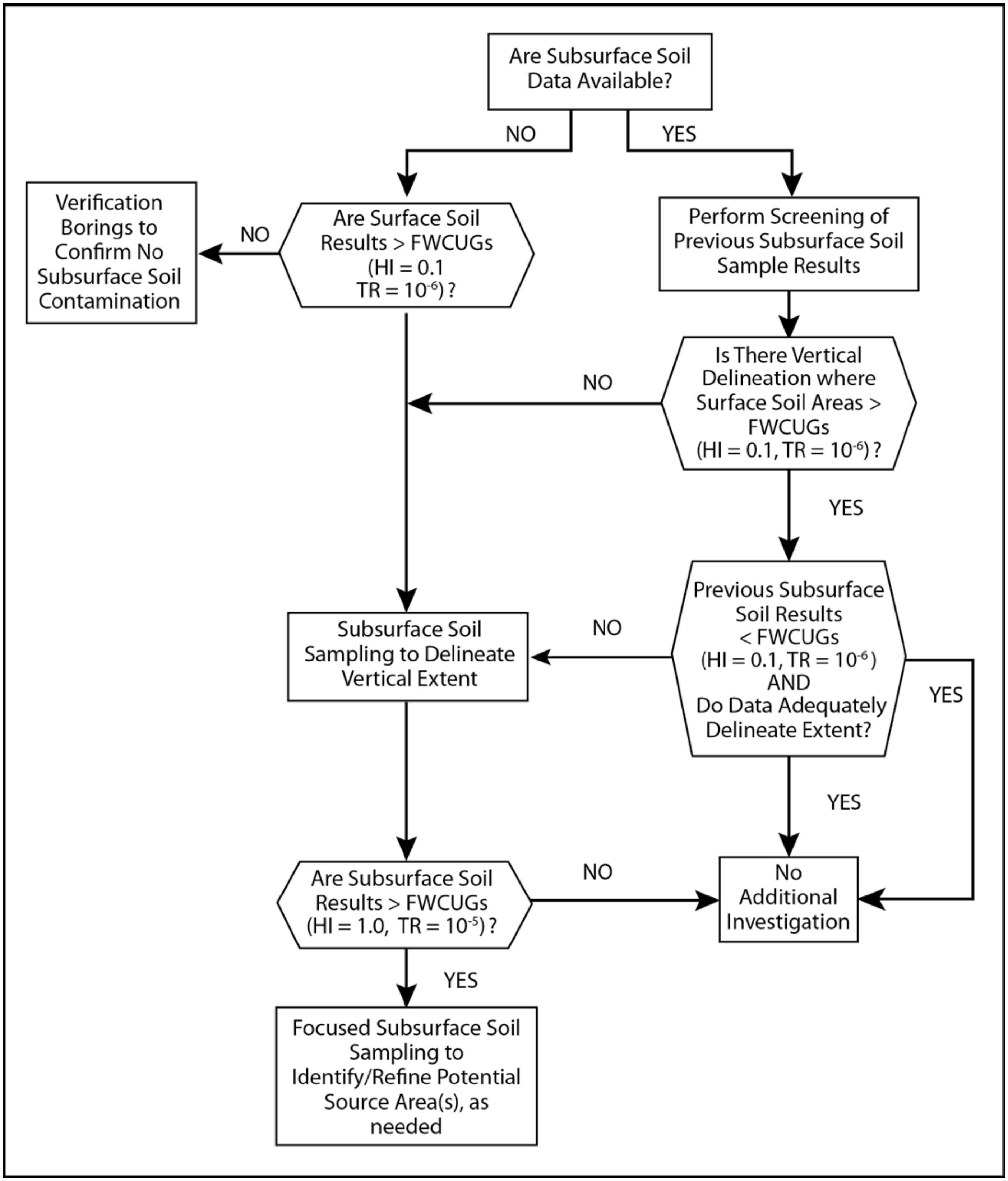
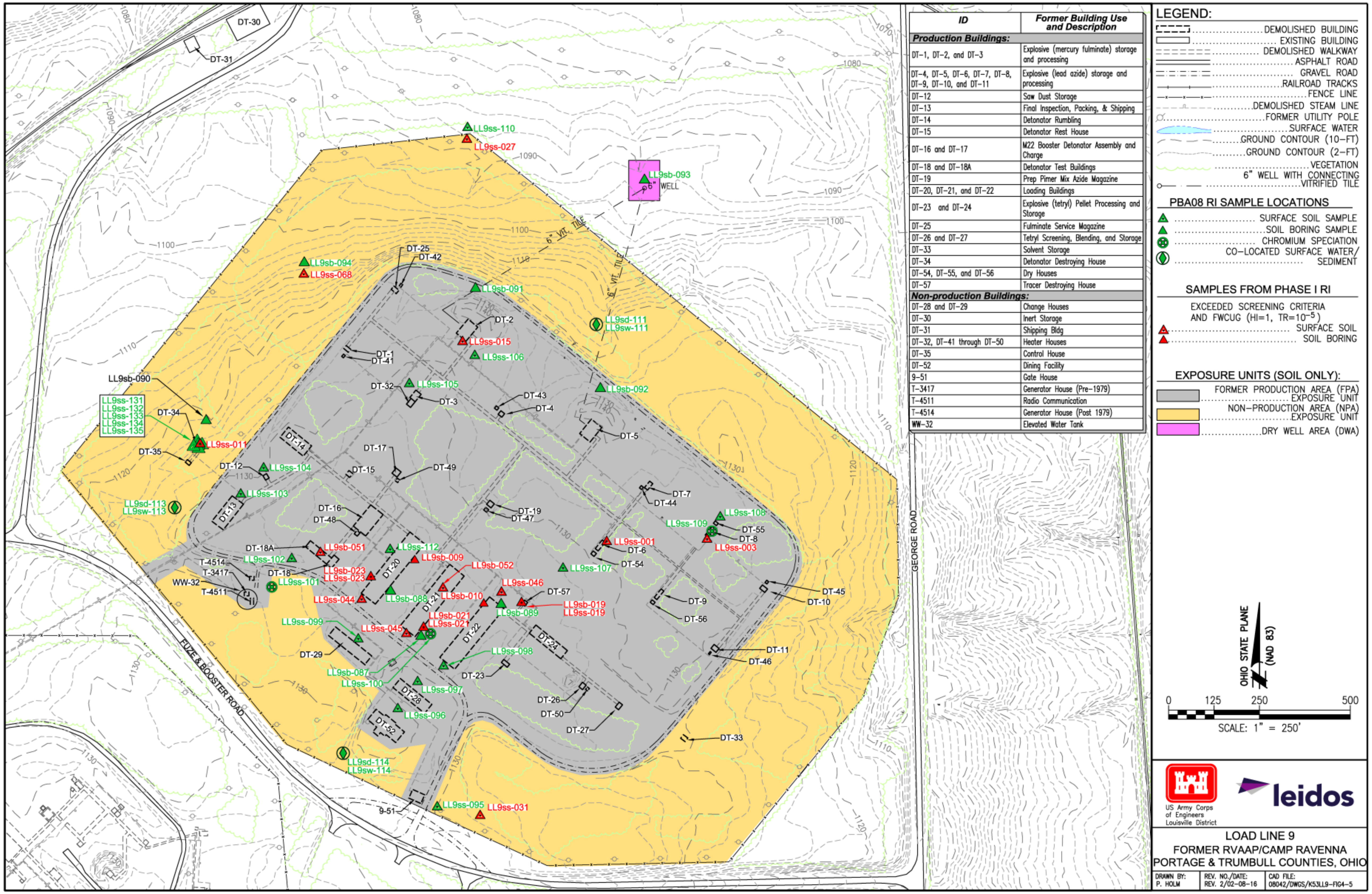


Figure 4-4. PBA08 RI Subsurface Soil Sampling



ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

Figure 4-5. PBA08 RI Sample Locations at Load Line 9

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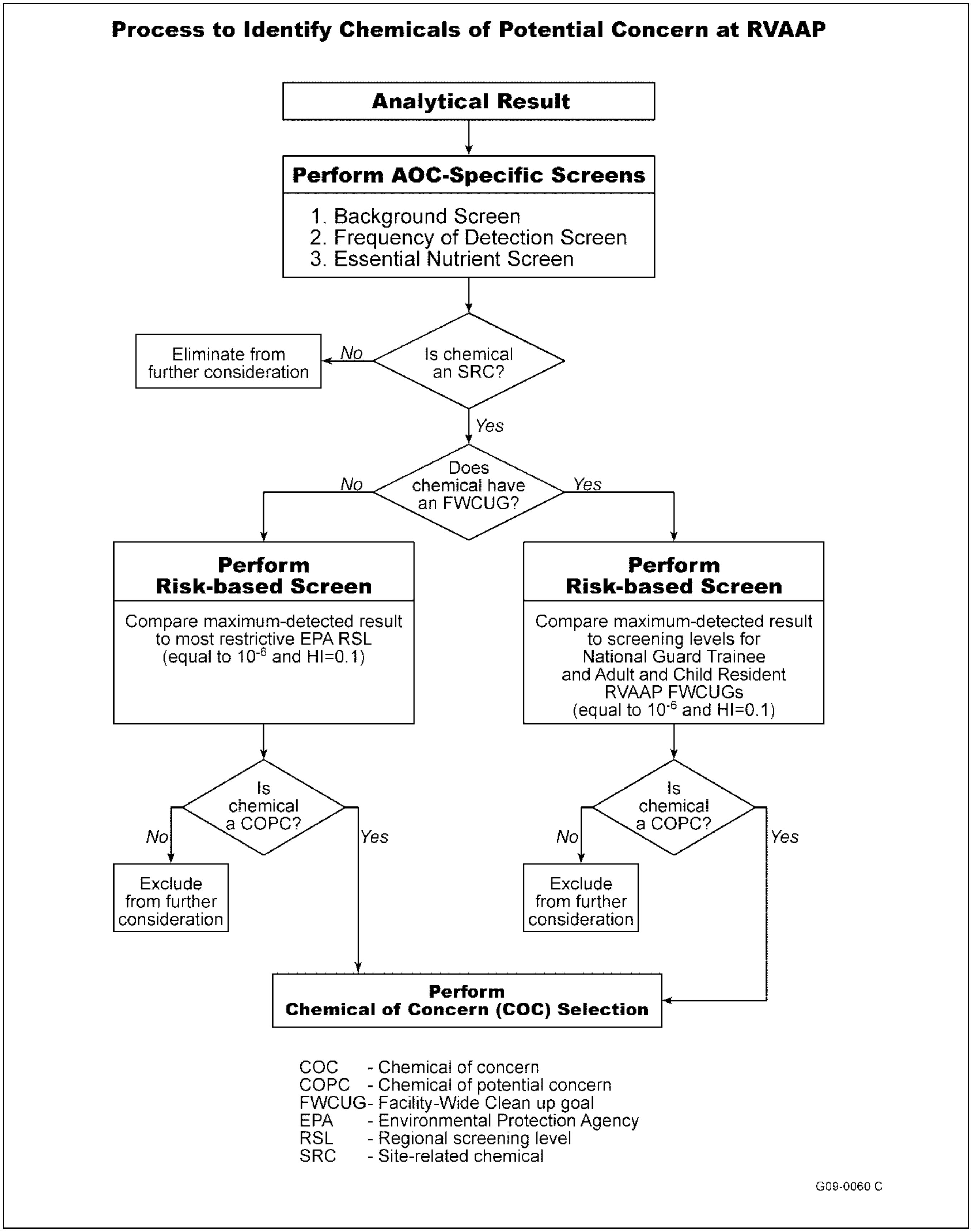

Figure 4-6. Process to Identify RVAAP COPCs in the HHRA (USACE 2010a)

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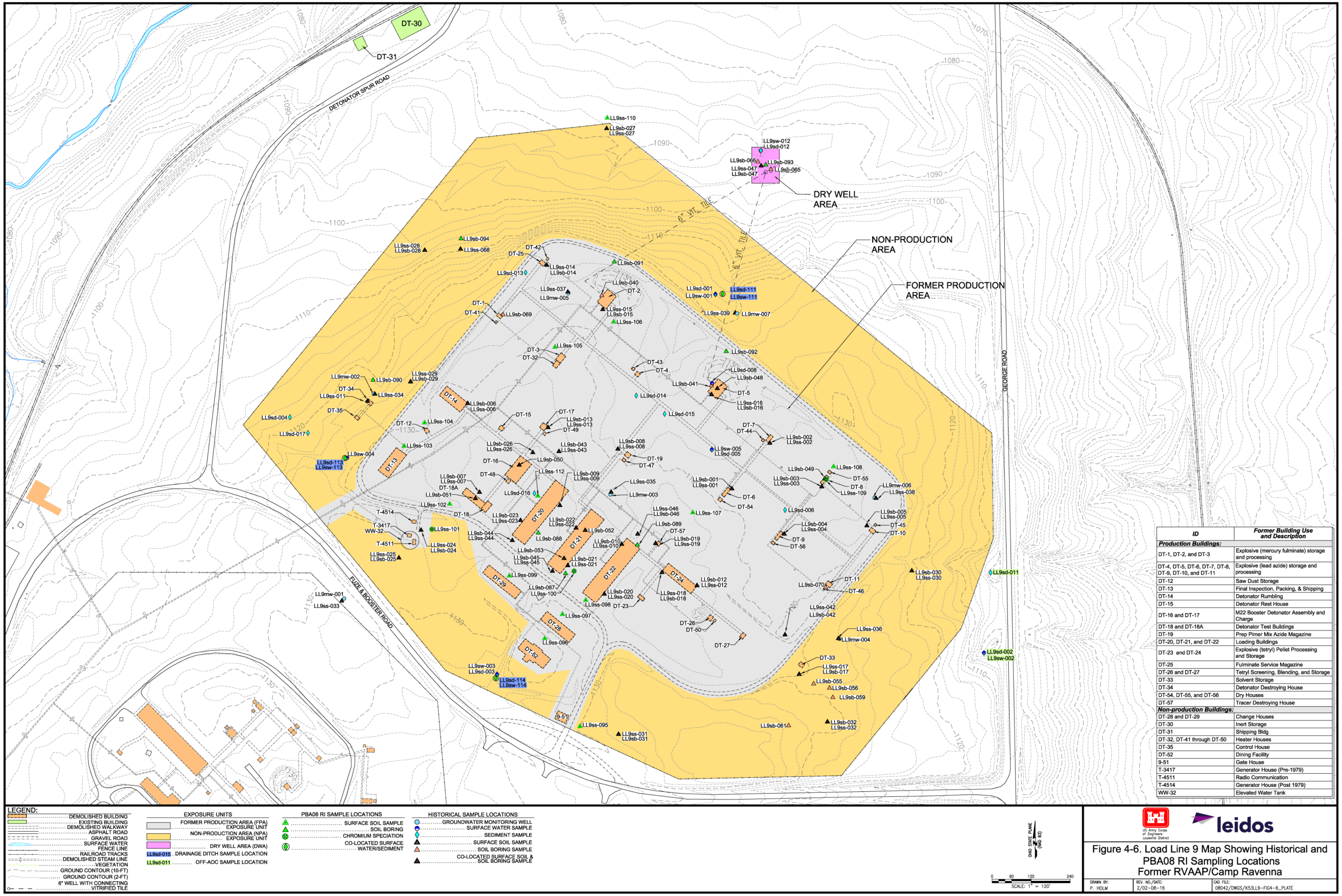

ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

Figure 4-7. All Load Line 9 RI Sample Locations

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5.0 NATURE AND EXTENT OF CONTAMINATION

This section evaluates the nature and extent of contamination at Load Line 9. This evaluation includes two types of chemicals: 1) SRCs identified as being previously used during operational activities or that potentially were associated with operations; and 2) SRCs that did not appear to have been used during historical operations previously but were analyzed during investigations.

The evaluation discusses the nature and extent of SRCs in environmental media at Load Line 9, with a focus on chemicals previously used during operational activities, using analytical data results obtained during the 2002 lead azide screening, 2003 Phase I RI, and 2010 and 2011 PBA08 RI. For purposes of this evaluation, references to the Phase I RI include samples collected in 2002 and 2003.

To support the evaluation of nature and extent of contamination, SRC concentrations were compared to SLs corresponding to the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 0.1 or TR of 1E-06, as presented in the FWCUG Report. The following figures in Section 5.0 illustrate the concentrations and distribution of SRCs that exceed SLs. For the inorganic chemicals, the figures are separated between inorganic chemicals that were potentially associated with AOC operations (arsenic, chromium, lead, and mercury) and inorganic SRCs that had exceedances of the SLs.

- Figure 5-1 – Exposure Units
- Figure 5-2 – Detected Concentrations of Explosives and Propellants in Surface Soil (Discrete Soil Borings)
- Figure 5-3 – Exceedances of FWCUG (HQ=0.1, TR=10-6) for Arsenic, Chromium, Lead, and Mercury in Soil (Discrete Soil Borings)
- Figure 5-4 – Exceedances of FWCUG (HQ=0.1, TR=10-6) for Aluminum, Cobalt, Copper, Manganese, and Thallium in Soil (Discrete Soil Borings)
- Figure 5-5 – PAH Exceedances of FWCUG (HQ=0.1, TR=10-6) in Soil (Discrete Soil Borings)
- Figure 5-6 – Detected Concentrations of VOCs, Pesticides, and PCBs in in Soil (Discrete Soil Borings)
- Figure 5-7 – Detected Concentrations of Explosives and Propellants in Surface Water and Sediment
- Figure 5-8 – Exceedances of FWCUG (HQ=0.1, TR=10-6) for Arsenic, Chromium, Cobalt, Lead, and Mercury in Surface Water and Sediment
- Figure 5-9 – PAH Exceedances of FWCUG (HQ=0.1, TR=10-6) in Surface Water and Sediment

As discussed in Section 4.0, data from all eligible samples were combined and screened to identify SRCs representing current conditions at Load Line 9. All validated Load Line 9 data from the RIs (2002 lead azide screening, 2003 Phase I RI, and 2010 and 2011 PBA08 RI) are included in Appendix D. Complete laboratory analytical data packages from the PBA08 RI are also included in Appendix D.

Contaminant nature and extent is presented below for each medium and class of analytes.

5.1 EXPOSURE UNITS DATA AGGREGATES

5.1.1 Soil Exposure Units

EUs were established at Load Line 9 as part of the data aggregation prior to the risk assessment evaluations. The EUs take into account how the areas were previously used and the extensiveness of potential contamination within a given area. In establishing EUs at Load Line 9, the area within the perimeter road is assumed to have the maximum exposure for future receptors; therefore, that area was identified as a separate EU (i.e., FPA) from the rest of the AOC (i.e., NPA). The FPA includes the area inside the perimeter road and all former buildings and operational areas. The NPA includes the area outside the production area to the fence line.

In addition to these two EUs (FPA and NPA), the DWA was evaluated as a potential hotspot. The DWA is in the vicinity of a 6-inch well that existed approximately 190 ft north of the AOC perimeter. This area was a drainage conduit from Load Line 9. The sumps were excavated during demolition operations conducted before the Phase I RI activities began.

Soil at Load Line 9 was evaluated in the three EUs as shown in Figure 5-1. The samples included in the soil EUs are located in Tables 5-1 and 5-2 for surface and subsurface, respectively.

5.1.2 Sediment and Surface Water Exposure Units

Two sediment and surface water EUs were established for Load Line 9. The Drainage Ditches EU represents sediment and surface water sample locations where surface water is encountered year-round, and the DWA EU consists of one sample collected to characterize the sediment and surface water collected within the well vault to determine whether releases from the fulminate and azide dry houses had occurred. Sediment and surface water EUs at Load Line 9 are shown in Figure 5-1. The samples included in the sediment and surface water EUs are located in Tables 5-3 and 5-4, respectively.

5.2 SURFACE SOIL DISCRETE SAMPLE RESULTS FOR CHROMIUM SPECIATION

During the 2010 PBA08 RI, surface soil samples were collected from three discrete sample locations and analyzed for hexavalent chromium and total chromium. Two sample locations were areas previously identified during the Phase I RI as having elevated total chromium concentrations (LL9ss-101 and LL9ss-109), and one sample location was an area previously identified as having a total chromium concentration near background concentrations (LL9ss-100). As discussed in Section 4.2.3.1, the chromium speciation sample collected at location LL9ss-101 was recollected in October 2010, as the original sample results had concentrations of hexavalent chromium that were higher than the total chromium results. The October 2010 speciation sample (LL9ss-101-5807-SO) was used to replace the sample collected in March 2010 for the speciation analysis.

This sampling determined the contribution of hexavalent chromium to total chromium over a range of concentrations in soil at Load Line 9 for use in the HHRA (Section 7.2). Chromium speciation results are shown in Table 5-5. One of three samples had a total chromium concentration below the facility-wide background concentration of 17.4 mg/kg, and two samples (LL9ss-101 and LL9ss-100) had total chromium concentrations (18 mg/kg and 21.4 mg/kg) slightly exceeding their facility-wide background concentrations. The range of hexavalent chromium concentrations was non-detect to 10.74J mg/kg and did not appear to be correlated to total chromium values. A detailed assessment of the speciation results respective to the HHRA is presented in Section 7.2.4.1.

5.3 CONTAMINANT NATURE AND EXTENT IN FORMER PRODUCTION AREA

Tables 4-20 and 4-23 present the results of the SRC screening for surface and subsurface soil, respectively, in the FPA at Load Line 9. The following subsections discuss the concentration and distribution of surface and subsurface soil results for the FPA.

5.3.1 Explosives and Propellants

Surface Soil

No explosives were identified as SRCs in surface soil at the Load Lind 9 FPA. One propellant, nitrocellulose, was identified as an SRC for the FPA and potentially related to previous AOC operations. The historical process buildings were evaluated for explosives and propellants during both of the investigations comprising the RI data set. Specifically, the soil samples around the buildings were analyzed during the Phase I RI and then data gaps were assessed during the 2010 and 2011 PBA08 RIs.

Figure 5-2 presents the locations that had detectable concentrations of nitrocellulose. It is not considered a COPC because all concentrations are below the SL.

Subsurface Soil

Nitrocellulose was detected at a concentration of 1.2J mg/kg in one subsurface soil sample collected in the FPA. The nitrocellulose detection occurred in the 1-3 ft bgs interval of a soil boring (LL9sb-005), at the southeast portion of the FPA near former Building DT-45. One sample location, LL9sb-089, collected near former Building DT-22 from 1-4 ft bgs, had a detected concentration of tetryl at 0.011J mg/kg. Tetryl was not detected in the three other samples (0-1, 4-7, or 7-13 ft bgs) collected at this boring location.

Figure 5-2 presents the locations that had detectable concentrations of nitrocellulose and tetryl. Nitrocellulose and tetryl are not considered subsurface soil COPCs because their concentrations are below the SLs.

5.3.2 Inorganic Chemicals

Surface Soil

Arsenic, chromium, lead, and mercury were identified as potential inorganic SRCs and potentially related to previous site use. All four of these inorganic chemicals had a maximum detection in exceedance of the background concentration at the FPA, as summarized in the list below.

- Arsenic was detected above its background concentration (15.4 mg/kg) in 10 samples with an MDC of 24 mg/kg observed at sample location LL9ss-015, which is adjacent to former Building DT-2.
- Total chromium was detected above its background concentration (17.4 mg/kg) in seven samples with an MDC of 110 mg/kg observed at sample location LL9ss-024, which is in the western corner of the FPA.
- Lead was detected above its background concentration (26.1 mg/kg) in 23 samples. Samples LL9ss-024 and LL9ss-025 were collected during the Phase I RI near the water tank in the western corner of the FPA. The concentration of surface soil at LL9ss-024 was 320 mg/kg (below the residential RSL of 400 mg/kg), and the concentration of surface soil at LL9ss-025 was 25 mg/kg.
- Mercury was detected above its background concentration (0.036 mg/kg) in 30 samples with an MDC of 1.3 mg/kg observed at sample location LL9ss-006, which is adjacent to former Building DT-14.

Figure 5-3 presents the locations with concentrations that exceeded SLs and background for these four chemicals. Chromium, lead, and mercury had no detections above the SL of Resident Receptor FWCUG at a TR of 1E-06, HQ of 0.1 (using FWCUG for trivalent chromium and residential RSL of 400 mg/kg for lead), and were therefore not considered COPCs. While arsenic was detected above the SL and background, the maximum concentration of arsenic (24 mg/kg) was only slightly higher than the established background concentration (15.4 mg/kg).

Although not identified as previously used during historical operations, 13 other inorganic chemicals were identified as SRCs from the RVAAP screening process, as presented in Table 4-20. Of these 13 chemicals, 3 (aluminum, cobalt, and manganese) exceeded their respective SLs of Resident Receptor FWCUG at a TR of 1E-06, HQ of 0.1 and background concentrations at the FPA, as presented in Figure 5-4. No apparent spatial trend in the distribution of inorganic chemicals throughout the AOC is evident, with the exception of manganese in the southern portion of the AOC near the entrance. Observations regarding other individual inorganic SRCs in Load Line 9 surface soil are presented below:

- Aluminum was detected above its background concentration of 17,700 mg/kg in 2 of 48 samples with an MDC of 20,000 mg/kg at location LL9sb-023, which is adjacent to former Building DT-20.
- Cobalt was detected above its background concentration of 10.4 mg/kg in 7 of 48 samples with an MDC of 17 mg/kg at location LL9sb-037, which is in the northern corner of the FPA.

- Manganese was detected above its background concentration of 1,450 mg/kg in 2 of 48 samples with an MDC of 3,240 mg/kg at location LL9sb-097, which is in the southern portion of the FPA near the entrance which exceeded the Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1 (2927 mg/kg). Additionally, sample locations (e.g., LL9ss-096) that exceeded the National Guard Trainee FWCUG at a TR of 1E-05, HQ of 1 (351 mg/kg) are also displayed on Figure 5-4.

Subsurface Soil

Arsenic, chromium, lead, and mercury were identified as potential inorganic contaminants from previous site use. All four of these inorganic chemicals had maximum detections in exceedance of their respective background concentrations. However, only arsenic was detected above the Resident Receptor FWCUG at a TR of 1E-06, HQ of 0.1 (using FWCUG for trivalent chromium and residential RSL of 400 mg/kg for lead) and background concentrations at the FPA as presented in Figure 5-3.

Arsenic was detected above its background concentration (19.8 mg/kg) in 6 of 43 subsurface samples with an MDC of 32 mg/kg observed at 1-3 ft bgs at sample location LL9ss-019, which is adjacent to former Building DT-57. This boring did not have a deeper sample, but an adjacent soil boring LL9sb-046 had a deeper sample that showed results below the background concentration for arsenic.

Although not identified as previously used during historical operations, seven other inorganic chemicals were identified as SRCs from the RVAAP screening process, as presented in Table 4-23. Of these seven chemicals, only thallium exceeded the SL of Resident Receptor FWCUG at a TR of 1E-06, HQ of 0.1 and background concentrations at the FPA as presented in Figure 5-4. Thallium was not detected in surface soil above SLs. Additionally, manganese detected above SLs in surface soil was not detected above SLs in subsurface soil, limiting the contamination of manganese to only surface soil.

No apparent spatial trend in the distribution of inorganic chemicals throughout the subsurface soil within the FPA is evident, with the exception of arsenic in the surface and subsurface soil in the southcentral portion of the FPA around the former loading buildings.

5.3.3 Semi-Volatile Organic Compounds

Surface and Subsurface Soil

SVOCs do not have background concentrations for comparison with chemical results; consequently, a large number of SVOCs were identified as SRCs. Of the 19 SVOC SRCs identified, concentrations of 6 PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] exceeded their respective SLs and were identified as COPCs in the FPA.

Surface soil samples collected from LL9ss-096 and LL9ss-097 had PAH concentrations greater than their respective Resident Receptor FWCUG at a TR of 1E-05, HQ of 1. Both soil borings were located near the former dining facility (DT-52) and former change house (DT-28) buildings. Although these buildings were not production buildings, they were most likely heated and had heavy vehicle traffic during operations. Subsurface samples were not collected at these locations. However, subsurface soil was characterized at the neighboring change house (DT-29) and did not contain PAH detections in deeper sample intervals (1-4 and 4-6 ft bgs).

5.3.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

There were no pesticide or PCB SRCs in surface or subsurface soil as presented in Tables 4-20 and 4-23, respectively. Only one VOC (toluene) was identified as an SRC in surface soil at the FPA. Toluene was detected at two locations (LL9ss-098 and LL9ss-104) at low, estimated concentrations below laboratory detection limits. No sources for VOCs were identified in the FPA. These detections were sporadic and isolated in distribution and extent and do not exhibit an apparent trend.

5.4 CONTAMINANT NATURE AND EXTENT IN NON-PRODUCTION AREA

Tables 4-21 and 4-24 present the results of the SRC screening for surface and subsurface soil, respectively, in the NPA at Load Line 9. The following subsections discuss the concentration and distribution of surface and subsurface soil results for the NPA.

5.4.1 Explosives and Propellants

Surface Soil

Two propellants (nitrocellulose and nitroguanidine) were identified as surface soil SRCs for the NPA and as potentially related to previous AOC operations. Figure 5-2 presents the locations that had detectable concentrations of nitroguanidine and nitrocellulose. The detected concentrations were below their respective SLs, so they are not considered COPCs.

Subsurface Soil

Nitrocellulose was the only explosive or propellant identified as an SRC in subsurface soil samples at the NPA. It was detected at soil boring LL9sb-032 from the 1-3 ft bgs interval. Figure 5-2 presents the location that had a detectable concentration of nitrocellulose. It is not considered COPC because the concentration is below the SL.

5.4.2 Inorganic Chemicals

Surface Soil

Arsenic, chromium, lead, and mercury were identified as potential inorganic SRCs and as potentially related to previous site use at Load Line 9. Chromium was not identified as an SRC for NPA.

However, the other three inorganic chemicals had maximum detections in exceedance of the background concentration at the NPA, as summarized in the list below.

- Arsenic was detected above its background concentration (15.4 mg/kg) in one sample with an MDC of 16.9 mg/kg observed at sample location LL9sb-011, which is adjacent to former Building DT-34.
- Mercury was detected above its background concentration (0.036 mg/kg) in 15 samples with an MDC of 882 mg/kg observed at sample location LL9ss-011, which is adjacent to Former Building DT-34. In addition, six samples were collected in April 2011 for the sole purpose of refining the mercury contamination in surface soil (0-1 ft bgs) at LL9ss-011. Of the six additional samples, the three samples near LL9ss-011 had concentrations of mercury greater than the Resident Receptor FWCUG (HQ=1, TR=10-5) of 22.7 mg/kg. The three remaining samples were below this concentration, thus delineating a potential area of contamination.
- Lead was detected above its background concentration (26.1 mg/kg) in five samples, with an MDC of 1,330 mg/kg observed at sample location LL9ss-011, which is adjacent to former Building DT-34. This is in the same location that contains the elevated levels of mercury noted above.

Figure 5-3 presents the locations with concentrations that exceeded SLs and background for these three chemicals. While arsenic was detected above the SL and background, the maximum concentration of arsenic (16.9 mg/kg) was only slightly higher than the established background concentration (15.4 mg/kg). Since there is no FWCUG for lead, the residential RSL of 400 mg/kg was used for the lead SL.

Although not identified as previously used during historical operations, 11 other inorganic chemicals were identified as SRCs from the RVAAP screening process, as presented in Table 4-21. Of these 11 chemicals, 3 (cobalt, copper, and manganese) had exceedances of their respective SLs of the National Guard Trainee or Resident Receptor FWCUGs at TR of 1E-06, HQ of 0.1 and background concentrations at the NPA as presented in Figure 5-4. No apparent spatial trend in the distribution of inorganic chemicals throughout the AOC is evident with the exception of manganese in the southern portions of the AOC near the entrance. Observations regarding other individual inorganic SRCs in Load Line 9 surface soil are presented below:

- Cobalt was detected above its background concentration (10.4 mg/kg) in 4 samples with an MDC of 18 mg/kg at location LL9sb-027, which is in the northern corner of the NPA.
- Copper was detected above its background concentration (17.7 mg/kg) in one sample, with an MDC of 1,240 mg/kg observed at sample location LL9sb-011, which is adjacent to former Building DT-34 and co-located with the location identified with high concentrations of mercury. The MDC of 1,240 mg/kg is less than the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1 (3,106 mg/kg)
- Manganese was detected above its background concentration (1,450 mg/kg) in two samples with an MDC of 3,800 mg/kg at location LL9sb-027, which is in the northern corner of the NPA, which exceeded the Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1 (2,927 mg/kg). Additionally, sample locations (e.g., LL9sb-031) that exceeded the

National Guard Trainee FWCUG at a TR of 1E-05, HQ of 1 (351 mg/kg) are also displayed on Figure 5-4.

Subsurface Soil

Arsenic, chromium, lead, and mercury were identified as potential inorganic contaminants from previous site use. Only mercury had a maximum detection exceeding its background concentrations. Mercury was detected above its background concentration (0.044 mg/kg) with an MDC of 0.76 mg/kg at location LL9sb-090, which is in the vicinity of former Building DT-34. However, it was below the Resident Receptor FWCUG at a TR of 1E-06, HQ of 0.1 and/or background concentrations at the NPA as presented in Figure 5-3. Additionally, mercury was detected above the SLs in the surface soil, but was not detected above the SLs in subsurface soil, limiting the contamination of mercury to only surface soil (0-1 ft bgs).

As shown in Table 4-24, the only other SRC for NPA subsurface soil is cadmium. Cadmium was detected above its background concentration (0 mg/kg) with an MDC of 0.065J mg/kg at location LL9sb-090 in the vicinity of former Building DT-34. However, this concentration was below the Resident Receptor FWCUG at a TR of 1E-06, HQ of 0.1.

5.4.3 Semi-Volatile Organic Compounds

Surface and Subsurface Soil

SVOCs do not have background concentrations for comparison with chemical results; consequently, a large number of SVOCs were identified as SRCs as presented in Table 4-21. Of the 19 SVOC SRCs identified, concentrations of 4 PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] exceeded their respective SLs and were identified as COPCs in the NPA.

Only one location (LL9ss-068) in the northern portion of the NPA along the fence line had a benzo(a)pyrene concentration (0.24 mg/kg) greater than the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1 as presented in Figure 5-5. All other samples collected in the NPA had PAH concentrations below their respective Resident Receptor FWCUGs at TR of 1E-05, HQ of 1.

5.4.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

There were no VOC, pesticide, or PCB SRCs in surface or subsurface soil, as presented in Tables 4-21 and 4-24, respectively. There are no suspected sources in the NPA for pesticide or PCB contamination. The only potential source for VOCs in the NPA is former solvent storage building (DT-33). Soil borings LL9sb-055 and LL9sb-056 were collected to evaluate VOCs in the vicinity of former DT-33, and no VOCs were detected.

5.5 CONTAMINANT NATURE AND EXTENT IN DRY WELL AREA

Tables 4-22 and 4-25 present the results of the SRC screening for surface and subsurface soil, respectively, in the DWA at Load Line 9. The following subsections discuss the concentration and distribution of surface and subsurface soil results for the DWA.

5.5.1 Explosives and Propellants

Surface and Subsurface Soil

No explosives or propellants were identified as SRCs in DWA surface or subsurface soil.

5.5.2 Inorganic Chemicals

Surface Soil

Only two inorganic chemicals (mercury and thallium) were identified as SRCs in DWA surface soil. Figures 5-3 and 5-4 present the locations with concentrations that exceeded SLs and background for these two chemicals. Thallium had no detections above the SL of the Resident Receptor FWCUG at a TR of 1E-06, HQ of 0.1, and was therefore not considered a COPC. Mercury was detected in both sample locations (LL9-sb-093 and LL9ss-047), with location LL9sb-093 having an MDC of 2.5 mg/kg. Mercury's background concentration is 0.036 mg/kg. All concentrations of mercury in the DWA surface soil are below the Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1, and were therefore not considered COCs.

Subsurface Soil

As shown in Table 4-22, only three inorganic chemicals (cadmium, lead, and mercury) were identified as SRCs at the DWA. Mercury was the only DWA subsurface soil SRC also identified as SRC for surface soil. Mercury and lead were detected in all five subsurface soil samples collected. However, lead was detected above its background concentration of 19.1 mg/kg at only one historical sample location (51 mg/kg at LL9sb-065). Mercury was detected above its background concentration of 0.044 mg/kg in three of the five subsurface samples, with the maximum concentration (9.7 mg/kg) also detected at historical sample location LL9sb-065. Cadmium was detected above the background SL of 0 mg/kg at one PBA08 RI sample location (0.083J mg/kg at LL9sb-093).

5.5.3 Semi-Volatile Organic Compounds

The DWA was not evaluated for PAHs in surface and subsurface soils as indicated in Tables 4-22 and 4-25, respectively. There are no suspected sources at the DWA for SVOC contamination.

5.5.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

There were no VOC, pesticide, or PCB surface or subsurface SRCs as presented in in Tables 4-22 and 4-25, respectively.

5.6 CONTAMINANT NATURE AND EXTENT IN SEDIMENT AND SURFACE WATER

Similar to the soil contaminant nature and extent evaluation, sediment and surface water were evaluated by two EUs (Drainage Ditches and DWA). The Off-AOC area east of the fence was also evaluated. For the Drainage Ditches, three co-located sediment and surface water samples were analyzed for RVAAP full-suite analytes. For the Off-AOC area, one sediment sample (LL9sd/sw-002) was analyzed for TAL metals and one surface water sample was analyzed for TAL metals and explosives. At a second Off-AOC location (LL9sd-011), one sediment sample was analyzed for TAL metals. Tables 4-26 and 4-28 present the sediment and surface water SRC screening results, respectively, for the Drainage Ditches.

One co-located sediment and surface water sample (LL9sd/sw-012) was used for the DWA SRC screening. The sediment sample was analyzed for TAL metals, and the surface water sample was analyzed for RVAAP full-suite analytes. Tables 4-27 and 4-29 present the sediment and surface water SRC screening results, respectively, for the DWA.

5.6.1 Explosives and Propellants

Drainage Ditches

As shown in Figure 5-7, two explosives were identified as SRCs in sediment samples at the Drainage Ditches. Nitroguanidine was detected at a concentration of 1.2 mg/kg in sample LL9sd-113, collected from the storm water drainage discharge point exiting the southwest side of Load Line 9. Pentaerythritol tetranitrate (PETN) was detected at a low, estimated concentration of 0.13J mg/kg in sample LL9sd-114, collected from the storm water drainage discharge point exiting the south side of Load Line 9. Both detections were below the Resident Receptor (Adult and Child) FWCUG at a TR of 1E-06, HQ of 0.1, and were therefore not considered COPCs. No SRCs were identified for surface water in the Drainage Ditches.

No explosives or propellants were detected in the Off-AOC surface water sample.

Dry Well Area

DWA sediment samples were not analyzed for explosives or propellants. One explosive (nitrocellulose) was detected at 0.12J mg/L in the DWA. This concentration was below the SL.

5.6.2 Inorganic Chemicals

Drainage Ditches

As shown in Table 4-26, eight inorganic chemicals were identified as SRCs in the Drainage Ditches sediment samples. As shown on Figure 5-8, only cobalt was detected above its screening criteria. Cobalt was detected above its background and screening criteria in the sediment sample collected off-AOC at LL9sd-011.

Nine inorganic chemicals were identified as SRCs in surface water at the Drainage Ditches as presented in Table 4-28. No background concentrations are established for surface water for eight of these inorganic chemicals. However, cobalt was detected above background and the SLs at LL9sw-113 as presented in Figure 5-7.

Three inorganic chemicals (lead, mercury, and nickel) were identified as SRCs in surface water at the same location at the DWA as presented in Table 4-29. All samples were below their respective SLs and are not considered COPCs.

5.6.3 Semi-Volatile Organic Compounds

Drainage Ditches

As shown in Table 4-26, 13 SVOCs (11 of which were PAHs) were identified as SRCs in sediment samples at the Drainage Ditches at Load Line 9. As shown on Figure 5-9, only benzo(a)pyrene was detected above the Resident Receptor (Adult and Child) FWCUG at a TR of 1E-06, HQ of 0.1 at two sediment sample locations, LL9sd-114 from the storm water drainage discharge point exiting to the south of Load Line 9, and LL9sd-113 from the storm water drainage discharge point exiting the AOC to the north. No SVOCs were detected in surface water samples.

Off-AOC sediment or surface water samples were not analyzed for SVOCs.

Dry Well Area

No SVOCs were identified as SRCs in DWA surface water samples.

5.6.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

Drainage Ditches

One VOC was identified as an SRC in sediment samples at the Drainage Ditches as presented in Table 4-26. Toluene was detected at a low, estimated concentration (0.00044J mg/kg) in sample LL9sd-113. No VOCs were detected in the surface water samples. Also, no pesticides or PCBs were detected in any of the sediment or surface water samples collected within the Load Line 9 Drainage Ditches.

Off-AOC sediment and surface water samples were not analyzed for VOCs, pesticides, or PCBs.

Dry Well Area

No VOCs, pesticides, or PCBs were identified as SRCs in DWA surface water samples.

5.7 SUMMARY OF CONTAMINANT NATURE AND EXTENT

Data from the 2002 lead azide screening, 2003 Phase I RI, and 2010 and 2011 PBA08 RIs provided effective characterization of the nature and extent of the contamination at the AOC. To support the evaluation of nature and extent of contamination, SRC concentrations were compared to SLs corresponding to the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 0.1 or TR of 1E-06, as presented in the FWCUG Report. Based on the information provided earlier in this section and the summary below, it can be concluded that the vertical and horizontal extent of contamination is defined, and no further sampling is needed to evaluate Load Line 9.

Sites where explosives were identified as potential contaminants from previous use were thoroughly evaluated, including around former process buildings and across each EU. The maximum concentrations for explosives and propellants were all below their respective SLs and were not considered COPCs. Results from the March 2002 sample screening indicated that there is no detectable safety concern related to azide contamination at Load Line 9. The March 2002 screening results also indicated that there is minimal contamination of secondary explosives at Load Line 9. No explosives were detected above reporting limits in any of the surface soil, sediment, or surface water samples.

The soil around the elevated water tank was evaluated by soil samples collected at LL9sb-024 and LL9sb-025. The concentrations for lead in surface and subsurface soil at these locations were below the residential RSL of 400 mg/kg, with a maximum concentration of 320 mg/kg at LL9ss-024 in surface soil (0-1 ft bgs).

As identified in the Phase I RI Report, concentrations of contaminants are generally low, with a notable exception being a localized spot at LL9ss–011 in surface soil (0-1 ft bgs). Mercury was detected above the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1 with an MDC of 882 mg/kg observed at sample location LL9ss-011 adjacent to a former detonator destroying house (DT-34). Additional samples analyzed for mercury in April 2011 helped delineate the lateral extent of mercury contamination at this location. In addition, lead had a concentration of 1,330 mg/kg at this location, exceeding the residential RSL of 400 mg/kg and industrial RSL of 800 mg/kg.

Soil borings LL9ss-096 and LL9ss-097 had PAH concentrations greater than their respective Resident Receptor FWCUG at a TR of 1E-05, HQ of 1. Both soil borings were located near the former dining facility (DT-52) and former change house (DT-28) buildings. Although these buildings were not production buildings, they were most likely heated and had heavy vehicle traffic during operations. Subsurface samples were not collected at these locations; however, subsurface soil was characterized at the neighboring change house (DT-29) and did not contain PAH detections in deeper sample intervals (1-4 and 4-6 ft bgs). In addition, identified PAH contamination at the former RVAAP has been predominately in the surface soil (0-1 ft bgs).

Building DT-33 was the only building at Load Line 9 whose purpose was solvent storage. The samples associated with former Building DT-33 (LL9sb-055 and LL9sb-056) had no detectable concentrations of VOCs in the surface soil. In addition, there were no detected concentrations of PCBs in the soil samples collected across the site, and none of the detected chemical concentrations in sediment or surface water were above the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1.

Table 5–1. Risk Assessment Data Set for Surface Soil (0-1 ft bgs) Discrete Samples

Station	Sample ID	Date	Depth (ft bgs)
Former Production Area			
LL9sb-087	LL9sb-087-5437-SO	3/8/2010	0 - 1
LL9sb-088	LL9sb-088-5441-SO	3/8/2010	0 - 1
LL9sb-089	LL9sb-089-5445-SO	3/8/2010	0 - 1
LL9sb-091	LL9sb-091-5453-SO	3/9/2010	0 - 1
LL9sb-092	LL9sb-092-5457-SO	3/9/2010	0 - 1
LL9ss-001	LL9ss-001-0001-SO	3/11/2002	0 - 1
LL9ss-002	LL9ss-002-0001-SO	12/4/2003	0 - 1
LL9ss-003	LL9ss-003-0001-SO	3/11/2002	0 - 1
LL9ss-004	LL9ss-004-0001-SO	12/4/2003	0 - 1
LL9ss-005	LL9ss-005-0001-SO	3/11/2002	0 - 1
LL9ss-006	LL9ss-006-0001-SO	12/11/2003	0 - 1
LL9ss-007	LL9ss-007-0001-SO	3/11/2002	0 - 1
LL9ss-008	LL9ss-008-0001-SO	12/10/2003	0 - 1
LL9ss-009	LL9ss-009-0001-SO	3/11/2002	0 - 1
LL9ss-010	LL9ss-010-0001-SO	12/8/2003	0 - 1
LL9ss-012	LL9ss-012-0001-SO	12/10/2003	0 - 1
LL9ss-013	LL9ss-013-0001-SO	12/10/2003	0 - 1
LL9ss-014	LL9ss-014-0001-SO	12/11/2003	0 - 1
LL9ss-015	LL9ss-015-0001-SO	12/11/2003	0 - 1
LL9ss-016	LL9ss-016-0001-SO	12/11/2003	0 - 1
LL9ss-018	LL9ss-018-0001-SO	12/10/2003	0 - 1
LL9ss-019	LL9ss-019-0001-SO	12/11/2003	0 - 1
LL9ss-020	LL9ss-020-0001-SO	12/8/2003	0 - 1
LL9ss-021	LL9ss-021-0001-SO	12/8/2003	0 - 1
LL9ss-022	LL9ss-022-0001-SO	12/10/2003	0 - 1
LL9ss-023	LL9ss-023-0001-SO	12/8/2003	0 - 1
LL9ss-024	LL9ss-024-0001-SO	12/10/2003	0 - 1
LL9ss-026	LL9ss-026-0001-SO	12/10/2003	0 - 1
LL9ss-035	LL9ss-035-0001-SO	11/11/2003	0 - 1
LL9ss-037	LL9ss-037-0001-SO	11/11/2003	0 - 1
LL9ss-038	LL9ss-038-0001-SO	11/11/2003	0 - 1
LL9ss-042	LL9ss-042-0001-SO	11/6/2003	0 - 1
LL9ss-043	LL9ss-043-0001-SO	11/6/2003	0 - 1
LL9ss-044	LL9ss-044-0001-SO	11/6/2003	0 - 1
LL9ss-045	LL9ss-045-0001-SO	11/6/2003	0 - 1
LL9ss-046	LL9ss-046-0001-SO	11/6/2003	0 - 1
LL9ss-096	LL9ss-096-5474-SO	3/1/2010	0 - 1
LL9ss-097	LL9ss-097-5475-SO	3/1/2010	0 - 1
LL9ss-098	LL9ss-098-5476-SO	3/1/2010	0 - 1

Table 5–1. Risk Assessment Data Set for Surface Soil (0-1 ft bgs) Discrete Samples (continued)

Station	Sample ID	Date	Depth (ft bgs)
LL9ss-099	LL9ss-099-5477-SO	3/2/2010	0 - 1
LL9ss-102	LL9ss-102-5480-SO	3/2/2010	0 - 1
LL9ss-103	LL9ss-103-5481-SO	3/2/2010	0 - 1
LL9ss-104	LL9ss-104-5482-SO	3/2/2010	0 - 1
LL9ss-105	LL9ss-105-5483-SO	3/2/2010	0 - 1
LL9ss-106	LL9ss-106-5484-SO	3/2/2010	0 - 1
LL9ss-107	LL9ss-107-5485-SO	3/2/2010	0 - 1
LL9ss-108	LL9ss-108-5486-SO	3/2/2010	0 - 1
LL9ss-112	LL9ss-112-5470-SO	3/9/2010	0 - 1
LL9ss-100[a]	LL9ss-100-5478-SO	3/1/2010	0 - 1
LL9ss-101[a]	LL9ss-101-5807-SO	10/18/2010	0 - 1
LL9ss-109[a]	LL9ss-109-5487-SO	3/1/2010	0 - 1
Non-Production Area			
LL9sb-090	LL9sb-090-5449-SO	3/9/2010	0 - 1
LL9sb-094	LL9sb-094-5465-SO	3/9/2010	0 - 1
LL9ss-011	LL9ss-011-0001-SO	3/11/2002	0 - 1
LL9ss-017	LL9ss-017-0001-SO	12/4/2003	0 - 1
LL9ss-025	LL9ss-025-0001-SO	12/10/2003	0 - 1
LL9ss-027	LL9ss-027-0001-SO	12/4/2003	0 - 1
LL9ss-028	LL9ss-028-0001-SO	12/4/2003	0 - 1
LL9ss-029	LL9ss-029-0001-SO	12/4/2003	0 - 1
LL9ss-030	LL9ss-030-0001-SO	12/4/2003	0 - 1
LL9ss-031	LL9ss-031-0001-SO	12/4/2003	0 - 1
LL9ss-032	LL9ss-032-0001-SO	12/4/2003	0 - 1
LL9ss-034	LL9ss-034-0001-SO	11/11/2003	0 - 1
LL9ss-036	LL9ss-036-0001-SO	11/11/2003	0 - 1
LL9ss-039	LL9ss-039-0001-SO	11/11/2003	0 - 1
LL9ss-068	LL9ss-068-0001-SO	12/12/2003	0 - 1
LL9ss-095	LL9ss-095-5473-SO	3/2/2010	0 - 1
LL9ss-110	LL9ss-110-5488-SO	3/2/2010	0 - 1
LL9ss-131	LL9ss-131-5865-SO	4/26/2011	0 - 1
LL9ss-132	LL9ss-132-5866-SO	4/26/2011	0 - 1
LL9ss-133	LL9ss-133-5867-SO	4/26/2011	0 - 1
LL9ss-134	LL9ss-134-5868-SO	4/26/2011	0 - 1
LL9ss-135	LL9ss-135-5869-SO	4/26/2011	0 - 1
Dry Well Area			
LL9sb-093	LL9sb-093-5461-SO	3/9/2010	0 - 1
LL9ss-047	LL9ss-047-0001-SO	11/6/2003	0 - 1

[a] Chromium speciation samples used to evaluate the presence of hexavalent chromium.

bgs = Below ground surface.

ft = Feet.

ID = Identification.

Table 5–2. Risk Assessment Data Set for Subsurface Soil Discrete Samples

Station	Sample ID	Date	Depth[a] (ft bgs)
Former Production Area			
	Subsurface Soil (1-13 ft bgs)		
LL9sb-001	LL9sb-001-0001-SO	12/4/2003	1 - 3
LL9sb-002	LL9sb-002-0001-SO	12/4/2003	1 - 3
LL9sb-003	LL9sb-003-0001-SO	12/4/2003	1 - 3
LL9sb-004	LL9sb-004-0001-SO	12/4/2003	1 - 3
LL9sb-005	LL9sb-005-0001-SO	12/4/2003	1 - 3
LL9sb-006	LL9sb-006-0001-SO	12/11/2003	1 - 2
LL9sb-007	LL9sb-007-0001-SO	12/8/2003	1 - 3
LL9sb-008	LL9sb-008-0001-SO	12/10/2003	1 - 3
LL9sb-009	LL9sb-009-0001-SO	12/8/2003	1 - 3
LL9sb-010	LL9sb-010-0001-SO	12/8/2003	1 - 2.5
LL9sb-012	LL9sb-012-0001-SO	12/10/2003	1 - 3
LL9sb-013	LL9sb-013-0001-SO	12/10/2003	1 - 3
LL9sb-014	LL9sb-014-0001-SO	12/11/2003	1 - 3
LL9sb-015	LL9sb-015-0001-SO	12/11/2003	1 - 3
LL9sb-016	LL9sb-016-0001-SO	12/11/2003	1 - 3
LL9sb-018	LL9sb-018-0001-SO	12/10/2003	1 - 3
LL9sb-019	LL9sb-019-0001-SO	12/11/2003	1 - 3
LL9sb-020	LL9sb-020-0001-SO	12/8/2003	1 - 3
LL9sb-021	LL9sb-021-0001-SO	12/8/2003	1 - 3
LL9sb-022	LL9sb-022-0001-SO	12/10/2003	1 - 3
LL9sb-023	LL9sb-023-0001-SO	12/8/2003	1 - 3
LL9sb-024	LL9sb-024-0001-SO	12/10/2003	1 - 3
LL9sb-026	LL9sb-026-0001-SO	12/10/2003	1 - 3
LL9sb-087	LL9sb-087-5438-SO	3/8/2010	1 - 4
LL9sb-088	LL9sb-088-5442-SO	3/8/2010	1 - 4
LL9sb-089	LL9sb-089-5446-SO	3/8/2010	1 - 4
LL9sb-091	LL9sb-091-5454-SO	3/9/2010	1 - 4
LL9sb-092	LL9sb-092-5458-SO	3/9/2010	1 - 4
LL9sb-046	LL9sb-046-0001-SO	11/6/2003	4 - 6
LL9sb-087	LL9sb-087-5439-SO	3/8/2010	4 - 7
LL9sb-088	LL9sb-088-5443-SO	3/8/2010	4 - 6
LL9sb-089	LL9sb-089-5447-SO	3/8/2010	4 - 7
LL9sb-091	LL9sb-091-5455-SO	3/9/2010	4 - 6
LL9sb-092	LL9sb-092-5459-SO	3/9/2010	4 - 6
LL9sb-040	LL9sb-040-0001-SO	10/27/2003	6 - 7
LL9sb-070	LL9sb-070-0001-SO	10/27/2003	6 - 7
LL9sb-041	LL9sb-041-0001-SO	10/27/2003	6.5 - 7.5
LL9sb-069	LL9sb-069-0001-SO	10/27/2003	6.5 - 7.5
LL9sb-089	LL9sb-089-5448-SO	3/8/2010	7 - 13
LL9sb-042	LL9sb-042-0001-SO	11/6/2003	8 - 10
LL9sb-044	LL9sb-044-0001-SO	11/6/2003	8 - 10
LL9sb-045	LL9sb-045-0001-SO	11/6/2003	8 - 10
LL9sb-043	LL9sb-043-0001-SO	11/6/2003	9 - 11
Non-Production Area			
	Subsurface Soil (1-13 ft bgs)		
LL9sb-017	LL9sb-017-0001-SO	12/4/2003	1 - 3
LL9sb-025	LL9sb-025-0001-SO	12/10/2003	1 - 3
LL9sb-027	LL9sb-027-0001-SO	12/4/2003	1 - 3
LL9sb-028	LL9sb-028-0001-SO	12/4/2003	1 - 3
LL9sb-029	LL9sb-029-0001-SO	12/4/2003	1 - 3
LL9sb-030	LL9sb-030-0001-SO	12/4/2003	1 - 3

Table 5-2. Risk Assessment Data Set for Subsurface Soil Discrete Samples (continued)

Station	Sample ID	Date	Depth[a] (ft bgs)
LL9sb-031	LL9sb-031-0001-SO	12/4/2003	1 - 3
LL9sb-032	LL9sb-032-0001-SO	12/4/2003	1 - 3
LL9sb-061	LL9sb-061-0001-SO	11/5/2003	1 - 3
LL9sb-090	LL9sb-090-5450-SO	3/9/2010	1 - 3.5
LL9sb-055	LL9sb-055-0001-SO	11/5/2003	1.5 - 3.5
LL9sb-056	LL9sb-056-0001-SO	11/5/2003	2 - 4
LL9sb-059	LL9sb-059-0001-SO	11/5/2003	3 - 5
Dry Well Area			
Subsurface Soil (4-7 ft bgs)			
LL9sb-093	LL9sb-093-5463-SO	3/9/2010	4 - 4.8
LL9sb-066	LL9sb-066-0001-SO	11/6/2003	5 - 7
Subsurface Soil (1-13 ft bgs)			
LL9sb-093	LL9sb-093-5462-SO	3/9/2010	1 - 4
LL9sb-047	LL9sb-047-0001-SO	11/6/2003	3 - 5
LL9sb-065	LL9sb-065-0001-SO	11/6/2003	3 - 5
LL9sb-093	LL9sb-093-5463-SO	3/9/2010	4 - 4.8
LL9sb-066	LL9sb-066-0001-SO	11/6/2003	5 - 7

[a] Samples were assigned to depth intervals based on starting depth. For example a sample collected from 3-5 ft bgs is included in the 0-4 ft deep surface soil interval.

[b] No samples collected in the 4-7 ft bgs interval because shallow bedrock was encountered at 1-5.5 ft bgs.

bgs = Below ground surface.
ft = Feet.
ID = Identification.

Table 5–3. Risk Assessment Data Set for Surface Water

Station	Sample ID	Date
Drainage Ditches		
LL9sw-111	LL9sw-111-5489-SW	2/18/2010
LL9sw-113	LL9sw-113-5491-SW	3/9/2010
LL9sw-114	LL9sw-114-5492-SW	3/9/2010
Dry Well Area		
LL9sw-012	LL9sw-012-0001-SW	12/9/2003

ID = Identification.

Table 5–4. Risk Assessment Data Set for Sediment

Station	Sample ID	Date	Depth (ft bgs)
Drainage Ditches			
LL9sd-111	LL9sd-111-5469-SD	2/18/2010	0 - 0.5
LL9sd-113	LL9sd-113-5471-SD	2/18/2010	0 - 0.5
LL9sd-114	LL9sd-114-5472-SD	2/18/2010	0 - 0.5
Dry Well Area			
LL9sd-012	LL9sd-012-0001-SD	12/9/2003	0 - 1

bgs = Below ground surface.
ft = Feet.
ID = Identification.

Table 5–5. Chromium Speciation Results

Sample Location	**Hexavalent Chromium Concentration (mg/kg)**	**Total Chromium Concentration[a] (mg/kg)**	**Percent Hexavalent Chromium (%)**
Former Production Area			
LL9ss-100	<1 U	18	NA
LL9ss-101	0.74J	21.4	3.5
LL9ss-109	<1U	10.2	NA

[a] Background concentration for total chromium = 17.4 mg/kg. No background concentration is available for hexavalent chromium.

J = Estimated value less than reporting limits.

mg/kg = Milligram per kilogram.

NA = Not applicable; hexavalent chromium not detected in sample.

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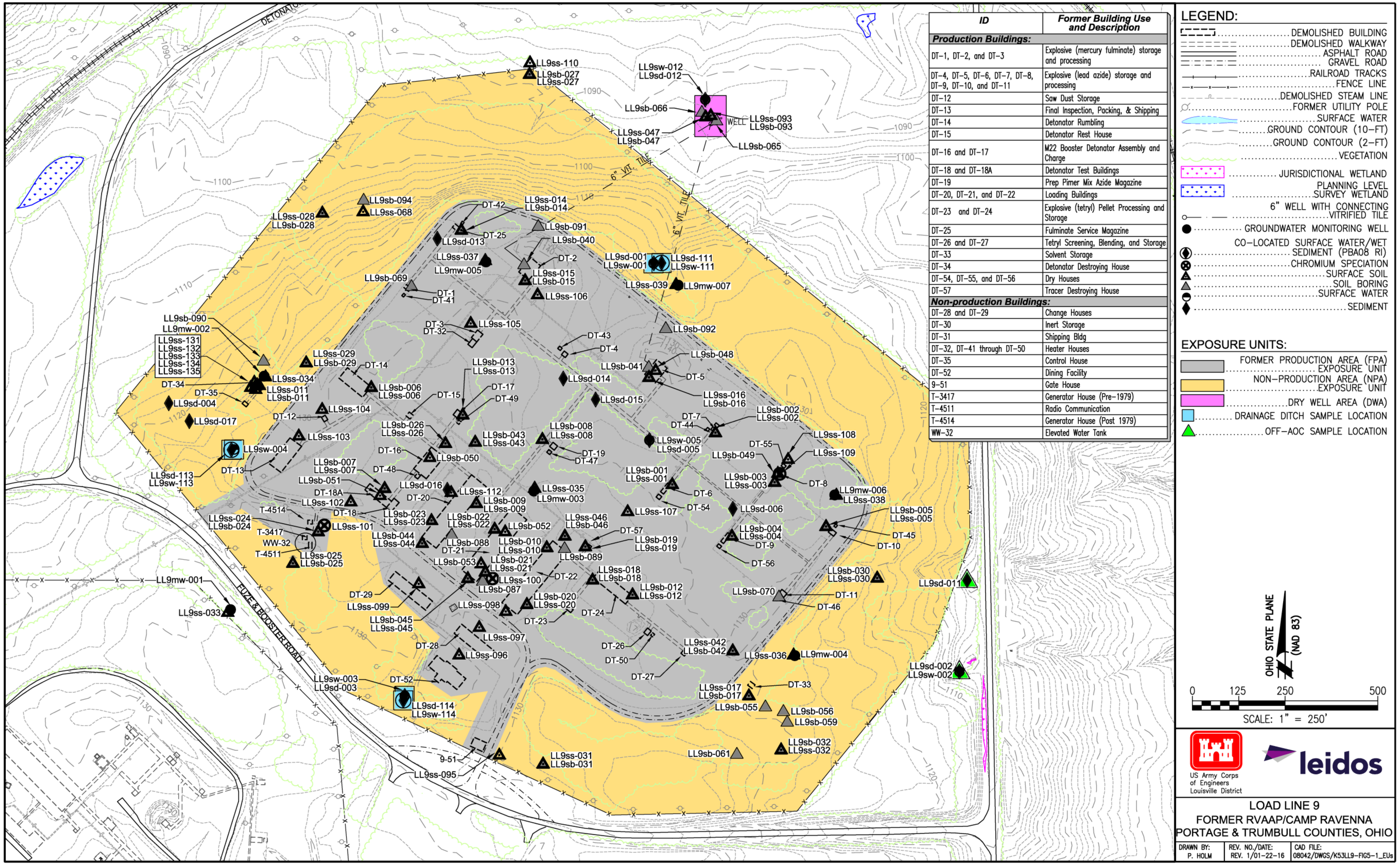
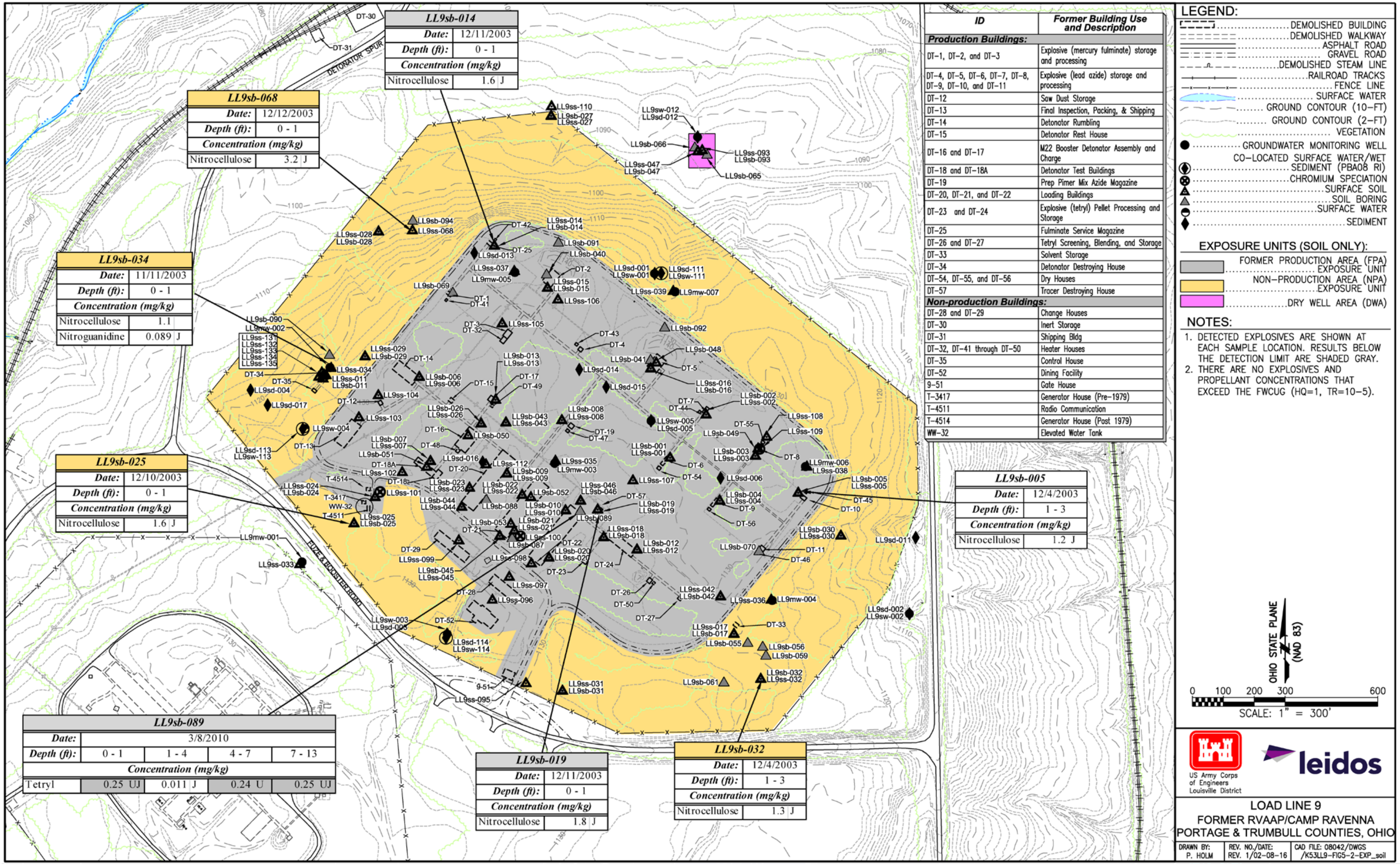


ID	Former Building Use and Description
Production Buildings:	
DT–1, DT–2, and DT–3	Explosive (mercury fulminate) storage and processing
DT–4, DT–5, DT–6, DT–7, DT–8, DT–9, DT–10, and DT–11	Explosive (lead azide) storage and processing
DT–12	Saw Dust Storage
DT–13	Final Inspection, Packing, & Shipping
DT–14	Detonator Rumbling
DT–15	Detonator Rest House
DT–16 and DT–17	M22 Booster Detonator Assembly and Charge
DT–18 and DT–18A	Detonator Test Buildings
DT–19	Prep Pimer Mix Azide Magazine
DT–20, DT–21, and DT–22	Loading Buildings
DT–23 and DT–24	Explosive (tetryl) Pellet Processing and Storage
DT–25	Fulminate Service Magazine
DT–26 and DT–27	Tetryl Screening, Blending, and Storage
DT–33	Solvent Storage
DT–34	Detonator Destroying House
DT–54, DT–55, and DT–56	Dry Houses
DT–57	Tracer Destroying House
Non-production Buildings:	
DT–28 and DT–29	Change Houses
DT–30	Inert Storage
DT–31	Shipping Bldg
DT–32, DT–41 through DT–50	Heater Houses
DT–35	Control House
DT–52	Dining Facility
9–51	Gate House
T–3417	Generator House (Pre–1979)
T–4511	Radio Communication
T–4514	Generator House (Post 1979)
WW–32	Elevated Water Tank

Figure 5-1. Exposure Units



LL9sb-014

Date:	12/11/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Nitrocellulose	1.6 J

LL9sb-068

Date:	12/12/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Nitrocellulose	3.2 J

LL9sb-034

Date:	11/11/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Nitrocellulose	1.1
Nitroguanidine	0.089 J

LL9sb-025

Date:	12/10/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Nitrocellulose	1.6 J

LL9sb-089

Date:	3/8/2010			
Depth (ft):	0 - 1	1 - 4	4 - 7	7 - 13
Concentration (mg/kg)				
Tetryl	0.25 UJ	0.011 J	0.24 U	0.25 UJ

LL9sb-019

Date:	12/11/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Nitrocellulose	1.8 J

LL9sb-032

Date:	12/4/2003
Depth (ft):	1 - 3
Concentration (mg/kg)	
Nitrocellulose	1.3 J

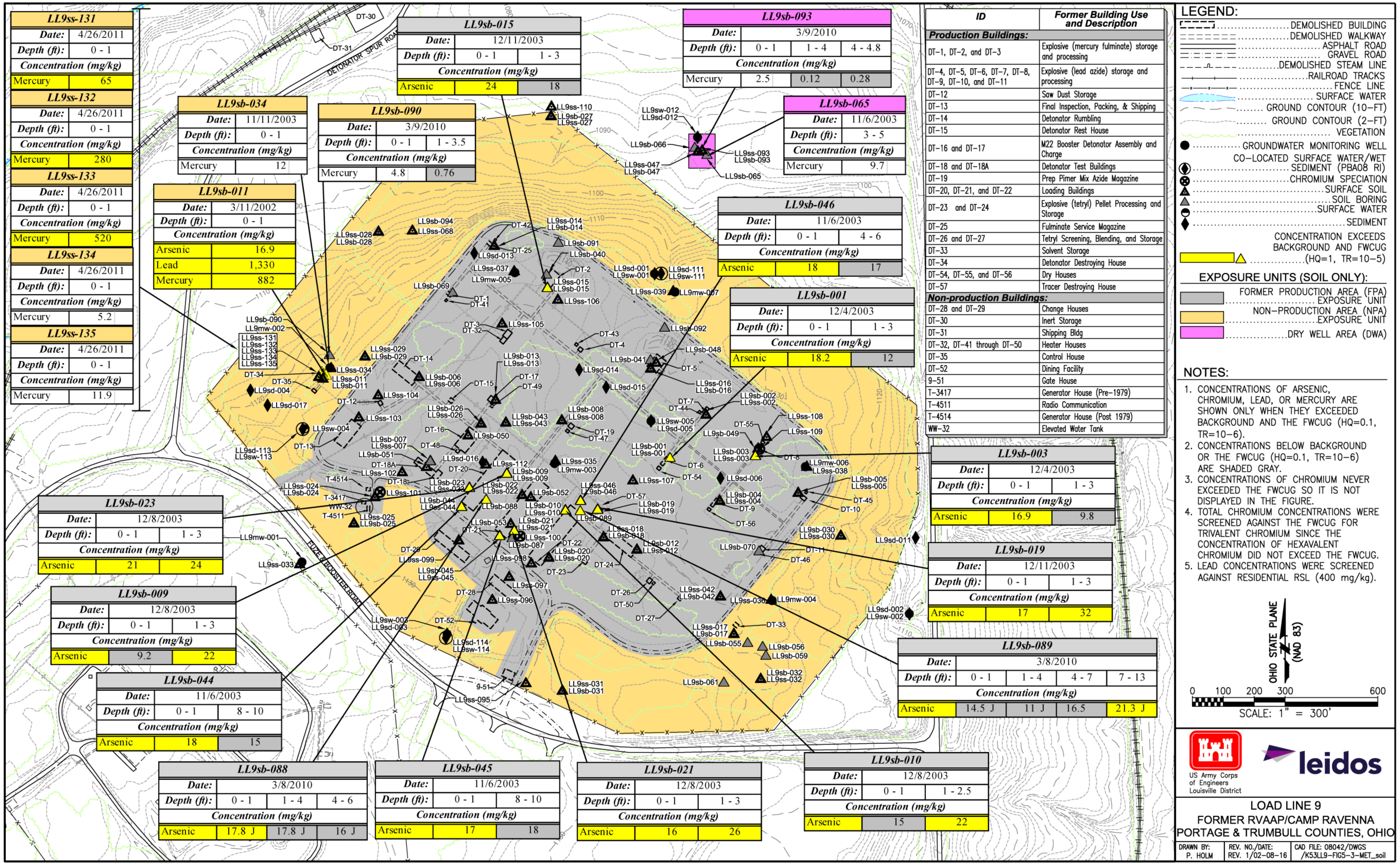
LL9sb-005

Date:	12/4/2003
Depth (ft):	1 - 3
Concentration (mg/kg)	
Nitrocellulose	1.2 J

ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

NOTES:
1. DETECTED EXPLOSIVES ARE SHOWN AT EACH SAMPLE LOCATION. RESULTS BELOW THE DETECTION LIMIT ARE SHADED GRAY.
2. THERE ARE NO EXPLOSIVES AND PROPELLANT CONCENTRATIONS THAT EXCEED THE FWCUG (HQ=1, TR=10-5).

Figure 5-2. Detected Concentrations of Explosives and Propellants in Surface Soil (Discrete Soil Borings)



LL9ss-131	
Date:	4/26/2011
Depth (ft):	0 - 1
Concentration (mg/kg)	
Mercury	65

LL9ss-132	
Date:	4/26/2011
Depth (ft):	0 - 1
Concentration (mg/kg)	
Mercury	280

LL9ss-133	
Date:	4/26/2011
Depth (ft):	0 - 1
Concentration (mg/kg)	
Mercury	520

LL9ss-134	
Date:	4/26/2011
Depth (ft):	0 - 1
Concentration (mg/kg)	
Mercury	5.2

LL9ss-135	
Date:	4/26/2011
Depth (ft):	0 - 1
Concentration (mg/kg)	
Mercury	11.9

LL9sb-034	
Date:	11/11/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Mercury	12

LL9sb-011	
Date:	3/11/2002
Depth (ft):	0 - 1
Concentration (mg/kg)	
Arsenic	16.9
Lead	1,330
Mercury	882

LL9sb-090		
Date:	3/9/2010	
Depth (ft):	0 - 1	1 - 3.5
Concentration (mg/kg)		
Mercury	4.8	0.76

LL9sb-015		
Date:	12/11/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Arsenic	24	18

LL9sb-093			
Date:	3/9/2010		
Depth (ft):	0 - 1	1 - 4	4 - 4.8
Concentration (mg/kg)			
Mercury	2.5	0.12	0.28

LL9sb-065	
Date:	11/6/2003
Depth (ft):	3 - 5
Concentration (mg/kg)	
Mercury	9.7

LL9sb-046		
Date:	11/6/2003	
Depth (ft):	0 - 1	4 - 6
Concentration (mg/kg)		
Arsenic	18	17

LL9sb-001		
Date:	12/4/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Arsenic	18.2	12

LL9sb-003		
Date:	12/4/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Arsenic	16.9	9.8

LL9sb-019		
Date:	12/11/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Arsenic	17	32

LL9sb-089				
Date:	3/8/2010			
Depth (ft):	0 - 1	1 - 4	4 - 7	7 - 13
Concentration (mg/kg)				
Arsenic	14.5 J	11 J	16.5	21.3 J

LL9sb-023		
Date:	12/8/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Arsenic	21	24

LL9sb-009		
Date:	12/8/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Arsenic	9.2	22

LL9sb-044		
Date:	11/6/2003	
Depth (ft):	0 - 1	8 - 10
Concentration (mg/kg)		
Arsenic	18	15

LL9sb-088			
Date:	3/8/2010		
Depth (ft):	0 - 1	1 - 4	4 - 6
Concentration (mg/kg)			
Arsenic	17.8 J	17.8 J	16 J

LL9sb-045		
Date:	11/6/2003	
Depth (ft):	0 - 1	8 - 10
Concentration (mg/kg)		
Arsenic	17	18

LL9sb-021		
Date:	12/8/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Arsenic	16	26

LL9sb-010		
Date:	12/8/2003	
Depth (ft):	0 - 1	1 - 2.5
Concentration (mg/kg)		
Arsenic	15	22

ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

LEGEND:

┌ ─ ─ ┐	DEMOLISHED BUILDING
= = = =	DEMOLISHED WALKWAY
═══	ASPHALT ROAD
═·═·═	GRAVEL ROAD
– – ⎍ – –	DEMOLISHED STEAM LINE
─┼─┼─	RAILROAD TRACKS
─x─x─	FENCE LINE
⬭	SURFACE WATER
— — —	GROUND CONTOUR (10-FT)
- - - -	GROUND CONTOUR (2-FT)
﹏﹏	VEGETATION
●	GROUNDWATER MONITORING WELL
◈	CO-LOCATED SURFACE WATER/WET SEDIMENT (PBA08 RI)
⊗	CHROMIUM SPECIATION
⚠	SURFACE SOIL
▲	SOIL BORING
◒	SURFACE WATER
◆	SEDIMENT
🟨 △	CONCENTRATION EXCEEDS BACKGROUND AND FWCUG (HQ=1, TR=10-5)

EXPOSURE UNITS (SOIL ONLY):

▨	FORMER PRODUCTION AREA (FPA) EXPOSURE UNIT
🟧	NON-PRODUCTION AREA (NPA) EXPOSURE UNIT
🟪	DRY WELL AREA (DWA)

NOTES:

1. CONCENTRATIONS OF ARSENIC, CHROMIUM, LEAD, OR MERCURY ARE SHOWN ONLY WHEN THEY EXCEEDED BACKGROUND AND THE FWCUG (HQ=0.1, TR=10-6).
2. CONCENTRATIONS BELOW BACKGROUND OR THE FWCUG (HQ=0.1, TR=10-6) ARE SHADED GRAY.
3. CONCENTRATIONS OF CHROMIUM NEVER EXCEEDED THE FWCUG SO IT IS NOT DISPLAYED IN THE FIGURE.
4. TOTAL CHROMIUM CONCENTRATIONS WERE SCREENED AGAINST THE FWCUG FOR TRIVALENT CHROMIUM SINCE THE CONCENTRATION OF HEXAVALENT CHROMIUM DID NOT EXCEED THE FWCUG.
5. LEAD CONCENTRATIONS WERE SCREENED AGAINST RESIDENTIAL RSL (400 mg/kg).

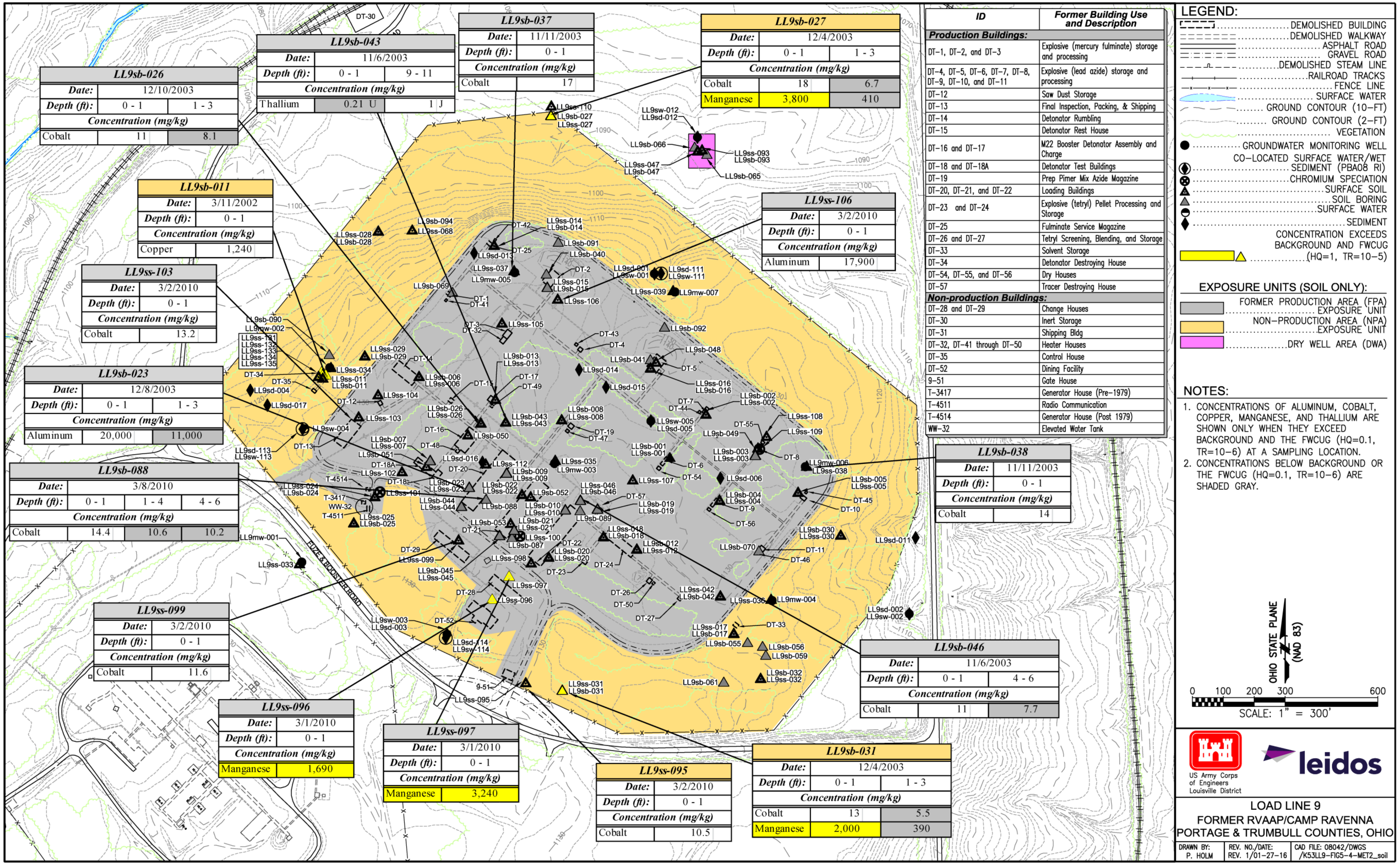
US Army Corps
of Engineers
Louisville District

leidos

LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE: 08042/DWGS
P. HOLM	REV. 1/02-08-16	/K53LL9-FIG5-3-MET_soil

Figure 5-3. Exceedances of FWCUG (HQ=0.1, TR=10-6) for Arsenic, Chromium, Lead, and Mercury in Soil (Discrete Soil Borings)



LL9sb-026		
Date:	12/10/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Cobalt	11	8.1

LL9sb-043		
Date:	11/6/2003	
Depth (ft):	0 - 1	9 - 11
Concentration (mg/kg)		
Thallium	0.21 U	1 J

LL9sb-037	
Date:	11/11/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Cobalt	17

LL9sb-027		
Date:	12/4/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Cobalt	18	6.7
Manganese	3,800	410

LL9sb-011	
Date:	3/11/2002
Depth (ft):	0 - 1
Concentration (mg/kg)	
Copper	1,240

LL9ss-106	
Date:	3/2/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Aluminum	17,900

LL9ss-103	
Date:	3/2/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Cobalt	13.2

LL9sb-023		
Date:	12/8/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Aluminum	20,000	11,000

LL9sb-038	
Date:	11/11/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Cobalt	14

LL9sb-088			
Date:	3/8/2010		
Depth (ft):	0 - 1	1 - 4	4 - 6
Concentration (mg/kg)			
Cobalt	14.4	10.6	10.2

LL9ss-099	
Date:	3/2/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Cobalt	11.6

LL9sb-046		
Date:	11/6/2003	
Depth (ft):	0 - 1	4 - 6
Concentration (mg/kg)		
Cobalt	11	7.7

LL9ss-096	
Date:	3/1/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Manganese	1,690

LL9ss-097	
Date:	3/1/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Manganese	3,240

LL9ss-095	
Date:	3/2/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Cobalt	10.5

LL9sb-031		
Date:	12/4/2003	
Depth (ft):	0 - 1	1 - 3
Concentration (mg/kg)		
Cobalt	13	5.5
Manganese	2,000	390

ID	**Former Building Use and Description**
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

LEGEND:

⌐ ‐ ‐ ‐ ¬	DEMOLISHED BUILDING
= = = =	DEMOLISHED WALKWAY
═══	ASPHALT ROAD
=·=·=	GRAVEL ROAD
‐ ‐ ⌒ ‐ ‐	DEMOLISHED STEAM LINE
─┼─┼─	RAILROAD TRACKS
─x─x─	FENCE LINE
🟦	SURFACE WATER
─ ─ ─	GROUND CONTOUR (10-FT)
- - - -	GROUND CONTOUR (2-FT)
︶︶︶	VEGETATION
●	GROUNDWATER MONITORING WELL
◈	CO-LOCATED SURFACE WATER/WET SEDIMENT (PBA08 RI)
⊗	CHROMIUM SPECIATION
△	SURFACE SOIL
▲	SOIL BORING
◒	SURFACE WATER
◆	SEDIMENT
🟨 △	CONCENTRATION EXCEEDS BACKGROUND AND FWCUG (HQ=1, TR=10-5)

EXPOSURE UNITS (SOIL ONLY):

⬜	FORMER PRODUCTION AREA (FPA) EXPOSURE UNIT
🟧	NON-PRODUCTION AREA (NPA) EXPOSURE UNIT
🟪	DRY WELL AREA (DWA)

NOTES:

1. CONCENTRATIONS OF ALUMINUM, COBALT, COPPER, MANGANESE, AND THALLIUM ARE SHOWN ONLY WHEN THEY EXCEED BACKGROUND AND THE FWCUG (HQ=0.1, TR=10-6) AT A SAMPLING LOCATION.
2. CONCENTRATIONS BELOW BACKGROUND OR THE FWCUG (HQ=0.1, TR=10-6) ARE SHADED GRAY.

US Army Corps
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Louisville District

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LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

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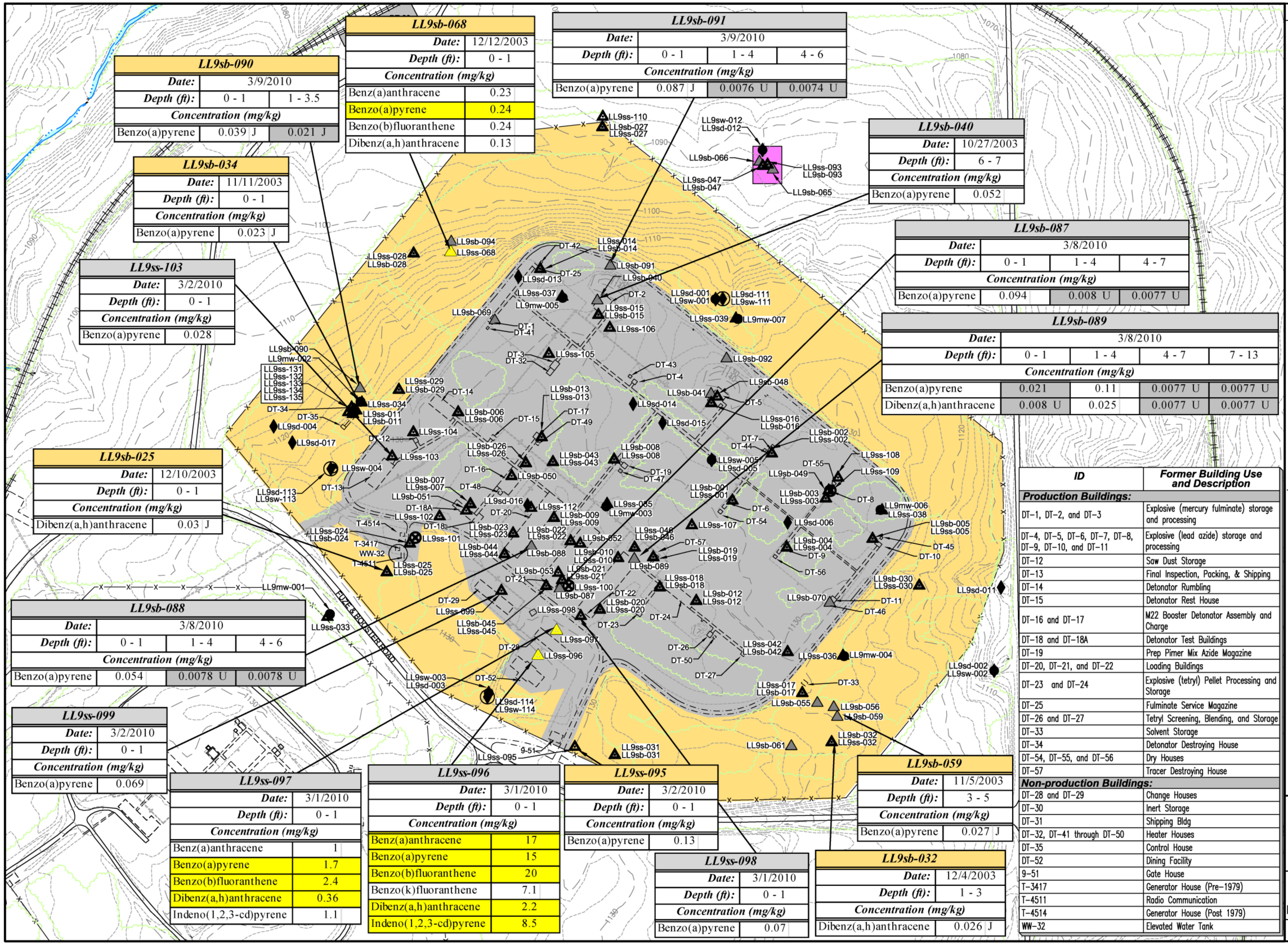
P. HOLM	REV. 1/01-27-16	/K53LL9-FIG5-4-MET2_soil

Figure 5-4. Exceedances of FWCUG (HQ=0.1, TR=10-6) for Aluminum, Cobalt, Copper, Manganese, and Thallium in Soil (Discrete Soil Borings)



LL9sb-090		
Date:	3/9/2010	
Depth (ft):	0 - 1	1 - 3.5
Concentration (mg/kg)		
Benzo(a)pyrene	0.039 J	0.021 J

LL9sb-068	
Date:	12/12/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benz(a)anthracene	0.23
Benzo(a)pyrene	0.24
Benzo(b)fluoranthene	0.24
Dibenz(a,h)anthracene	0.13

LL9sb-091			
Date:	3/9/2010		
Depth (ft):	0 - 1	1 - 4	4 - 6
Concentration (mg/kg)			
Benzo(a)pyrene	0.087 J	0.0076 U	0.0074 U

LL9sb-034	
Date:	11/11/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benzo(a)pyrene	0.023 J

LL9sb-040	
Date:	10/27/2003
Depth (ft):	6 - 7
Concentration (mg/kg)	
Benzo(a)pyrene	0.052

LL9ss-103	
Date:	3/2/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benzo(a)pyrene	0.028

LL9sb-087			
Date:	3/8/2010		
Depth (ft):	0 - 1	1 - 4	4 - 7
Concentration (mg/kg)			
Benzo(a)pyrene	0.094	0.008 U	0.0077 U

LL9sb-089				
Date:	3/8/2010			
Depth (ft):	0 - 1	1 - 4	4 - 7	7 - 13
Concentration (mg/kg)				
Benzo(a)pyrene	0.021	0.11	0.0077 U	0.0077 U
Dibenz(a,h)anthracene	0.008 U	0.025	0.0077 U	0.0077 U

LL9sb-025	
Date:	12/10/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Dibenz(a,h)anthracene	0.03 J

LL9sb-088			
Date:	3/8/2010		
Depth (ft):	0 - 1	1 - 4	4 - 6
Concentration (mg/kg)			
Benzo(a)pyrene	0.054	0.0078 U	0.0078 U

LL9ss-099	
Date:	3/2/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benzo(a)pyrene	0.069

LL9ss-097	
Date:	3/1/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benz(a)anthracene	1
Benzo(a)pyrene	1.7
Benzo(b)fluoranthene	2.4
Dibenz(a,h)anthracene	0.36
Indeno(1,2,3-cd)pyrene	1.1

LL9ss-096	
Date:	3/1/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benz(a)anthracene	17
Benzo(a)pyrene	15
Benzo(b)fluoranthene	20
Benzo(k)fluoranthene	7.1
Dibenz(a,h)anthracene	2.2
Indeno(1,2,3-cd)pyrene	8.5

LL9ss-095	
Date:	3/2/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benzo(a)pyrene	0.13

LL9ss-098	
Date:	3/1/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benzo(a)pyrene	0.07

LL9sb-059	
Date:	11/5/2003
Depth (ft):	3 - 5
Concentration (mg/kg)	
Benzo(a)pyrene	0.027 J

LL9sb-032	
Date:	12/4/2003
Depth (ft):	1 - 3
Concentration (mg/kg)	
Dibenz(a,h)anthracene	0.026 J

ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

LEGEND:

⌐‐‐‐‐┘	DEMOLISHED BUILDING
═ ═ ═	DEMOLISHED WALKWAY
═══	ASPHALT ROAD
═·═·═	GRAVEL ROAD
‐ ‐ ‐ ⌒ ‐ ‐ ‐	DEMOLISHED STEAM LINE
─┼─┼─	RAILROAD TRACKS
─x─x─	FENCE LINE
🟦	SURFACE WATER
─ ─ ─	GROUND CONTOUR (10-FT)
‐‐‐‐‐	GROUND CONTOUR (2-FT)
∿∿∿	VEGETATION
●	GROUNDWATER MONITORING WELL
◈	CO-LOCATED SURFACE WATER/WET SEDIMENT (PBA08 RI)
⊗	CHROMIUM SPECIATION
△	SURFACE SOIL
▲	SOIL BORING
◒	SURFACE WATER
◆	SEDIMENT
🟨 △	CONCENTRATION EXCEEDS FWCUG (HQ=1, TR=10-5)

EXPOSURE UNITS (SOIL ONLY):

▨	FORMER PRODUCTION AREA (FPA) EXPOSURE UNIT
🟧	NON-PRODUCTION AREA (NPA) EXPOSURE UNIT
🟪	DRY WELL AREA (DWA)

NOTES:

1. ANALYTES THAT EXCEED THE FWCUG (HQ=0.1, TR=10-6) ARE SHOWN AT EACH SAMPLE LOCATION.
2. RESULTS BELOW THE FWCUG ARE SHADED GRAY

OHIO STATE PLANE (NAD 83)

0 100 200 300 600

SCALE: 1" = 300'

US Army Corps of Engineers Louisville District

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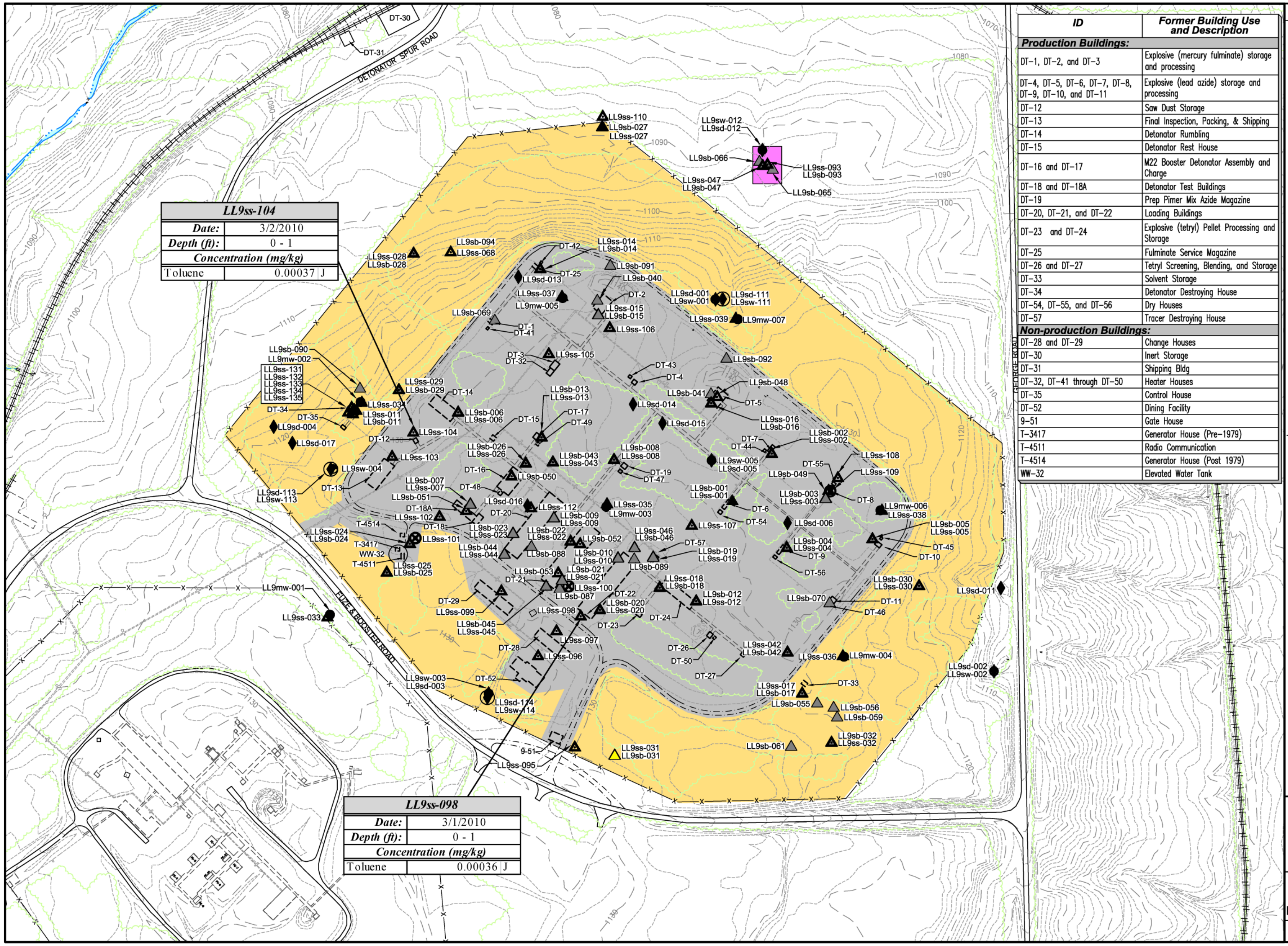
LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE: 08042/DWGS
P. HOLM	REV. 1/01-27-16	/K53LL9-FIG5-5-PAH_soil

Figure 5-5. PAH Exceedances of FWCUG (HQ=0.1, TR=10-6) in Soil (Discrete Soil Borings)



LL9ss-104	
Date:	3/2/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Toluene	0.00037 J

LL9ss-098	
Date:	3/1/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Toluene	0.00036 J

ID	***Former Building Use and Description***
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

LEGEND:

DEMOLISHED BUILDING
DEMOLISHED WALKWAY
ASPHALT ROAD
GRAVEL ROAD
DEMOLISHED STEAM LINE
RAILROAD TRACKS
FENCE LINE
SURFACE WATER
GROUND CONTOUR (10-FT)
GROUND CONTOUR (2-FT)
VEGETATION
● GROUNDWATER MONITORING WELL
CO-LOCATED SURFACE WATER/WET SEDIMENT (PBA08 RI)
⊗ CHROMIUM SPECIATION
△ SURFACE SOIL
▲ SOIL BORING
◒ SURFACE WATER
◆ SEDIMENT

EXPOSURE UNITS (SOIL ONLY):

▨ FORMER PRODUCTION AREA (FPA) EXPOSURE UNIT
🟨 NON-PRODUCTION AREA (NPA) EXPOSURE UNIT
🟪 DRY WELL AREA (DWA)

NOTES:

THERE ARE NO PESTICIDES OR PCBs DETECTED. THERE ARE NO VOC, PESTICIDE, OR PCB CONCENTRATIONS THAT EXCEED THE FWCUG (HQ=1, TR=10-5).

OHIO STATE PLANE (NAD 83)

0 100 200 300 600

SCALE: 1" = 300'

US Army Corps
of Engineers
Louisville District

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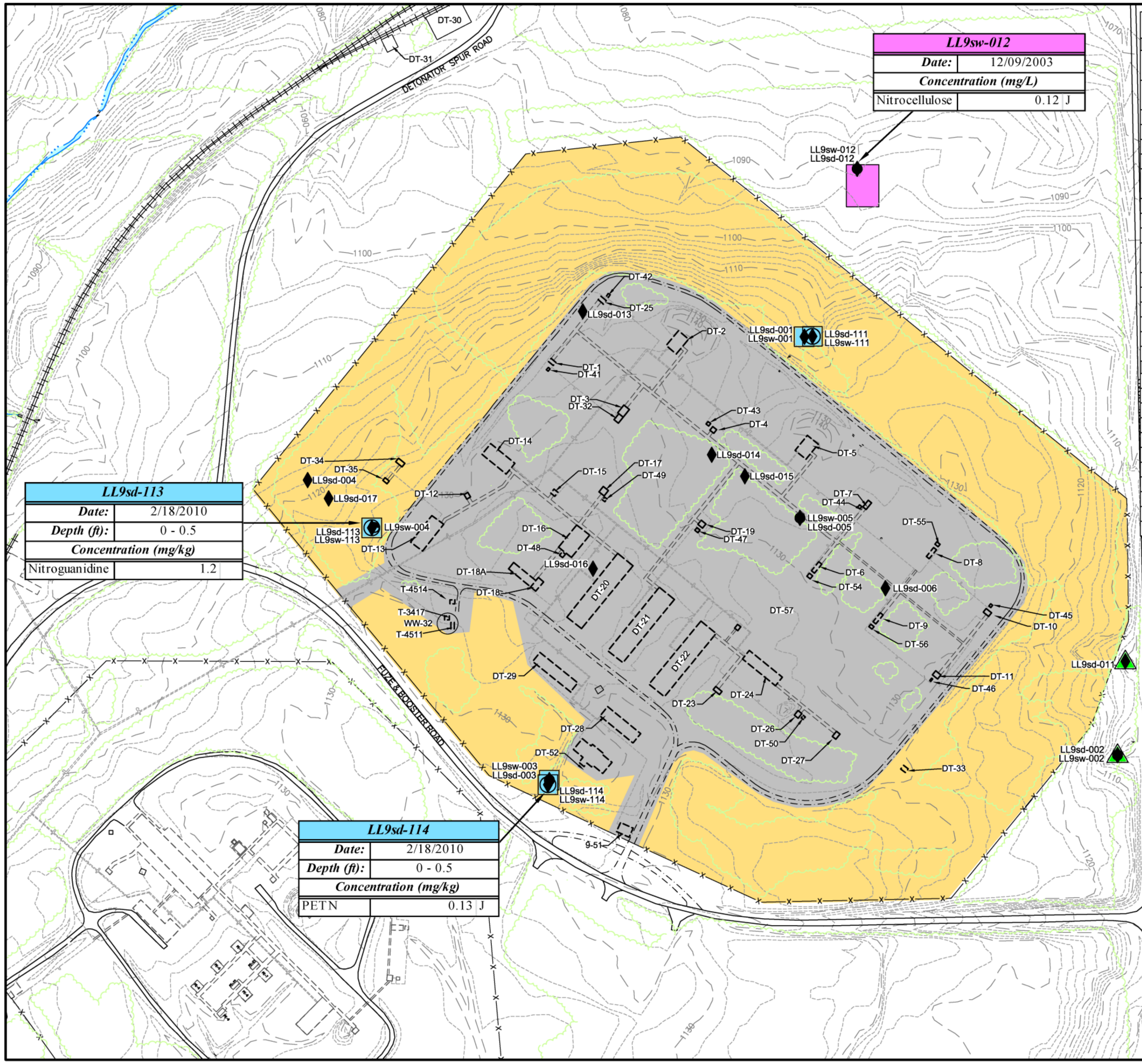
LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY: P. HOLM	REV. NO./DATE: REV. 1/01-22-16	CAD FILE: 08042/DWGS /K53LL9-FIG5-6-ORG_soil

Figure 5-6. Detected Concentrations of VOCs, Pesticides, and PCBs in Soil (Discrete Soil Borings)



LL9sw-012	
Date:	12/09/2003
Concentration (mg/L)	
Nitrocellulose	0.12 J

LL9sd-113	
Date:	2/18/2010
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
Nitroguanidine	1.2

LL9sd-114	
Date:	2/18/2010
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
PETN	0.13 J

ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

LEGEND:

⌐- - -¬	DEMOLISHED BUILDING
= = = =	DEMOLISHED WALKWAY
═	ASPHALT ROAD
═·═	GRAVEL ROAD
– – –⌒– – –	DEMOLISHED STEAM LINE
–+–+–	RAILROAD TRACKS
–x–x–	FENCE LINE
▬	SURFACE WATER
— — —	GROUND CONTOUR (10-FT)
- - - -	GROUND CONTOUR (2-FT)
﹏	VEGETATION
◈	CO-LOCATED SURFACE WATER/WET SEDIMENT (PBA08 RI)
◓	SURFACE WATER
◆	SEDIMENT

EXPOSURE UNITS

▨	FORMER PRODUCTION AREA (FPA) EXPOSURE UNIT
🟨	NON-PRODUCTION AREA (NPA) EXPOSURE UNIT
🟪	DRY WELL AREA (DWA)
🟦	DRAINAGE DITCH SAMPLE LOCATION
▲	OFF-AOC SAMPLE LOCATION

NOTES:

1. DETECTED EXPLOSIVES ARE SHOWN AT EACH SAMPLE LOCATION.
2. THERE ARE NO EXPLOSIVES CONCENTRATIONS THAT EXCEED THE FWCUG (HQ=1, TR=10-5)
3. SEDIMENT SAMPLES (AND CO-LOCATED SURFACE WATER SAMPLES) LL9SD-005, -006, -013, -014, -015, AND -016 WERE NOT USED FOR HHRA AND ERA BECAUSE DRAINAGE CHANGED IN PRODUCTION AREA AFTER BUILDING DEMOLITION
4. SEDIMENT SAMPLES (AND CO-LOCATED SURFACE WATER SAMPLES) LL9SD-001, -003, -004, AND -017 WERE NOT USED FOR HHRA AND ERA BECAUSE MORE RECENT SAMPLES WERE TAKEN NEAR THE SAME LOCATIONS

OHIO STATE PLANE (NAD 83)

0 100 200 300 600

SCALE: 1" = 300'

US Army Corps
of Engineers
Louisville District

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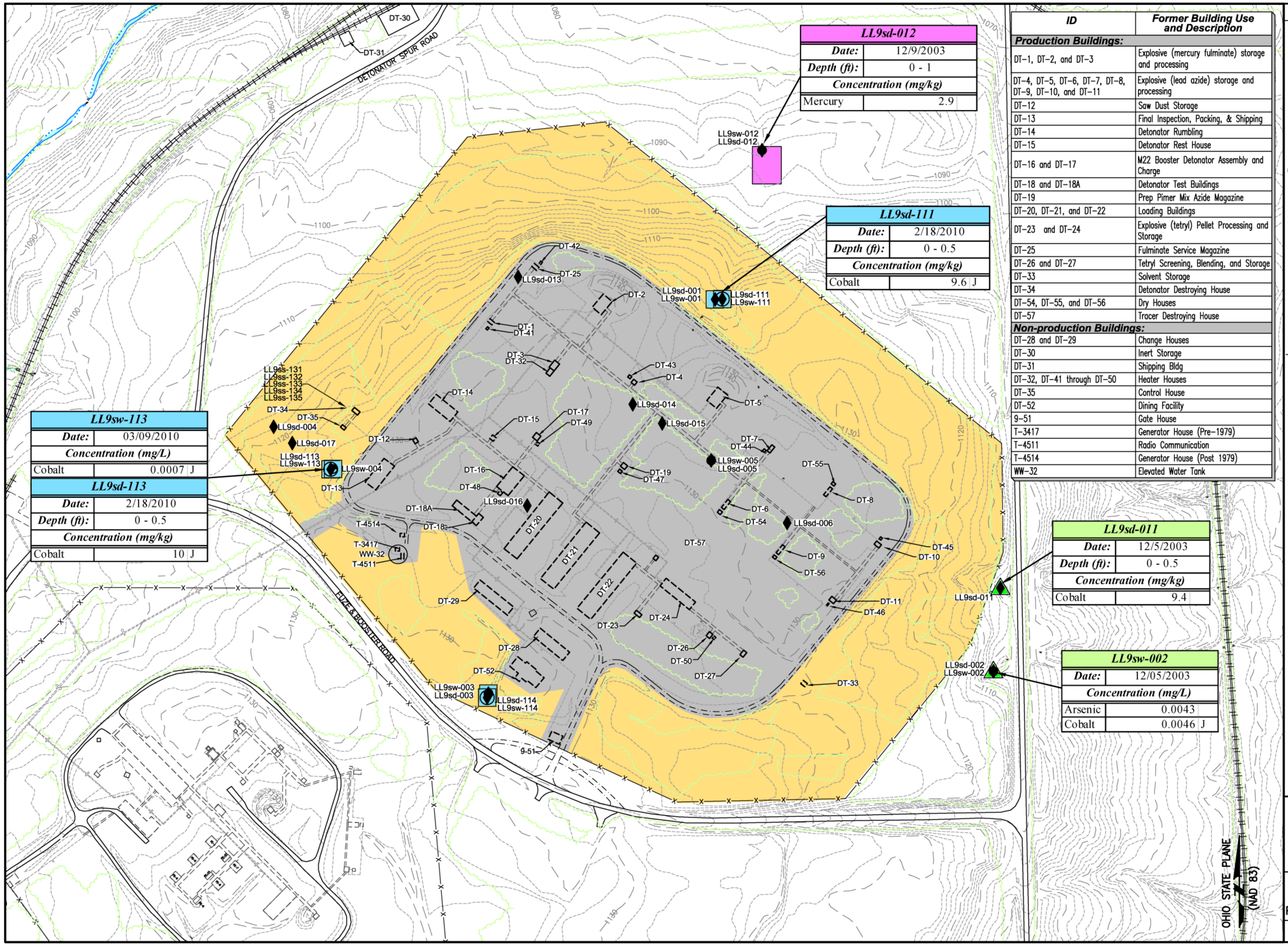
LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE: 08042/DWGS
P. HOLM	REV. 1/01-22-16	/K53LL9-FIG5-7-EXP_SW-SED

Figure 5-7. Detected Concentrations of Explosives and Propellants in Surface Water and Sediment



LL9sd-012

Date:	12/9/2003
Depth (ft):	0 - 1
Concentration (mg/kg)	
Mercury	2.9

LL9sd-111

Date:	2/18/2010
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
Cobalt	9.6 J

LL9sw-113

Date:	03/09/2010
Concentration (mg/L)	
Cobalt	0.0007 J

LL9sd-113

Date:	2/18/2010
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
Cobalt	10 J

LL9sd-011

Date:	12/5/2003
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
Cobalt	9.4

LL9sw-002

Date:	12/05/2003
Concentration (mg/L)	
Arsenic	0.0043
Cobalt	0.0046 J

ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

LEGEND:

⌐‐‐┐	DEMOLISHED BUILDING
═ ═ ═	DEMOLISHED WALKWAY
═══	ASPHALT ROAD
═·═·═	GRAVEL ROAD
‐ ‐ ⎍ ‐ ‐	DEMOLISHED STEAM LINE
─┼─┼─	RAILROAD TRACKS
─x─x─	FENCE LINE
▬	SURFACE WATER
─ ─ ─	GROUND CONTOUR (10-FT)
‐ ‐ ‐	GROUND CONTOUR (2-FT)
﹏	VEGETATION
◈	CO-LOCATED SURFACE WATER/WET SEDIMENT (PBA08 RI)
◓	SURFACE WATER
◆	SEDIMENT

EXPOSURE UNITS:

▨	FORMER PRODUCTION AREA (FPA) EXPOSURE UNIT
🟨	NON-PRODUCTION AREA (NPA) EXPOSURE UNIT
🟪	DRY WELL AREA (DWA)
🟦	DRAINAGE DITCH SAMPLE LOCATION
▲	OFF-AOC SAMPLE LOCATION

NOTES:

1. CONCENTRATIONS OF ARSENIC, CHROMIUM, COBALT, LEAD, OR MERCURY ARE SHOWN ONLY WHEN THEY EXCEEDED BACKGROUND AND THE FWCUG (HQ=0.1, TR=10-6).
2. CONCENTRATIONS OF CHROMIUM DID NOT EXCEED THE FWCUG, AND CONCENTRATIONS OF LEAD DID NOT EXCEED RESIDENTIAL RSL.
3. TOTAL CHROMIUM CONCENTRATIONS WERE SCREENED AGAINST THE FWCUG FOR TRIVALENT CHROMIUM SINCE THE CONCENTRATION OF HEXAVALENT CHROMIUM DID NOT EXCEED THE FWCUG.
4. SEDIMENT SAMPLES (AND CO-LOCATED SURFACE WATER SAMPLES) LL9SD-005, -006, -013, -014, -015, AND -016 WERE NOT USED FOR HHRA AND ERA BECAUSE DRAINAGE CHANGED IN PRODUCTION AREA AFTER BUILDING DEMOLITION
5. SEDIMENT SAMPLES (AND CO-LOCATED SURFACE WATER SAMPLES) LL9SD-001, -003, -004, AND -017 WERE NOT USED FOR HHRA AND ERA BECAUSE MORE RECENT SAMPLES WERE TAKEN NEAR THE SAME LOCATIONS

0 100 200 300 600
SCALE: 1" = 300'

US Army Corps
of Engineers
Louisville District

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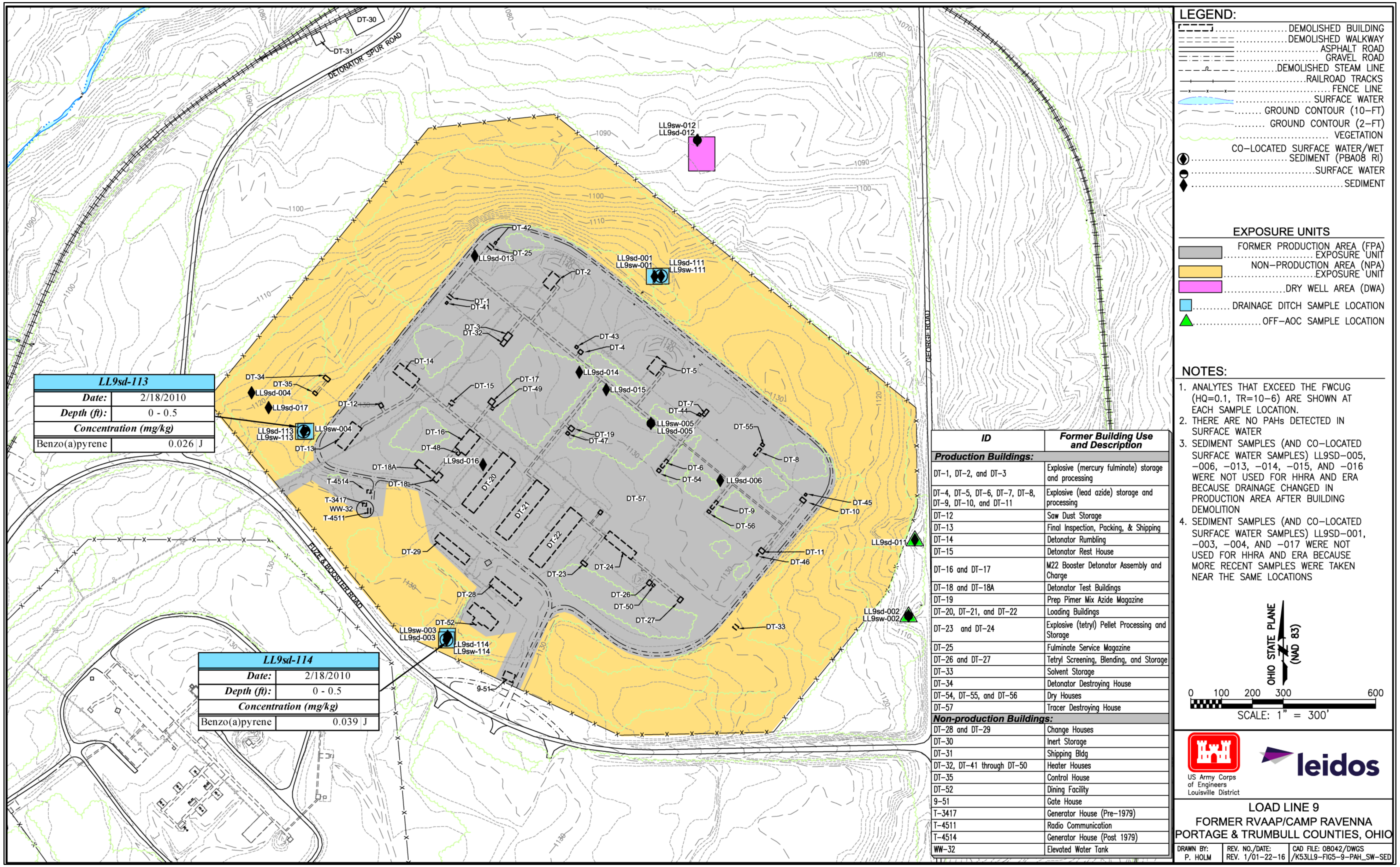
LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE: 08042/DWGS
P. HOLM	REV. 1/01-22-16	/K53LL9-FIG5-8-MET_SW-SED

Figure 5-8. Exceedances of FWCUG (HQ=0.1, TR=10-6) for Arsenic, Chromium, Cobalt, Lead, and Mercury in Surface Water and Sediment



LL9sd-113	
Date:	2/18/2010
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
Benzo(a)pyrene	0.026 J

LL9sd-114	
Date:	2/18/2010
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
Benzo(a)pyrene	0.039 J

ID	Former Building Use and Description
Production Buildings:	
DT–1, DT–2, and DT–3	Explosive (mercury fulminate) storage and processing
DT–4, DT–5, DT–6, DT–7, DT–8, DT–9, DT–10, and DT–11	Explosive (lead azide) storage and processing
DT–12	Saw Dust Storage
DT–13	Final Inspection, Packing, & Shipping
DT–14	Detonator Rumbling
DT–15	Detonator Rest House
DT–16 and DT–17	M22 Booster Detonator Assembly and Charge
DT–18 and DT–18A	Detonator Test Buildings
DT–19	Prep Pimer Mix Azide Magazine
DT–20, DT–21, and DT–22	Loading Buildings
DT–23 and DT–24	Explosive (tetryl) Pellet Processing and Storage
DT–25	Fulminate Service Magazine
DT–26 and DT–27	Tetryl Screening, Blending, and Storage
DT–33	Solvent Storage
DT–34	Detonator Destroying House
DT–54, DT–55, and DT–56	Dry Houses
DT–57	Tracer Destroying House
Non-production Buildings:	
DT–28 and DT–29	Change Houses
DT–30	Inert Storage
DT–31	Shipping Bldg
DT–32, DT–41 through DT–50	Heater Houses
DT–35	Control House
DT–52	Dining Facility
9–51	Gate House
T–3417	Generator House (Pre–1979)
T–4511	Radio Communication
T–4514	Generator House (Post 1979)
WW–32	Elevated Water Tank

LEGEND:

▭	DEMOLISHED BUILDING
═	DEMOLISHED WALKWAY
═	ASPHALT ROAD
═	GRAVEL ROAD
╌	DEMOLISHED STEAM LINE
┼	RAILROAD TRACKS
×	FENCE LINE
🟦	SURFACE WATER
╌	GROUND CONTOUR (10–FT)
╌	GROUND CONTOUR (2–FT)
∿	VEGETATION
◈	CO–LOCATED SURFACE WATER/WET SEDIMENT (PBA08 RI)
◓	SURFACE WATER
◆	SEDIMENT

EXPOSURE UNITS

▨	FORMER PRODUCTION AREA (FPA) EXPOSURE UNIT
🟨	NON–PRODUCTION AREA (NPA) EXPOSURE UNIT
🟪	DRY WELL AREA (DWA)
🟦	DRAINAGE DITCH SAMPLE LOCATION
▲	OFF–AOC SAMPLE LOCATION

NOTES:

1. ANALYTES THAT EXCEED THE FWCUG (HQ=0.1, TR=10–6) ARE SHOWN AT EACH SAMPLE LOCATION.
2. THERE ARE NO PAHs DETECTED IN SURFACE WATER
3. SEDIMENT SAMPLES (AND CO–LOCATED SURFACE WATER SAMPLES) LL9SD–005, –006, –013, –014, –015, AND –016 WERE NOT USED FOR HHRA AND ERA BECAUSE DRAINAGE CHANGED IN PRODUCTION AREA AFTER BUILDING DEMOLITION
4. SEDIMENT SAMPLES (AND CO–LOCATED SURFACE WATER SAMPLES) LL9SD–001, –003, –004, AND –017 WERE NOT USED FOR HHRA AND ERA BECAUSE MORE RECENT SAMPLES WERE TAKEN NEAR THE SAME LOCATIONS

OHIO STATE PLANE (NAD 83)

0 100 200 300 600

SCALE: 1" = 300'

US Army Corps
of Engineers
Louisville District

leidos

LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE: 08042/DWGS
P. HOLM	REV. 1/01–22–16	/K53LL9–FIG5–9–PAH_SW–SED

Figure 5-9. PAH Exceedances of FWCUG (HQ=0.1, TR=10-6) in Surface Water and Sediment

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6.0 CONTAMINANT FATE AND TRANSPORT

Contaminant fate and transport modeling assesses the potential for SRCs to leach from surface soil, subsurface soil, and sediment sources at Load Line 9 and impact groundwater beneath the sources and downgradient receptor locations. Modeling results were included in the decision-making process to determine whether performing remedial actions may be necessary to protect groundwater resources. Surface water exposure pathways are evaluated in the HHRA and ERA presented in Sections 7.2 and 7.3, respectively. A summary of the principles of contaminant fate and transport are presented in this section along with the results of the modeling.

Section 6.1 describes physical and chemical properties of SRCs found in soil and sediment at the AOC. Section 6.2 presents a conceptual model for contaminant fate and transport that considers AOC topography, hydrogeology, contaminant sources, and release mechanisms. Section 6.3 presents the soil screening analysis, and Section 6.4 presents the sediment screening analysis to identify SRCs with the potential to migrate from soil and sediment to groundwater as initial CMCOPCs. Section 6.5 describes fate and transport modeling of final CMCOPCs and presents CMCOCs. Section 6.6 provides a list of the remaining final CMCOPCs and a qualitative assessment of the results and considerations of the limitations and assumptions. Section 6.7 presents summary and conclusions of the fate and transport analysis.

6.1 PHYSICAL AND CHEMICAL PROPERTIES OF SITE-RELATED CONTAMINANTS

The major contaminants of the former RVAAP are TNT, composition B (a combination of TNT and RDX), sulfates, nitrates, lead styphnate, and lead azide. Additional site-specific contaminants include heavy metals (lead, chromium, mercury, and arsenic) from munitions assembly activities; VOCs from former Building DT-33 that was utilized for solvent storage; PCBs from on-site transformers; and PAHs from former Buildings DT-32 and DT-41 through DT-50 that were used as heater houses. This evaluation of contaminant fate and transport presents not only those chemicals identified as potential contaminants from previous use but also presents chemicals that were evaluated as part of the overall RI. The comprehensive list of surface and subsurface soil SRCs (i.e., 17 inorganic chemicals and 24 organic chemicals) and sediment SRCs (i.e., 8 inorganic chemicals and 16 organic chemicals) were detailed in Section 4.0 and are summarized below:

- Inorganic SRCs in surface and subsurface soil: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc.
- Inorganic SRCs in sediment: antimony, beryllium, cadmium, cobalt, lead, mercury, nickel, and silver.
- Organic SRCs in surface and subsurface soil: 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(*ghi*)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, di-n-butyl phthalate, dibenz(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, nitrocellulose, nitroguanidine, phenanthrene, pyrene, tetryl, and toluene.

- Organic SRCs in sediment: 2-methylnaphthalene, benz(a)anthracene, benzenemethanol, benzo(a)pyrene, benzo(b)fluoranthene, benzo(*ghi*)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, nitroguanidine, PETN, phenanthrene, pyrene, and toluene.

Chemicals released into the environment are susceptible to several degradation pathways, including hydrolysis, oxidation, reduction, isomerization, photolysis, photo-oxidation, biotransformation, and biodegradation. Transformed products resulting from these processes may behave differently than their parent chemical in the environment.

The migration of chemicals is governed by their physical and chemical properties and the surface and subsurface media through which chemicals are transferred. In general, chemicals and structures with similar physical and chemical characteristics will show similar patterns of transformation, transport, or attenuation in the environment. Solubility, vapor pressure data, chemical partitioning coefficients, degradation rates, and Henry's Law Constant (HLC) provide information that can be used to evaluate contaminant mobility in the environment. Partitioning coefficients are used to assess relative affinities of chemicals for solution or solid phase adsorption. However, the synergistic effects of multiple migrating chemicals and complexity of soil/water interactions, including pH and oxidation-reduction potential, grain size, and clay mineral variability, are typically unknown.

The physical properties of the chemicals defined as SRCs in surface and subsurface soil are summarized in Tables E-1 and E-2 in Appendix E. These properties are used to assess the anticipated behavior of each chemical under environmental conditions. The physical properties of the chemicals defined as SRCs detected in soil and sediment are summarized in Sections 6.1.1 through Section 6.1.5.

6.1.1 Chemical Factors Affecting Fate and Transport

The water solubility of a chemical is a measure of the saturated concentration of the chemical in water at a given temperature and pressure. The tendency for a chemical to be transported by groundwater is directly related to its solubility and inversely related to its tendencies to adsorb to soil and volatilize from water (OGE 1988). Chemicals with high water solubilities tend to desorb from soil, are less likely to volatilize from water, and are susceptible to biodegradation. The water solubility of a chemical varies with temperature, pH, and the presence of other dissolved chemicals (including organic carbon and humic acids).

The octanol-water partition coefficient (K_{ow}) can be used to estimate the tendency for a chemical to partition between environmental phases of different polarity. The K_{ow} is a laboratory-determined ratio of the concentration of a chemical in the n-octanol phase of a two-phase system to the concentration in the water phase. Chemicals with log K_{ow} values less than one are highly hydrophilic, while chemicals with log K_{ow} values greater than four will partition to soil particles (Lyman et al. 1990).

The water/organic carbon partition coefficient (K_{oc}) is a measure of the tendency of an organic chemical to partition between water and organic carbon in soil. The K_{oc} is defined as the ratio of the absorbed chemical per unit weight of organic carbon to the aqueous solute concentration.

This coefficient can be used to estimate the degree to which an organic chemical will adsorb to soil and thus not migrate with groundwater. The higher the K_{oc} value, the greater is the tendency of the chemical to partition into soil (OGE 1988). The soil/water partitioning coefficient (K_d) is calculated by multiplying the K_{oc} value by the fraction of organic carbon in the soil.

Vapor pressure is a measure of the pressure at which a chemical and its vapor are in equilibrium. The value can be used to determine the extent to which a chemical would travel in air, as well as the rate of volatilization from soil and solution (OGE 1988). In general, chemicals with vapor pressures lower than 10^{-7} mm mercury will not be present in the atmosphere or air spaces in soil in significant amounts, while chemicals with vapor pressures higher than 10^{-2} mm mercury will exist primarily in the air (Dragun 1988).

The HLC value for a chemical is a measure of the ratio of the chemical’s vapor pressure to its aqueous solubility. The HLC value can be used to make general predictions about a chemical’s tendency to volatilize from water. Chemicals with HLC values less than 10^{-7} atm-m^3/mol will generally volatilize slowly, while chemicals with a HLC greater than 10^{-3} atm-m^3/mol will volatilize rapidly (Lyman et al. 1990).

6.1.2 Biodegradation

Organic chemicals with differing chemical structures will biodegrade at different rates. Primary biodegradation consists of any biologically induced structural change in an organic chemical. Complete biodegradation is the biologically mediated degradation of an organic chemical into carbon dioxide, water, oxygen, and other metabolic inorganic products (Dragun 1988). The first order biodegradation rate of an organic chemical is proportional to the concentration:

$$-dC/dt = kC \qquad \text{(Equation 6-1)}$$

Where:

C = concentration
t = time
k = biodegradation rate constant = $\ln 2 / t_{1/2}$
$t_{1/2}$ = biodegradation half-life

The biodegradation half-life is the time necessary for half of the chemical to degrade. The biodegradation rate of an organic chemical generally depends on the presence and population size of soil microorganisms that are capable of degrading the chemical.

6.1.3 Inorganic Chemicals

Inorganic chemicals detected in soil and sediment samples are associated with the aqueous phase and leachable metal ions on soil particles. The transport of this material from unsaturated soil to the underlying water table is controlled by the physical processes of precipitation percolation, chemical interaction with the soil, and downward transport of metal ions by continued percolation. The chemistry of inorganic chemical interactions with percolating precipitation and varying soil conditions is complex and includes numerous chemical transformations that may result in altered oxidation states, including ion exchange, adsorption, precipitation, or complexation. The chemical reactions, which are affected by environmental conditions (pH, oxidation/reduction conditions, type and amount of organic matter, clay content, and the presence of hydrous oxides), may act to enhance or reduce the mobility and toxicity of metal ions. In general, these reactions are reversible and add to the variability commonly observed in distributions of inorganic chemicals in soil.

The chemical form of an inorganic chemical determines its solubility and mobility in the environment; however, chemical speciation is complex and difficult to delineate in routine laboratory analysis. Inorganic chemicals in soil are commonly found in several forms, including dissolved concentrations in soil pore water, metal ions occupying exchange sites on inorganic soil constituents (adsorbed to inorganic soil constituents), metal ions associated with insoluble organic matter, precipitated inorganic chemicals as pure or mixed solids, and metal ions present in the structure of primary or secondary minerals.

The dissolved (aqueous) fraction and its equilibrium sorbed fraction are important when considering the migration potential of inorganic chemicals through soil. Of the inorganic chemicals that are likely to form, chlorides, nitrates, and nitrites are commonly the most soluble. Sulfate, carbonate, and hydroxides generally have low to moderate solubility. Soluble chemicals are transported in aqueous forms subject to attenuation, whereas less soluble chemicals remain as a precipitate and limit the overall dissolution of metal ions. The solubility of the metal ions is also regulated by ambient chemical conditions, including pH and oxidation/reduction.

The attenuation of metal ions in the environment can be estimated numerically using the retardation factor (R), dispersion in higher flow systems (high conductivity environments), and diffusion in low conductivity environments. R defines the extent to which the velocity of the contaminant is slowed, which is largely derived from the K_d. R is calculated using the following equation:

$$R = 1 + (K_d \rho_b)/ \theta_w \qquad \text{(Equation 6-2)}$$

Where:

ρ_b = the soil bulk dry density (g/cm^3)
θ_w = soil moisture content (dimensionless)

Metal ion concentrations in the environment do not attenuate by natural or biological degradation because of low volatility and solubility of the ions. Inorganic chemicals may be biotransformed or bioconcentrated through microbial activity.

6.1.4 Organic Chemicals

Organic chemicals, such as SVOCs or VOCs, may be transformed or degraded in the environment by processes including hydrolysis, oxidation/reduction, photolysis, volatilization, biodegradation, or biotransformation. The half-life of organic chemicals in transport media can vary from minutes to years, depending on environmental conditions and chemical structures. Some types of organic chemicals are very stable, and degradation rates can be very slow. Organic degradation may either enhance (by producing more toxic byproducts) or reduce (reducing concentrations) the toxicity of a chemical in the environment.

6.1.5 Explosives – Related Chemicals

Several explosive compounds were detected in soil and sediment at Load Line 9. Nitrocellulose is an aliphatic nitrate ester that will gelatinize with nitroglycerin when mixed together. Nitrocellulose occurs as a fibrous solid that can act as a sorbent that will dissolve in water under highly basic conditions with high temperatures. Nitrocellulose can undergo denitrification as a degradation pathway. Degradation of nitrocellulose to non-reactive nitrocellulose has been observed under methanogenic and fungus-mediated reducing conditions (USACE 2006). Nitroguanidine is a mobile nitramine chemical that can be biotransformed in aquatic environments and in soil under aerobic and anaerobic conditions. The rate of degradation of nitroguanidine in soil is dependent on the amount of organic carbon and microbial adaptation to nitroguanidine. Biotransformation products of nitroguanidine include cyanamide, melamine, and guanidine (USACE 2006). Tetryl may undergo biotransformation, hydrolysis, and photodegradation to produce several different transformation products, such as n-methylpicramide and 4-amino-n-methyl-n,2,6-trinitroaniline (USACE 1994). PETN undergoes biodegradation forming trinitrate and then dinitrate, which is then further degraded. PETN has low volatility and low solubility in water, and therefore has low bioavailability for most organisms. Neutron radiation degrades PETN, producing carbon dioxide and some pentaerythritol dinitrate and trinitrate. Like other nitrate esters, the primary degradation mechanism is the loss of nitrogen dioxide (German et.al. 1998).

6.2 CONCEPTUAL MODEL FOR FATE AND TRANSPORT

The conceptual site model (CSM), which defines the framework for fate and transport modeling, describes conditions at Load Line 9, including the contaminant sources, surficial and subsurface hydrogeologic conditions, contaminant migration and pathways, and contaminant release mechanisms. As discussed in Section 2.2.5, three different soil spatial aggregates exist at this AOC: FPA, NPA, and DWA. Each of the soil aggregates at Load Line 9 were screened separately for CMCOPCs using a soil screening analysis. Data for two different sediment aggregates (Drainage Ditches and DWA) were screened separately using a sediment screening analysis.

The AOC conditions described in Sections 2.0 through 5.0 include contaminant source information, the surrounding geologic and hydrologic conditions, and the magnitude of SRCs and their current spatial distribution. Information from Section 3.0 and the nature and extent evaluation in Section 5.0 was used to develop the CSM for fate and transport modeling by identifying SRCs and migration pathways. The CSM is based on information and data collected for historical investigations, this RI/FS Report, and informed assumptions about the AOC. Assumptions contained in the CSM are reiterated throughout this section. The better the information and the greater the accuracy of the assumptions, the more accurately the CSM describes the AOC, and therefore, the more reliable the fate and transport modeling predictions can be. A summary of the salient elements of the CSM that apply to fate and transport modeling are summarized in the following sections.

6.2.1 Contaminant Sources

No primary contaminant sources are located on the AOC. Secondary sources (contaminated media including sediment) identified in previous investigations are further evaluated in this report.

6.2.2 Hydrogeology

A description of regional and AOC-specific geology and hydrology are provided in Sections 3.3.3 and 3.4.2, respectively, and are summarized below.

- The topography at Load Line 9 ranges from approximately 1,088–1,136 ft amsl. Surface water drainage associated with heavy rainfall events follows the topography and drain from south to the north (Figure 3-1).
- Soil beneath the AOC consists mostly of medium- to fine-grained sandy loam and sandy silt that is well drained and exhibits seasonal wetness and low permeability (USDA 2010).
- Seven groundwater monitoring wells were installed at the AOC ranging from 18.5–32 ft bgs for an average depth of 25 ft bgs. Depth to bedrock underneath Load Line 9 ranges from 0–16 ft bgs. Bedrock is at ground surface in the northwest portion of the AOC.
- The potentiometric surface shows the groundwater flowing from a potentiometric high in the south-central portion of the AOC outward in a radial pattern, with a dominant northeasterly flow direction (Figure 3-1). The average hydraulic gradient is 0.0231 ft/ft (Figure 3-1).
- Water level elevations at the AOC range from 1,110.36–1,124.15 ft amsl with the highest elevation at well LL9mw-003 (Figure 3-1). Potentiometric data indicate the groundwater table occurs within bedrock throughout the AOC.

6.2.3 Contaminant Release Mechanisms and Migration Pathways

Based on the information presented above, the following contaminant release mechanisms and migration pathways have been identified at the AOC:

- Contaminant leaching from soil to the water table (vertical migration) and lateral transport to downgradient receptors (i.e., unnamed tributary to Sand Creek and unnamed tributary to the Mahoning River);
- Contaminated sediment transported to potential downstream receptors;
- Contaminated surface water migrating to potential downstream receptors; and
- Contaminated sediment within drainage ditches and shallow conveyances as a secondary source of leaching to the water table (vertical migration) and lateral transport to potential downgradient receptors.

The first of these pathways, which considers a primary groundwater transport pathway, is treated explicitly in this fate and transport section. Sediment and surface water exposure pathways are evaluated in the HHRA and ERA presented in Sections 7.2 and 7.3, respectively. The fourth pathway listed above, which considers a secondary groundwater transport pathway, is evaluated using the sediment screening analysis presented in Section 6.4.

One of the principal migration pathways at the AOC is percolation through the unsaturated soil to the water table (i.e., vertical leaching of contaminants from soil into groundwater). However, because of the very heterogeneous nature of the unconsolidated glacial material, groundwater flow patterns within the unconsolidated soil are difficult to predict. Precipitation that does not leave the AOC as surface runoff percolates into the subsurface. Some of the percolating water leaves this environment via evapotranspiration after little or no vertical migration. The remainder of the water percolates into the water table. As discussed in Section 6.2.4, the rate of percolation is controlled by soil cover, ground slope, saturated conductivity of the soil, and meteorological conditions. Figure 6-1 illustrates the contaminant migration conceptual model.

Once the contaminant leachate percolates through the soil and reaches the water table, it migrates with the local groundwater and discharges at the downgradient receptors. Groundwater flow likely occurs along preferential pathways (e.g., sand seams, channel deposits, or other stratigraphic discontinuities) having higher permeabilities. For inorganic chemicals, lateral migration through groundwater will be very limited due to their high retardation by the bedrock material (USACE 2003b).

Additional factors that affect the leaching rate include a chemical’s solubility, sorption capacity (expressed by the K_d), and the amount of percolation. Insoluble chemicals will precipitate out of the solution in the subsurface or remain in insoluble forms with little leaching.

Another factor that affects whether a chemical will reach the water table through percolation of precipitation is the chemical’s rate of decay. Most organic compounds decay at characteristic rates proportional to the chemical’s half-life. For a given percolation rate, those chemicals with long half-lives have a greater potential for contaminating groundwater than those with shorter half-lives. For this analysis, the rate of decay/half-life was not considered.

Contaminant releases through gaseous emissions and airborne particulates are not significant at Load Line 9. The AOC is vegetated, located in a humid temperate climate, and soil moisture is typically high, which prevents dust borne contaminant migration. Therefore, there is likely little to no gaseous emission, and contaminant levels in the air pathway are minor to nonexistent.

6.2.4 Water Budget

The potential for contaminant transport begins with precipitation. Percolation is the driving mechanism for soil contaminants leaching to groundwater. The actual amount of rainwater available for flow and percolation to groundwater is highly variable and depends upon soil type and climatic conditions. A water balance calculation can be used as a tool to quantitatively account for all components of the hydrologic cycle. The quantified elements of the water balance are used for inputs to the soil leaching and groundwater transport models discussed later. The components of a simple steady-state water balance model include precipitation, evapotranspiration, surface runoff, and groundwater recharge or percolation.

These terms are defined as follows:

$$P = ET + Sr + q \quad \text{(Equation 6-3)}$$

or

$$\text{Rainwater available for flow} = Sr + q = P - ET \quad \text{(Equation 6-4)}$$

Where:

P = precipitation
Sr = surface runoff
ET = evapotranspiration
q = groundwater recharge or percolation

It is expected that loss of runoff also occurs in the form of evaporation. The remaining water, after runoff and evaporation, is available for percolation which includes loss to the atmosphere by evapotranspiration. The water balance estimations were developed using the Hydrologic Evaluation of Landfill Performance (HELP) model (USEPA 1994). See Table E-3 in Appendix E for parameters used in the HELP model to develop the water budget estimates used in the evaluation. Calculations using precipitation and temperature data for a 100-year period were generated synthetically using coefficients for Cleveland, Ohio (e.g., the nearest weather station to Camp Ravenna with HELP model coefficients).

The annual average water balance estimates indicate an evapotranspiration of 28% (10.3 inches) of total precipitation (37 inches). The remaining 72% (26.7 inches) of rainwater is available for surface water runoff and percolation to groundwater. Of the 72% (27 inches) of water available for runoff or percolation, groundwater recharge (percolation) accounts for 13% (3.6 inches), and surface runoff (along downgradient topography to nearest surface water bodies) accounts for the remaining 87% (23.1 inches).

6.3 SOIL SCREENING ANALYSIS

Soil screening analyses are screening evaluations performed to identify SRCs with the potential to leach to groundwater as CMCOPCs. This section describes the soil screening analysis approach and presents the limitations and assumptions.

6.3.1 Analysis Approach

The five steps for the soil leachability analysis are illustrated in Figure 6-2 and described below.

The first step of the soil screening analysis is developing SRCs, as presented in Section 4.0. A summary of SRCs identified for soil and sediment is presented in Section 6.1.

The second step of the soil screening process (Figure 6-2) involves comparing the maximum concentrations of the SRCs with MCL-based generic soil screening levels (GSSLs). GSSLs were developed for Superfund sites for contaminant migration to groundwater (USEPA 1996b, USEPA 2015). The GSSL is defined as the concentration of a chemical in soil that represents a level of contamination below which there is no concern for impacts to groundwater under CERCLA, provided conditions associated with USEPA risk-based soil screening levels (SSLs) are met. Generally, if chemical concentrations in soil fall below the GSSL, and there are no groundwater receptors of concern or anticipated exposures, then no further study or action is warranted for that chemical. If the GSSL for a chemical is not available, the USEPA risk-based SSL for groundwater migration, dated June 2015 (USEPA 2015), will be obtained from the USEPA RSL website and used. If neither the GSSL nor the USEPA risk-based SSL for a chemical are available, then no further evaluation of the chemical is performed and it is eliminated from the list of the initial CMCOPCs. However, some chemicals have been assigned surrogates by risk assessors if the chemical without an SSL is similar to another chemical with an SSL. Surrogates used for this analysis include acenaphthene for acenaphthylene and pyrene for benzo(*ghi*)perylene and phenanthrene.

The initial CMCOPC screen, as presented in Table E-4 in Appendix E, eliminated 6 inorganic and 12 organic SRCs from the FPA, 3 inorganic and 16 organic SRCs from the NPA, and 2 inorganic SRCs from the DWA from further consideration. A total of 11 inorganic and 10 organic SRCs from the FPA, 11 inorganic and 5 organic SRCs from the NPA, and 2 inorganic SRCs from the DWA were carried forward to the third step of the soil CMCOPC screening process.

The third step of the soil screening process (Figure 6-2) involves comparing the maximum chemical concentrations with the site-specific soil screening levels (SSSLs). The SSSL is defined as the GSSL (or the USEPA risk-based SSL for groundwater protection if a GSSL is not available) multiplied by the AOC-specific dilution attenuation factor (DAF). Direct partitioning is used to derive the GSSLs, assuming groundwater is in contact with the chemicals in soil and the groundwater concentration is equal to the leachate concentration. However, as leachate moves through soil, chemical concentrations are attenuated by adsorption and degradation. When the leachate reaches the water table, dilution by groundwater further reduces leachate concentrations. This concentration reduction can be expressed by a DAF. DAFs can vary based on AOC-specific characteristics (e.g., hydrogeologic properties, contaminated source area, and depth to contamination). As described in the *Soil Screening Guidance: Technical Background Document* (USEPA 1996b), chemical dilution in groundwater is estimated at each AOC from an AOC-specific DAF. The DAF, which is defined as the ratio of soil leachate concentration to receptor point concentration, is minimally equal to one. Dilution in groundwater is derived from a simple mixing zone equation (Equation 6-5) and relies upon estimating the mixing zone depth (Equation 6-6).

$$\mathrm{DAF} = 1 + \frac{(\mathrm{K} \times i \times \mathrm{d})}{(\mathrm{q} \times \mathrm{L})} \qquad \text{(Equation 6-5)}$$

Where:

DAF = dilution attenuation factor

K = aquifer hydraulic conductivity (m/yr)

i = horizontal hydraulic gradient (m/m)

q = percolation rate (m/yr)

L = source length parallel to groundwater flow (m)

d = mixing zone depth (m) (which is defined below) and

$$d = \sqrt{0.0112 \times L^2} + d_a \times \left[1 - \exp\left(\frac{-L \times I}{K \times i \times d_a} \right) \right] \qquad \text{(Equation 6-6)}$$

Where:

d_a = aquifer thickness (m)
$d \leq d_a$

As stated above, if the aquifer thickness is less than the calculated mixing zone depth, then the aquifer thickness is used for "d" in the DAF calculation. The DAF calculation for the AOC is presented in Table E-5 in Appendix E. It should be noted that the purpose of this screen is not to identify the chemicals that may pose risk at downgradient locations, but to target those chemicals that pose the greatest problem if they migrate from the AOC.

Based on this screening and AOC-specific DAFs of 1.93 for the FPA, 3.22 for the NPA, and 4.72 for the DWA, nickel at the FPA; barium, zinc, and indeno(1,2,3-cd)pyrene at the NPA; and lead at the DWA were eliminated from further consideration. All the remaining SRCs exceeded their published or calculated GSSL multiplied by the respective DAF and were identified as initial CMCOPCs based on leaching to groundwater. The SRCs identified as initial CMCOPCs are presented in Table E-6 in Appendix E.

The fourth step of the soil screening process (Figure 6-2) involves eliminating initial CMCOPCs identified in the SSSL evaluation which require more than 1,000 years to leach through the unsaturated zone before reaching the water table from further consideration. A period of 1,000 years was conservatively selected to evaluate eventual migration of the contaminant front to the water table despite uncertainties in vadose zone hydraulic parameters and groundwater recharge over time. Additionally, USACE suggests a screening value of 1,000 years be used due to the high uncertainty associated with predicting conditions beyond that time frame (USACE 2003b). Therefore, the initial CMCOPCs at the selected sources were screened against a travel time of greater than 1,000 years. The travel time in this screen is the time required for a CMCOPC to migrate vertically from the base of the soil interval detected above the background concentration to the water table. This distance is the leaching zone, which is evaluated in Table E-7 of Appendix E, may vary across the AOC based on the varying depths of soil sample concentrations above the facility-wide background concentrations and the elevation of the water table. The estimated travel time for each initial CMCOPC to reach the water table is determined using the following equations:

$$T = \frac{Lz \times R}{V_p} \qquad \text{(Equation 6-7)}$$

Where:

T = leachate travel time (year)
Lz = thickness of attenuation zone (ft)
R = retardation factor (dimensionless) (Equation 6-2)
V_p = porewater velocity (ft/year)

and

$$V_p = \frac{q}{\theta_w} \qquad \text{(Equation 6-8)}$$

Where:

q = percolation rate (ft/year)
θ_w = fraction of total porosity that is filled by water

If the travel time for a chemical from a source area exceeded 1,000 years, then the chemical was eliminated from the list of initial CMCOPCs. A total of 15 inorganic and organic SRCs at the FPA and 8 inorganic and organic SRCs at the NPA were eliminated from further consideration based on their travel times exceeding 1,000 years. Initial CMCOPCs with travel times less than 1,000 years were retained for further evaluation (Appendix E, Table E-7). The constituents selected for further evaluation with Seasonal Soil Compartment Model (SESOIL) modeling are listed in Table 6-1.

In the fifth step (Figure 6-2), the initial CMCOPCs were further evaluated using fate and transport models provided in Section 6.5.

6.3.2 Limitations and Assumptions of Soil Screening Analysis

It is important to recognize that acceptable soil concentrations for individual chemicals are highly AOC-specific. The GSSLs used in this screening are based on a number of default assumptions chosen to be protective of human health for most AOC conditions (USEPA 1996b). These GSSLs are expected to be more conservative than SSSLs based on AOC conditions. The conservative assumptions included in this analysis are: (1) no adsorption in the unsaturated zone or in the aquifer; (2) no biological or chemical degradation in the soil or aquifer; and (3) contamination is uniformly distributed throughout the source. However, the GSSL does not incorporate the existence of contamination already present within the aquifer.

6.4 SEDIMENT SCREENING ANALYSIS

Sediment SRCs were developed in Section 4.0 and are presented in Section 6.1. The purpose of this screening analysis is to identify CMCOPCs based on contaminant migration from the sediment to groundwater. Any identified CMCOPCs are modeled with Analytical Transient 1-, 2-, 3-Dimensional (AT123D) to a downgradient receptor if present. The four steps for the sediment screening analysis are illustrated in Figure 6-3.

Sediment SRCs were screened by developing leachate concentrations assuming equilibrium between sediment and groundwater. The predicted leachate concentrations were diluted based on a sample-specific DAF calculated by dividing the calculated leachate concentrations by the co-located surface water concentrations. The DAF was calculated for each chemical that was detected in the sediment and surface water at the same sample location. The calculated DAF was then used to calculate the maximum groundwater concentration, considering dilution for sediment SRCs and assuming that the sediment is in direct contact with groundwater. The lowest DAF calculated for the sample area was used for sediment SRCs that did not have a sample-specific DAF. The DAFs calculated for each chemical are shown in Table 6-2.

This sediment screening analysis assumed that the sediment concentration and the recharging groundwater concentration were in equilibrium and a sample-specific DAF for each chemical was used for dilution in the aquifer. Based on this screening analysis (see Table 6-2), the 3 inorganic SRCs (beryllium, mercury, and nickel) from the DWA, and 7 inorganic SRCs (antimony, beryllium, cadmium, cobalt, lead, nickel, and silver) and 11 organic SRCs [2-methylnaphthalene, benzenemethanol, benzo(a)pyrene, benzo(*ghi*)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, and toluene] from the Drainage Ditches did not exceed the risk-based screening criteria and were eliminated from further evaluation. The remaining six SRCs from the Drainage Ditches [mercury, benz(a)anthracene, benzo(b)fluoranthene, naphthalene, nitroguanidine, and PETN] were evaluated with the AT123D model described in Section 6.5.

6.5 FATE AND TRANSPORT MODELING

Contaminant fate and transport modeling represents the fifth step in the fate and transport screening and evaluation process (Figure 6-2). SESOIL modeling was performed for chemicals identified as initial CMCOPCs from the soil screening analysis presented in Section 6.3 and summarized in Table 6-1. SESOIL modeling was performed to predict chemical concentrations in the leachate immediately beneath the selected source areas and just above the water table. If the predicted maximum leachate concentration of an initial CMCOPC was higher than the facility-wide background concentration and the lowest risk-based screening value (Resident Receptor Adult FWCUG, MCL, or RSL), the CMCOPC was further evaluated using the AT123D model to predict future maximum concentrations in groundwater beneath the source, as well as at downgradient receptor locations, if applicable. The downgradient receptor location (if required) is the closest surface water body feature downgradient of the source areas that is connected to the groundwater. The predicted concentrations of CMCOPCs in groundwater beneath the source were compared to available groundwater monitoring results for the AOC to validate modeling results and provide WOE for identifying or eliminating CMCOCs.

6.5.1 Modeling Approach

Contaminant transport includes the movement of water and dissolved material from the source areas to groundwater. This occurs as rainwater infiltrates the surface and percolates through the area of contamination, its surrounding soil, and into the saturated zone. The downward movement of water, driven by gravitational potential, capillary pressure, and other components of total fluid potential mobilizes the contaminants and carries them through the soil into the mixing zone with the water table. Lateral transport within the shallow bedrock is controlled by the groundwater gradient. Vertical transport (evaluated with the SESOIL model) through the overburden to the water table and horizontal transport (evaluated with the AT123D model) through the shallow bedrock to downgradient receptor locations are illustrated in Figure 6-1.

The output of the contaminant fate and transport modeling is presented as the expected maximum concentration of modeled contaminants at the selected receptor locations. For SESOIL, the receptor location is the groundwater table beneath the source area. For this analysis, eight sampling locations [two discrete samples and six incremental sampling methodology (ISM) areas] were considered as sources of contamination based on the results of the soil screening analysis. A separate SESOIL analysis was performed for each initial CMCOPC listed in Table 6-1 and is presented in Figure 6-4.

The predicted maximum leachate concentration just above the water table, observed in the SESOIL results, was compared against its applicable RVAAP facility-wide background concentration, as well as RVAAP FWCUGs for the Resident Receptor Adult, MCLs, and RSLs. If the predicted maximum leachate concentration of an initial CMCOPC was higher than the facility-wide background concentration and the lowest risk-based screening value (Resident Receptor Adult FWCUG, MCL, or RSL), the CMCOPC was further evaluated using the AT123D model to predict future maximum concentrations in groundwater beneath the source, as well as at downgradient receptor locations, if applicable.

If a predicted maximum leachate concentration was lower than the screening criteria, the chemical was no longer considered a CMCOPC.

For chemicals identified as CMCOPCs, maximum concentrations predicted by AT123D in groundwater directly below the source areas and at the downgradient receptor locations were compared to the applicable RVAAP facility-wide background concentrations, as well as RVAAP FWCUGs for the Resident Receptor Adult, MCLs, and RSLs. If the predicted maximum concentration of a CMCOPC is higher than its facility-wide background concentration, and the lowest risk-based screening value (i.e., Resident Receptor Adult FWCUG, MCL, or RSL), the chemical was retained as a CMCOC. If the predicted maximum concentration of a CMCOPC in groundwater directly below the source areas and at the downgradient receptor location was lower than the screening criteria, the chemical was not considered a CMCOC.

CMCOCs identified by modeling results were evaluated with respect to WOE for retaining or eliminating CMCOCs from further consideration as a basis for potential soil or sediment remedial actions. Lines of evidence include validating modeling results using available AOC-specific groundwater monitoring data. Modeled timelines for potential leaching and lateral transport were evaluated with respect to estimated times for contaminant releases during RVAAP operations to determine if peak leaching concentrations would likely have occurred in the past. Some CMCOCs present at or below RVAAP soil or sediment background concentrations may have predicted leachate or groundwater concentrations exceeding risk-based criteria due to conservative model assumptions; therefore, these were also identified and considered in the evaluation. Additionally, identified CMCOCs were compared to COCs identified in the HHRA to determine if they had an associated risk related to direct exposure to soil or sediment or if CMCOCs and COCs were co-located and may be addressed simultaneously under a potential remedial action.

6.5.2 Model Applications

The SESOIL model (GSC 1998) used for leachate modeling, when applicable, estimates pollutant concentrations in the soil profile following introduction via direct application and/or interaction with transport media. The AT123D model (DOE 1992) is an analytical groundwater pollutant fate and transport model. It computes the spatial-temporal concentration distribution of waste in the aquifer system and predicts the transient spread of a contaminant plume through a groundwater aquifer. The application of both of these models is discussed in the following subsections.

6.5.2.1 SESOIL Modeling

The SESOIL model defines the soil column as compartments extending from the ground surface through the unsaturated zone and to the upper level of the saturated soil zone or top of bedrock. Processes simulated in SESOIL are categorized in three cycles: hydrologic, sedimentation, and pollutant. Each cycle is a separate submodule in the SESOIL code. The hydrologic cycle includes rainfall, surface runoff, percolation, soil-water content, evapotranspiration, and groundwater recharge. The sediment washload cycle includes erosion and sediment transport.

The pollutant cycle includes convective transport, volatilization, adsorption/desorption, and degradation/decay. A chemical in SESOIL can partition in up to four phases (liquid, adsorbed, air, and pure). Data requirements for SESOIL are not extensive and utilize a minimum of AOC-specific soil and chemical parameters and monthly or seasonal meteorological values as input.

The SESOIL model output includes pollutant concentrations at various soil depths and pollutant loss from the unsaturated soil zone in terms of surface runoff, percolation to groundwater, volatilization, and degradation. The mathematical representations in SESOIL generally consider the rate at which the modeled processes occur, the interaction of different processes with each other, and the initial conditions of the waste area and surrounding subsurface matrix material.

The input data for SESOIL can be grouped into four types: climatic, chemical, soil, and application data. There are 61 separate parameters contained in these four data groups. Wherever possible, AOC-specific parameter values were used for modeling. However, certain parameters were not available for the source areas and were estimated based on pertinent scientific literature, geochemical investigations, and checks for consistency between model results and historical data. Conservative estimates were used when a range of values existed or parameter values were not available.

6.5.2.2 Climate Data

The climatic data file of SESOIL consists of an array of mean monthly temperature, mean monthly cloud cover fraction, average monthly relative humidity, average monthly reflectivity of the earth’s surface (i.e., shortwave albedo), average daily evapotranspiration, monthly precipitation, mean number of storm events per month, mean duration of rainfall, and mean length of rainy season. The climatic data are presented in Table E-9 of Appendix E. The data set was taken from the Youngstown National Weather Service Office weather station at the Youngstown-Warren Regional Airport in Vienna, Ohio, as it was determined to be most appropriate in corresponding to the latitude and longitude at Camp Ravenna.

Climate data from the Youngstown weather station did not have all of the necessary climatic parameters for the HELP model simulation. Accordingly, the water balance evaluation presented in

Section 6.2.4 was based on the nearest available weather station data with all necessary coefficients stored within the HELP model (Cleveland, Ohio). Inputs for the SESOIL model (Youngstown station) and HELP model (Cleveland station) produced virtually the same recharge rate (9.40 cm/yr for Cleveland and 9.42 cm/yr for Youngstown) for each location. Therefore, the use of the two different weather station data sets did not impact modeling results.

6.5.2.3 Chemical Data

The pollutant fate cycle of SESOIL focuses on various chemical transport and transformation processes that may occur in the soil zone. These processes include volatilization/diffusion, adsorption/desorption, cation exchange, biodegradation and hydrolysis, and metal complexation. The chemical-specific parameters used for SESOIL are presented in Appendix E (Table E-10). The distribution coefficients (K_ds) for inorganic chemicals and the K_{oc} values or organic chemicals were obtained from the chemical-specific parameter table associated with the USEPA Risk Based Generic Screening Tables (USEPA 2015). The K_ds for organic chemicals were estimated from organic, carbon-based K_{oc} using the relationship $K_d = (f_{oc})(K_{oc})$, where f_{oc} = mass fraction of the organic carbon soil content obtained from AOC-specific measurements. In general, biodegradation rates are not applicable for inorganic CMCOPCs and biodegradation was not considered for the organic chemicals in this evaluation.

6.5.2.4 Soil Data

The soil data file of SESOIL contains input parameters describing the physical characteristics of the subsurface soil and is presented in Table 6-3. These parameters include soil bulk density, intrinsic permeability, soil disconnectedness index, soil porosity, organic carbon content, and cation exchange capacity. AOC-specific data were used from geotechnical samples collected at the AOC during the PBA08 RI (Table 5-4). There is, however, no measurement method for the soil disconnectedness index or a measured value of the Freundlich exponent. The soil disconnectedness index is a parameter that relates the soil permeability to the moisture content. Thus, SESOIL default values were used for these two parameters.

An average intrinsic permeability for the vadose zone, representing the unconsolidated zone above the water table, was calibrated using the percolation rate of 9.42 cm/yr (3.6 inches/year) as the calibration target. The model was calibrated against the percolation rate by varying the intrinsic permeability and keeping all other AOC-specific geotechnical parameters fixed. The final hydrogeologic parameter values used in this modeling are shown in Table 6-3. The soil porosity was set to the AOC-specific value. The intrinsic permeability, calibrated in SESOIL to the percolation rate (determined from a water balance estimated in HELP), was found to match the AOC-specific measurements from geotechnical samples.

The soil disconnectedness index replaces the moisture retention curves (or characteristic curves) used by other unsaturated zone leaching models. SESOIL's User Guide defines this parameter to be the exponent relating the "wetting" and "drying" time-dependent permeability of soil to its saturated permeability (Hetrick and Scott 1993). This "one variable" approach of using the soil disconnectedness index in SESOIL simplifies the data estimation process and reduces computational time. In addition, this parameter was calibrated for four different soil types ranging from sandy loam to clay (Hetrick et al. 1986), and calibrated values fell within the default range specified in the SESOIL's User Guide.

6.5.2.5 Source Terms

Analytical data from surface and subsurface soil collected at the AOC were used as source terms for SESOIL modeling. All the samples collected at different depth intervals were compiled to provide a detailed loading option for the SESOIL model. The maximum soil concentrations for each CMCOPC, listed in Table 6-1, were used as source term concentrations for the SESOIL model.

6.5.2.6 Application Data

Seven different layering schemes were developed for sample locations within the AOC due to varying thicknesses of the loading and leaching zones that are based on varying soil sample and groundwater depths throughout the AOC. Details of the model layers utilized in this modeling are presented in Table E-11 in Appendix E.

Each model was arranged in four layers. The top layer (Layer 1) for each model consisted of the loading zone, with the exception of the arsenic, cobalt, manganese, mercury, and thallium models.

The thicknesses of Layers 2 and 4 varied between the models for each chemical but served as a leaching zone in each. Layer 4 was a thin layer, included just above the water table to read output results at the water table/vadose zone interface (i.e., leachate concentration entering groundwater).

For the arsenic model, Layers 1 and 2 served as a loading zone in the 9-ft thick vadose zone. Layers 3 and 4 served as the leaching zone of 6 ft. For the cobalt and manganese models, Layers 1, 2, and 3 served as a loading zone in the 3-ft thick vadose zone. Layer 4 served as the leaching zone of 0.25 ft. For the mercury model, Layers 1, 2, and 3 served as a loading zone in the 5-ft thick vadose zone. Layer 4 served as the leaching zone of 0.25 ft. For the thallium model, Layers 1, 2, and 3 served as a loading zone in the 11-ft thick vadose zone. Layer 4 served as the leaching zone of 0.25 ft. In each of these models, Layer 4 was included just above the water table to read output results at the water table/vadose zone interface (i.e., leachate concentration entering groundwater).

6.5.3 SESOIL Modeling Results

SESOIL modeling was performed for initial CMCOPCs (i.e., arsenic, selenium, thallium, naphthalene, and phenanthrene from the FPA; cadmium, cobalt, manganese, selenium, and naphthalene from the NPA; and mercury from the DWA) that have the potential to reach the water table within 1,000 years based on the soil screening analysis results (Table 6-1). Table 6-4 presents the predicted peak leachate concentrations beneath the source areas relative to the discrete sample locations and ISM areas corresponding to the time of peak leachate concentrations. The Resident Receptor Adult FWCUGs, RVAAP facility-wide background concentrations, and MCL/RSL values for the CMCOPCs, if available, are also shown in this table for comparison purposes. All initial CMCOPCs modeled in SESOIL were selected as final CMCOPCs based on the results of the SESOIL modeling, as the predicted leachate concentrations below the source and just above the water table exceeded their respective screening criteria. These leachate concentrations do not reflect the groundwater concentrations beneath the source. When the leachate reaches the water table, dilution by groundwater further reduces leachate concentrations. Figures E-1 through E-11 in Appendix E show the leachate mass flux versus time plots generated by SESOIL that were used as input to the AT123D models.

6.5.4 AT123D Modeling in the Saturated Zone

The fate and transport processes accounted for in the AT123D model include advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in three dimensions in the groundwater resulting from a mass release over a source area (point, line, area, or volume source). The model can handle instantaneous, as well as continuous, source loadings of CMCOPC concentrations. AT123D is frequently used by the scientific and technical community to perform quick and conservative estimates of groundwater plume movements in space and time. SESOIL and AT123D are linked in a software package (RISKPRO) so that mass loading to the groundwater predicted by SESOIL can be transferred directly to AT123D. Therefore, AT123D was chosen to predict the maximum concentration of contaminants in groundwater after mixing with the leachate and the future concentrations for the contaminants in groundwater at the receptor locations.

The hydrogeologic parameter values used in this modeling are shown in Table 6-3. Most of the parameters presented in this table are AOC-specific values, unless otherwise indicated. The chemical-specific parameters used for AT123D are presented in Appendix E (Table E-12). A discussion of model assumptions and limitations is presented in Section 6.5.6.

Figures E-12 through E-28 show the predicted concentration versus time curves based on AT123D modeling at the source as well as at the receptor location. The screening criteria (MCL/RSL and Resident Receptor FWCUG) are also plotted in these figures as a constant line.

6.5.5 AT123D Modeling Results

Results of AT123D modeling for final soil and sediment CMCOPCs are shown in Table 6-5. The results show predicted groundwater concentrations for CMCOPCs beneath the source area and at the selected downgradient receptor locations (i.e., unnamed tributary to Sand Creek and unnamed tributary to the Mahoning River). Using the closest available downgradient monitoring wells for comparison with modeled source areas, observed groundwater concentrations from AOC monitoring wells are included in Table 6-5. The observed groundwater concentrations were added for comparison, not for screening criteria. The distances to the downgradient receptors were based on the distance along the groundwater flow direction to the closest surface water body.

For final soil CMCOPCs, the maximum predicted concentrations of selenium, thallium, and phenanthrene at the FPA and cadmium, selenium, and naphthalene at the NPA in groundwater were not predicted to exceed the screening criteria beneath the source area and were eliminated as CMCOCs. The maximum predicted concentrations of arsenic and naphthalene at the FPA, cobalt and manganese at the NPA, and mercury at the DWA were predicted to exceed the screening criteria in groundwater beneath the source area and were, therefore, modeled to the downgradient receptor locations (i.e., unnamed tributary to Sand Creek and unnamed tributary to the Mahoning River). The identified sediment CMCOPCs [mercury, benz(a)anthracene, benzo(b)fluoranthene, naphthalene, nitroguanidine, and PETN at the Drainage Ditches] were also predicted by analytical solutions to exceed screening criteria in groundwater beneath their source and were retained for lateral transport modeling using the AT123D model.

Lateral transport modeling showed that of all the soil CMCOPCs only naphthalene at the FPA was predicted to exceed the screening criteria at the downgradient receptor location (unnamed tributary to Sand Creek north of the AOC). None of the sediment CMCOPCs were predicted to exceed screening criteria at their downgradient receptor (unnamed tributary to the Mahoning River). Figure 6-5 presents CMCOCs identified based on AT123D modeling. The detailed input and output of the SESOIL and AT123D modeling are provided on a CD ROM included in Attachments 1 and 2, respectively, of Appendix E.

6.5.6 Limitations/Assumptions

In general, a conservative modeling approach was used, which may overestimate the contaminant concentration in the leachate for migration from observed soil concentrations. Listed below are important assumptions used in this analysis:

- The contaminant fate and transport evaluation included not only chemicals identified as being previously used during historical operations, but also included all chemicals identified as soil SRCs during the data screening and reduction process.
- Some soil SRCs were identified due to the absence of a background concentration or as having limited or slight exceedances of the established background concentrations.
- Chemical and biological degradation rates for organic CMCOPCs were not considered in the SESOIL and AT123D models.
- Using K_d and R to describe the reaction term of the transport equation assumes that an equilibrium relationship exists between the solid- and solution-phase concentrations and that the relationship is linear and reversible.
- Since AOC-specific data are not available, the K_d and K_{oc} values used in this analysis for all CMCOPCs represent literature or calculated values and may not represent conditions at the AOC.
- The K_d for inorganic chemicals used in the modeling evaluation assumed a pH of 6.8 [i.e., the middle value in the USEPA's evaluation presented in the soil screening guidance document (USEPA 1996b)]. The K_d for inorganic chemicals varies with pH (generally decreasing with decreasing pH, although there are few exceptions); therefore, if AOC-specific pH

measurements are greater or less than 6.8, the K_d and calculated screening parameters (such as R) will deviate from those presented here.

- Flow and transport in the vadose zone is one-dimensional (i.e., only in the vertical direction).
- This modeling used current soil concentrations that were collected approximately 65 years after historical operations were terminated at the AOC. Therefore, it does not account for constituents that have already leached to groundwater.
- Flow and transport are not affected by density variations. Variability in the distribution of soil contamination and overall impacts to predicted groundwater concentrations were not considered in the models. A realistic distribution of soil contamination was not considered. The maximum concentration value was used as the source term concentration for SESOIL model layers; this is a highly conservative assumption that is expected to produce higher leachate concentrations for CMCOPCs than the average condition. The horizontal distribution of soil contamination was assumed based on concentration levels from nearby sample locations as opposed to taking into account the entire area.
- The water balance represents an overall average rainwater recharge and assumes an even distribution of infiltration in the modeled area. An average water balance assumes some areas will have higher or lower recharge based on the heterogeneity of the soil and varying topography.

The inherent uncertainties associated with using these assumptions must be recognized. K_d values are highly sensitive to changes in the major chemistry of the solution phase. Therefore, it is important that the values be measured or estimated under conditions that will closely represent those of the contaminant plume. Deviations of actual AOC-specific parameter values from assumed literature values may significantly affect contaminant fate predictions. It is also important to note that the contaminant plume will change over time and will be affected by multiple solutes present at the AOC. The effects of heterogeneity and anisotropy are not addressed in these simulations. The discrepancy between the contaminant concentrations measured in the field and the values predicted by the model could be investigated by performing sensitivity analyses on the model input parameters that have the most influence on the model predictions.

These parameters are: (1) biodegradation rate constants for organic chemicals; (2) saturated hydraulic conductivity; (3) soil porosity; (4) f_{oc} for organic chemicals; (5) K_d for inorganic chemicals; and (6) longitudinal, transverse, and vertical dispersivity values. Generally, higher biodegradation rates will produce lower concentrations, and lower rates will produce higher concentrations for organic chemicals without impacting the results of the inorganic chemicals. In this analysis, biodegradation rates for organic chemicals have been assumed to be zero, thereby predicting higher concentrations for the organic chemicals in groundwater than would be expected to be observed in the future. Higher hydraulic conductivity and dispersivity causes higher advection and dispersion, thereby producing lower peaks near the source area, but increasing the migration distance. The reverse will be true with lower hydraulic conductivity and dispersivity values. Higher f_{oc} values have a similar effect on organic chemicals as higher K_d has on inorganic chemicals; they decrease the mobility of the chemicals as well as produce lower concentrations in groundwater.

6.6 EVALUATION TO IDENTIFY CMCOCS

This evaluation of contaminant fate and transport uses a soil screening analysis to identify SRCs that have potential to leach to groundwater, performs SESOIL modeling to conservatively estimate final CMCOPC leachate concentrations before the SRCs enter the groundwater system beneath the sources with highest level of contamination, and uses AT123D modeling to present a conservative maximum concentration in groundwater of final CMCOPCs beneath the sources and at downgradient receptor locations.

This analysis also includes a sediment screening analysis that was performed for sediment samples at the AOC. Chemical-specific DAFs were calculated using co-located surface water and sediment concentrations for identified sediment SRCs. These DAFs were used in the sediment screening analysis to identify CMCOPCs for predictive modeling and further evaluation.

The limitations and assumptions of the overall process are presented in Section 6.5.6. The text below provides a list of the remaining final CMCOPCs in soil and sediment, and a qualitative assessment of the results and considerations of the limitations and assumptions.

6.6.1 Evaluation of Remaining Soil CMCOPCs

6.6.1.1 Former Production Area (FPA)

Arsenic – The maximum surface soil concentration for arsenic (32 mg/kg at LL9sb-019) was above the Resident Receptor Adult FWCUG at a TR of 1E-06, HQ of 0.1. The exposure point concentrations (EPCs) for arsenic in surface soil (13 mg/kg) and subsurface soil (15 mg/kg) at the FPA are below their respective facility-wide background concentrations. Therefore, arsenic concentrations in soil are representative of background. In addition, arsenic concentrations in AOC groundwater samples collected from 2009–2010 were below the MCL (Table 6-5). Also, based on AT123D modeling results, arsenic is not predicted to migrate to the downgradient receptor location at detectable concentrations within 1,000 years (see Table 6-5).

Naphthalene – The maximum surface soil concentration for naphthalene (0.92 mg/kg at LL9ss-096) was below the Resident Receptor Adult FWCUG at a TR of 1E-06, HQ of 0.1, and naphthalene was not considered a soil COPC in the HHRA. Naphthalene modeling results using this maximum concentration indicate groundwater concentrations beneath the source area could potentially exceed its RSL in less than 30 years; naphthalene was not detected in the AOC groundwater samples collected from 2009–2010 (Table 6-5). Based on the AOC period of operations, naphthalene should have already been detected in groundwater. Therefore, this evaluation concludes that the model-predicted concentrations are conservative and naphthalene would be expected to be below its RSL based on its estimated site-specific biodegradation rate.

6.6.1.2 Non-Production Area (NPA)

Cobalt – The maximum soil concentration for cobalt in the NPA (18 mg/kg) is below the facility-wide background concentration for subsurface soil (23.2 mg/kg). Therefore, the soil concentrations of cobalt within this aggregate are representative of background concentrations and do not reflect contamination from historical AOC operations. Therefore, any impacts to groundwater predicted by the model reflect naturally occurring processes and cobalt is not considered a CMCOC.

Manganese – The maximum surface soil concentration for manganese (3,800 mg/kg at LL9ss-027) was above the Resident Receptor Adult FWCUG at a TR of 1E-06, HQ of 0.1, but below the Resident Receptor Adult FWCUG at a TR of 1E-05, HQ of 1. The EPC in surface soil (1,200 mg/kg) is below the surface soil background concentration (1,450 mg/kg). In addition, all subsurface soil samples had manganese concentrations below the subsurface background concentration (3,030 mg/kg) and do not reflect contamination from historical AOC operations. Therefore, any impacts to groundwater predicted by the model reflect naturally occurring processes and manganese is not considered a CMCOC.

6.6.1.3 Dry Well Area (DWA)

Mercury – The maximum surface soil concentration for mercury in the DWA (9.7 mg/kg at LL9sb-065) was below the Resident Receptor Adult FWCUG at a TR of 1E-06 and HQ of 0.1, and mercury was not identified as a soil COC in the HHRA in the DWA. Mercury was not detected in the AOC groundwater samples collected from 2009–2010 (Table 6-5). Mercury modeling results for the DWA indicate it would take nearly 300 years for a breakthrough in groundwater beneath the source at the maximum concentration of 0.0027 mg/L which is slightly above the MCL (0.002 mg/L), and mercury is not predicted to migrate to the downgradient receptor location at detectable concentrations (see Table 6-5).

6.6.2 Evaluation of Remaining Sediment CMCOPCs

6.6.2.1 Drainage Ditches

Mercury – The maximum sediment concentration for mercury in the Drainage Ditches (0.37 mg/kg) was below the Resident Receptor Adult FWCUG at a TR of 1E-06 and HQ of 0.1, and mercury was not identified as a sediment COPC in the HHRA for this area. Mercury was not detected in the AOC groundwater samples collected from 2009–2010 (Table 6-5). Mercury modeling results indicate concentrations decreasing below its MCL after the first year and continuing to decrease into the future, and mercury is not predicted to migrate to the downgradient receptor location at detectable concentrations (see Table 6-5). The sediment modeling approach is conservative in that it does not take into account chemical attenuation or biodegradation processes. Operations at Load Line 9 ceased in 1945, or about 50 years before RI samples were collected. Given that no mercury was detected in AOC monitoring wells and the model predicts concentrations below the MCL after the first year, no impacts to groundwater from mercury are anticipated.

Benz(a)anthracene – The maximum sediment concentration for benz(a)anthracene was below the Resident Receptor Adult FWCUG at a TR of 1E-06 and HQ of 0.1, and benz(a)anthracene was not identified as a sediment COC in the HHRA for this area. Benz(a)anthracene was not detected in the AOC groundwater samples collected from 2009–2010 (Table 6-5). Benz(a)anthracene modeling results indicate concentrations decreasing below the RSL after 20 years and continuing to decrease into the future, and benz(a)anthracene is not predicted to migrate to the downgradient receptor location at detectable concentrations (see Table 6-5). The sediment modeling approach is conservative in that it does not take into account chemical attenuation or biodegradation processes. Benz(a)anthracene would be expected to be below its RSL based on its estimated site-specific biodegradation rate. Operations at Load Line 9 ceased in 1945, or about 50 years before RI samples were collected. Given that no benz(a)anthracene was detected in AOC monitoring wells and the model predicts concentrations below the RSL after 20 years under conservative assumptions, no impacts to groundwater from benz(a)anthracene are anticipated.

Benzo(b)fluoranthene – The maximum sediment concentration for benzo(b)fluoranthene was below the Resident Receptor Adult FWCUG at a TR of 1E-06 and HQ of 0.1, and benzo(b)fluoranthene was not identified as a sediment COC in the HHRA for this area. Benzo(b)fluoranthene was not detected in the AOC groundwater samples collected from 2009–2010 (Table 6-5). Benzo(b)fluoranthene modeling results indicate concentrations decreasing below the RSL after the first year and continuing to decrease into the future, and benzo(b)fluoranthene is not predicted to migrate to the downgradient receptor location at detectable concentrations (see Table 6-5). The sediment modeling approach is conservative in that it does not take into account chemical attenuation or biodegradation processes. Benzo(b)fluoranthene would be expected to be below its RSL based on its estimated site-specific biodegradation rate. Operations at Load Line 9 ceased in 1945, or about 50 years before RI samples were collected. Given that no benzo(b)fluoranthene was detected in AOC monitoring wells and the model predicts concentrations below the RSL after the first year, no impacts to groundwater from benzo(b)fluoranthene are anticipated.

Naphthalene – The only detected sediment concentration for naphthalene in the Drainage Ditches (0.0092 mg/kg at LL9sd-114) was below the Resident Receptor Adult FWCUG at a TR of 1E-06 and HQ of 0.1, and naphthalene was not identified as a sediment COC in the HHRA for this area. Naphthalene was not detected in the AOC groundwater samples collected from 2009–2010 (Table 6-5). Naphthalene modeling results at the Drainage Ditches indicate concentrations decreasing below the RSL in less than 10 years and continuing to decrease into the future, and naphthalene is not predicted to migrate to the downgradient receptor location at concentrations above the RSL (see Table 6-5). The sediment modeling approach is conservative in that it does not take into account chemical attenuation or biodegradation processes. Operations at Load Line 9 ceased in 1945, or about 50 years before RI samples were collected. Naphthalene would be expected to be below its RSL based on its estimated site-specific biodegradation rate. Given that no naphthalene was detected in AOC monitoring wells and the model predicts concentrations below the RSL after 10 years under conservative assumptions, no impacts to groundwater from naphthalene are anticipated.

Nitroguanidine – The maximum sediment concentration for nitroguanidine in the Drainage Ditches (1.4 mg/kg at LL9sd-113) has no Resident Receptor Adult FWCUG available for comparison.

Nitroguanidine was not identified as a sediment COC in the HHRA for this area. Nitroguanidine was not detected in the AOC groundwater samples collected from 2009–2010 (Table 6-5). Nitroguanidine modeling results at the Drainage Ditches indicate concentrations decreasing below the RSL after approximately five years and continuing to decrease into the future, and nitroguanidine is not predicted to migrate to the downgradient receptor location at concentrations above the RSL (see Table 6-5). The sediment modeling approach is conservative in that it does not take into account chemical attenuation or biodegradation processes. Operations at Load Line 9 ceased in 1945, or about 50 years before RI samples were collected. Nitroguanidine would be expected to be below its RSL based on its estimated site-specific biodegradation rate. Given that no nitroguanidine was detected in AOC monitoring wells and the model predicts concentrations below the RSL after five years under conservative assumptions, no impacts to groundwater from nitroguanidine are anticipated.

PETN – There was only one detected sediment concentration for PETN and a Resident Receptor Adult FWCUG is not available for comparison. PETN was not identified as a sediment COC in the HHRA for this area and was not detected above the RSL in the AOC groundwater samples collected from 2009–2010 (Table 6-5). PETN modeling results indicate concentrations decreasing below the RSL after the first year and continuing to decrease into the future, and PETN is not predicted to migrate to the downgradient receptor location at concentrations above the RSL (see Table 6-5). The sediment modeling approach is conservative in that it does not take into account chemical attenuation or biodegradation processes. Operations at Load Line 9 ceased in 1945, or about 50 years before RI samples were collected. PETN would be expected to be below its RSL based on its estimated site-specific biodegradation rate. Given that PETN was not detected above the RSL in AOC monitoring wells and the model predicts concentrations below the RSL after the first year, no impacts to groundwater from PETN are anticipated.

This qualitative assessment concludes that the soil and sediment contaminants identified as final CMCOPCs for evaluation, due to predicted groundwater concentrations beneath a source or at the downstream receptor location, are not adversely impacting groundwater quality based on current data and are not predicted to have future impacts. Potential additional investigation under the Facility-wide Groundwater AOC may be warranted, but based on the fate and transport evaluation, CMCOCs are not identified for Load Line 9, and no further action is required of soil and sediment to be protective of groundwater.

6.7 SUMMARY AND CONCLUSIONS

Inorganic and organic SRCs exist in surface soil, subsurface soil, and sediment at Load Line 9. These SRCs include chemicals that were identified as potential contaminants from previous site usage and chemicals that were identified from the SRC screening process using available data. All SRCs were further evaluated to determine if residual concentrations in soil and sediment may potentially impact groundwater quality and warrant evaluation in an FS.

All SRCs identified in the surface and subsurface soil and sediment at Load Line 9 were evaluated through the stepwise fate and transport evaluation.

The evaluation of modeling results with respect to current AOC groundwater data and model limitations identified the following CMCOPCs:

- Among the soil CMCOPCs, arsenic, cobalt, manganese, mercury, and naphthalene were predicted to exceed the screening criteria in groundwater beneath the source area, and only naphthalene was predicted to be above its criteria at the downgradient receptor location.
- Among the sediment CMCOPCs, mercury, nitroguanidine, PETN, benz(a)anthracene, benzo(b)fluoranthene, and naphthalene were predicted to exceed the screening criteria in groundwater beneath the source area; however, none of these CMCOPCs were predicted to be above criteria in the downgradient receptor location.

A qualitative assessment of the sample results and considerations of the limitations and assumptions of the models were performed to identify if any CMCOCs are present in soil and sediment at Load Line 9 that may impact the groundwater beneath the source or at the downstream receptor location. This qualitative assessment concluded that there were no CMCOCs present in soil and sediment that may impact the groundwater beneath the source or at the downstream receptor location. No further action is required of soil and sediment at Load Line 9 for the protection of groundwater.

Table 6–1. Initial CMCOPCs Evaluated with SESOIL Modeling

SRC	Maximum Concentration (mg/kg)	Discrete Sample Location	Sample Depth (ft bgs)	Leachate Modeling? (Yes/No)
Former Production Area				
Inorganic chemicals				
Arsenic	3.20E+01	LL9sb-019-0001-SO	0-3	Yes
Selenium	1.40E+00	LL9ss-097-5475-SO	0-1	Yes
Thallium	1.00E+00	LL9sb-043-0001-SO	9-11	Yes
Semi-volatile organic compounds				
Naphthalene	9.20E-01	LL9ss-096-5474-SO	0-1	Yes
Phenanthrene	4.30E+01	LL9ss-096-5474-SO	0-1	Yes
Non-Production Area				
Inorganic chemicals				
Cadmium	2.70E+00	LL9ss-068-0001-SO	0-1	Yes
Cobalt	1.80E+01	LL9ss-027-0001-SO	0-3	Yes
Manganese	3.80E+03	LL9ss-027-0001-SO	0-3	Yes
Selenium	1.80E+00	LL9ss-068-0001-SO	0-1	Yes
Semi-volatile organic compounds				
Naphthalene	1.90E-02	LL9ss-068-0001-SO	0-1	Yes
Dry Well Area				
Inorganic chemicals				
Mercury	9.70E+00	LL9sb-065-0001-SO	3-5	Yes

bgs = Below ground surface.
Ft = Feet.
mg/kg = Milligrams per kilogram.
SRC = Site-related contaminant.

Table 6–2. Sediment Screening Results for Load Line 9

Analyte	CAS Number	Background Criteria (mg/kg)[a]	Maximum Sediment Concentration (mg/kg)	Sediment Sample ID	K_{oc} (L/kg)	Reference	K_d (L/kg)	Reference	Maximum Groundwater Concentration (mg/L)[b]	DAF[c]	Maximum Groundwater Concentration (mg/L)/DAF	MCL or RSL (mg/L)	MCL or RSL?	CMCOPC (Yes/No)
Drainage Ditches														
Inorganic Chemicals														
Antimony	7440-36-0	0.00E+00	1.60E-01	LL9sd-113-5471-SD	NA	-	4.50E+01	f	3.56E-03	2	1.78E-03	6.00E-03	MCL	No
Beryllium	7440-41-7	3.80E-01	8.90E-01	LL9sd-113-5471-SD	NA	-	7.90E+02	f	1.13E-03	9	1.25E-04	4.00E-03	MCL	No
Cadmium	7440-43-9	0.00E+00	7.20E-01	LL9sd-113-5471-SD	NA	-	7.50E+01	f	9.60E-03	140	6.86E-05	5.00E-03	MCL	No
Cobalt	7440-48-4	9.10E+00	1.00E+01	LL9sd-113-5471-SD	NA	-	4.50E+01	f	2.22E-01	317	7.01E-04	6.00E-03	RSL	No
Lead	7439-92-1	2.74E+01	3.11E+01	LL9sd-113-5471-SD	NA	-	9.00E+02	f	3.46E-02	10	3.46E-03	1.50E-02	MCL	No
Mercury	**7439-97-6**	**5.90E-02**	**3.70E-01**	**LL9sd-114-5472-SD**	**NA**	**-**	**5.20E+01**	**f**	**7.12E-03**	**2**	**3.56E-03**	**2.00E-03**	**MCL**	**Yes**
Nickel	7440-02-0	1.77E+01	1.93E+01	LL9sd-113-5471-SD	NA	-	6.50E+01	f	2.97E-01	106	2.80E-03	3.90E-01	RSL	No
Silver	7440-22-4	0.00E+00	6.60E-02	LL9sd-113-5471-SD	NA	-	8.30E+00	f	7.95E-03	2	3.98E-03	9.40E-02	RSL	No
Explosives														
Nitroguanidine	**556-88-7**	**None**	**1.20E+00**	**LL9sd-113-5471-SD**	**2.07E+01**	**f**	**2.48E-02**	**g**	**4.84E+01**	**2**	**2.42E+01**	**2.00E+00**	**RSL**	**Yes**
PETN	**78-11-5**	**None**	**1.30E-01**	**LL9sd-114-5472-SD**	**6.48E+02**	**f**	**7.78E-01**	**g**	**1.67E-01**	**2**	**8.36E-02**	**1.90E-02**	**RSL**	**Yes**
Semi-volatile Organic Compounds														
2-Methylnaphthalene	91-57-6	None	1.40E-02	LL9sd-114-5472-SD	2.48E+03	f	2.98E+00	g	4.70E-03	2	2.35E-03	3.60E-02	RSL	No
Benz(*a*)anthracene	**56-55-3**	**None**	**3.60E-02**	**LL9sd-114-5472-SD**	**1.77E+05**	**f**	**2.12E+02**	**g**	**1.69E-04**	**2**	**8.47E-05**	**1.20E-05**	**RSL**	**Yes**
Benzenemethanol	100-51-6	None	3.60E-02	LL9sd-113-5471-SD	2.15E+01	f	2.58E-02	g	1.40E+00	2	6.98E-01	2.00E+00	RSL	No
Benzo(*a*)pyrene	50-32-8	None	3.90E-02	LL9sd-114-5472-SD	5.87E+05	f	7.04E+02	g	5.54E-05	2	2.77E-05	2.00E-04	MCL	No
Benzo(*b*)fluoranthene	**205-99-2**	**None**	**5.80E-02**	**LL9sd-114-5472-SD**	**5.99E+05**	**f**	**7.19E+02**	**g**	**8.07E-05**	**2**	**4.03E-05**	**3.40E-05**	**RSL**	**Yes**
Benzo(*ghi*)perylene[d]	191-24-2	None	2.70E-02	LL9sd-114-5472-SD	1.07E+07	h	1.28E+04	g	2.10E-06	2	1.05E-06	1.20E-01	RSL	No
Benzo(*k*)fluoranthene	207-08-9	None	1.90E-02	LL9sd-114-5472-SD	5.87E+05	f	7.04E+02	g	2.70E-05	2	1.35E-05	3.40E-04	RSL	No
Chrysene	218-01-9	None	4.00E-02	LL9sd-114-5472-SD	1.81E+05	f	2.17E+02	g	1.84E-04	2	9.21E-05	3.40E-03	RSL	No
Fluoranthene	206-44-0	None	9.50E-02	LL9sd-114-5472-SD	5.55E+04	f	6.66E+01	g	1.43E-03	2	7.13E-04	8.00E-01	RSL	No
Indeno(1,2,3-*cd*)pyrene	193-39-5	None	2.40E-02	LL9sd-114-5472-SD	1.95E+06	f	2.34E+03	g	1.03E-05	2	5.13E-06	3.40E-05	RSL	No
Naphthalene	**91-20-3**	**None**	**9.20E-03**	**LL9sd-114-5472-SD**	**1.54E+03**	**f**	**1.85E+00**	**g**	**4.98E-03**	**2**	**2.49E-03**	**1.70E-04**	**RSL**	**Yes**
Phenanthrene[e]	85-01-8	None	3.90E-02	LL9sd-114-5472-SD	1.82E+04	h	2.18E+01	g	1.79E-03	2	8.93E-04	1.20E-01	RSL	No
Pyrene	129-00-0	None	6.70E-02	LL9sd-114-5472-SD	5.43E+04	f	6.52E+01	g	1.03E-03	2	5.14E-04	1.20E-01	RSL	No
Volatile Organic Compounds														
Toluene	108-88-3	None	4.40E-04	LL9sd-113-5471-SD	2.34E+02	f	2.81E-01	g	1.57E-03	2	3.62E-04	1.00E+00	MCL	No
Dry Well Area														
Inorganic Chemicals														
Beryllium	7440-41-7	3.80E-01	8.60E-01	LL9sd-012-0001-SD	NA	-	7.90E+02	f	1.09E-03	13	8.37E-05	4.00E-03	MCL	No
Mercury	7439-97-6	5.90E-02	2.90E+00	LL9sd-012-0001-SD	NA	-	5.20E+01	f	5.58E-02	186	3.00E-04	2.00E-03	MCL	No
Nickel	7440-02-0	1.77E+01	1.90E+01	LL9sd-012-0001-SD	NA	-	6.50E+01	f	2.92E-01	55	5.31E-03	3.90E-01	RSL	No

[a] Background criteria for sediment from final facility-wide background values for the Ravenna Army Ammunition Plant, published in the Final *Phase II Remedial Investigation Report for Winklepeck Burning Grounds at Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2001).

[b] Maximum groundwater concentration = maximum sediment concentration divided by the distribution coefficient.

[c] An exposure unit-specific DAF was calculated based on the sediment and co-located surface water concentrations (Table 6-2). The lowest calculated DAF for each exposure unit (i.e., 2 for the Load Line 9 Drainage Ditches and 13 for the Dry Well Area) was used for analytes that did not have an exposure unit-specific DAF.

[d] Pyrene RSL was used as a surrogate for benzo(*ghi*)perylene.

[e] Pyrene RSL was used as a surrogate for phenanthrene.

[f] USEPA RSL Generic Tables June 2015; found at: < http://www2.epa.gov/risk/risk-based-screening-table-generic-tables>.

[g] K_d value for organic chemicals calculated by multiplying K_{oc} by foc of 0.0012 (average geotechnical data from Load Line 7, Load Line 10, and Load Line 11).

[h] USEPA 1994. Risk Reduction Engineering Laboratory Treatability Database, Ver. 5.0, Office of Research and Development, Cincinnati, Ohio.

CAS = Chemical Abstract Service.
CMCOPC = Contaminant Migration Chemical of Potential Concern.
DAF = Dilution Attenuation Factor.
ID = Identification.
K_d = Distribution coefficient.
K_{oc} = Organic carbon distribution coefficient.
L/kg = Liters per kilogram.
MCL = Maximum Contaminant Level.
mg/kg = Milligrams per kilogram.
mg/L = Milligrams per liter.
NA = Not Applicable.
RSL = Regional Screening Level (USEPA 2015).
SRC = Site-related Contaminant.
Bold = Final CMCOPC to be modeled with Analytical Transient 1-, 2-, 3-Dimensional model.

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Table 6–3. Unit-Specific Parameters Used in SESOIL and AT123D Modeling

Parameters	Symbol	Units	Value	Source for Value
SESOIL				
Percolation Rate (Recharge Rate)	q	m/yr	9.42E-02	0.1 SESOIL Precipitation for Youngstown, Ohio
Horizontal Area of Aggregate	A_p	cm^2	Varies	Sample specific
Intrinsic Permeability - clayey sand	p	cm^2	1.05E-10	Calibrated from SESOIL model
Disconnectedness Index	c	unitless	11	Calibrated from SESOIL model
Freundlich Equation Exponent	n	unitless	1	SESOIL default
Fraction Organic Carbon	f_{oc}	unitless	1.20E-03	Average from the PBA08 RI Geotechnical Samples from Load Lines 7, 10, and 11
Bulk Density	ρ_b	kg/L	1.7	
Moisture Content	w	wt %	18.3	
Water-filled Soil Porosity	Tw	unitless	0.311	
Air-filled Soil Porosity	Ta	unitless	0.068	
Porosity – total	n_T	unitless	0.379	
Vadose Zone Thickness	Vz	m	0.61 to 2.7	Average depth to water table from potentiometric surface map (Figure 6-4)
Leaching Zone Thickness	Th	m	0–2.4	Based on distance from deepest detection of a CMCOPC to the water table from potentiometric surface maps (Figure 6-4)
AT123D				
Aquifer Thickness	h	m	6	Conservative assumption for sallow bedrock aquifer. Facility-wide assumption for the unconsolidated aquifer presented the Load Line 1 investigation was 6 meters (USACE 2003b)
Hydraulic Conductivity in Saturated Zone	K_S	cm/s	3.99E-04	Average of slug test results (MKM 2007)
Hydraulic Gradient	i	unitless	2.31E-02	Average gradient determined from Figure 3-1.

Table 6-3. Unit-Specific Parameters Used in SESOIL and AT123D Modeling (continued)

Parameters	Symbol	Units	Value	Source for Value
Effective porosity	n_e	unitless	0.2	Assumed for sandstone (USEPA 1985)
Dispersivity, longitudinal	α_L	m	30	Assumed
Dispersivity, transverse	α_T	m	3	0.1 α_L
Dispersivity, vertical	α_V	m	0.3	0.01 α_L
Retardation factor	R_d	unitless	chemical-specific	Presented in Table E-7 in Appendix E

MKM 2007. Report for the Phase I Remedial Investigation at Load Line 9 (March 2007).

USACE 2003b. Phase II Remedial Investigation Report for the Load Line 1 at the Ravenna Army Ammunition Plant, Ravenna, Ohio. June 2003.

USEPA 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water, Revised 1985 Parts 1 and 2, EPA/600/6-85/002. Office of Research and Development, Environmental Research Laboratory, Athens, Georgia. September 1985.

AT123D = Analytical Transient 1-,2-,3-Dimensional model.
cm^2 = Square centimeters.
CMCOPC = Contaminant migration chemical of potential concern.
cm/s = Centimeters per second.
kg/L = Kilograms per liter.
m = Meter.
m/yr = Meters per year.
PBA08 RI = Performance Based Acquisition 2008 Remedial Investigation.
SESOIL = Seasonal soil compartment model.
wt % = Weight bb percent.

Table 6–4. Summary of SESOIL Modeling Results

Initial CMCOPC	Maximum Soil Concentration (mg/kg)	Discrete Sample Location	Maximum Depth of Contamination (ft bgs)	Depth to Groundwater (ft bgs)	Predicted $C_{L, max}$ Beneath Source (mg/L)	Time Required to Reach $C_{leachate, max}$ (years)	MCL/RSL (mg/L)	Resident Receptor Adult FWCUG[a] (mg/L)	Facility-wide Background Bedrock Groundwater (mg/L)	Final CMCOPC?[b] (yes/no)
Former Production Area										
Inorganic Chemicals										
Arsenic	**3.20E+01**	**LL9sb-019-0001-SO**	**3**	**9**	**4.94E-01**	**597**	**1.00E-02**	**5.60E-05**	**0.00E+00**	**Yes**
Selenium	**1.40E+00**	**LL9ss-097-5475-SO**	**1**	**6**	**9.89E-02**	**84**	**5.00E-02**	**None**	**0.00E+00**	**Yes**
Thallium	**1.00E+00**	**LL9sb-043-0001-SO**	**11**	**11**	**1.32E-02**	**407**	**2.00E-03**	**2.91E-04**	**0.00E+00**	**Yes**
Semi-volatile Organic Compounds										
Naphthalene	**9.20E-01**	**LL9ss-096-5474-SO**	**1**	**6**	**1.34E-01**	**33**	**1.70E-04**	**None**	**None**	**Yes**
Phenanthrene	**4.30E+01**	**LL9ss-096-5474-SO**	**1**	**6**	**1.40E-01**	**349**	**1.20E-01**	**None**	**None**	**Yes**
Non-Production Area										
Inorganic Chemicals										
Cadmium	**2.70E+00**	**LL9ss-068-0001-SO**	**1**	**2**	**4.40E-02**	**457**	**5.00E-03**	**1.47E-03**	**0.00E+00**	**Yes**
Cobalt	**1.80E+01**	**LL9ss-027-0001-SO**	**3**	**3**	**3.76E-01**	**263**	**6.00E-03**	**7.29E-02**	**0.00E+00**	**Yes**
Manganese	**3.80E+03**	**LL9ss-027-0001-SO**	**3**	**3**	**3.72E+01**	**464**	**4.30E-01**	**1.58E-01**	**1.34E+00**	**Yes**
Selenium	**1.80E+00**	**LL9ss-068-0001-SO**	**1**	**2**	**4.40E-01**	**32**	**5.00E-02**	**None**	**0.00E+00**	**Yes**
Semi-volatile Organic Compounds										
Naphthalene	**1.90E-02**	**LL9ss-068-0001-SO**	**1**	**2**	**7.91E-03**	**12**	**1.70E-04**	**None**	**None**	**Yes**
Dry Well Area										
Inorganic Chemicals										
Mercury	**9.70E+00**	**LL9sb-065-0001-SO**	**5**	**5**	**1.38E-01**	**296**	**2.00E-03**	**None**	**0.00E+00**	**Yes**

[a] The FWCUG is based on a target risk of 10^{-6} and a Hazard Index of 0.1.

[b] The Final CMCOPC was identified comparing predicted maximum leachate concentration to MCL/RSL, FWCUGs, and facility-wide background. A constituent is an initial CMCOPC if its predicted leachate concentration exceeds its MCL/RSL within 1,000 years.

bgs = Below ground surface.
CMCOPC = Contaminant migration chemical of potential concern.
ft = Feet.
FWCUG=Facility-wide cleanup goal.
MCL=Maximum contaminant level.
mg/kg = Milligram per kilogram.
mg/L = Milligram per liter.
RSL=Regional screening level.
Bold = CMCOPCs exceeding MCL/RSL, FWCUGs, and facility-wide background concentrations.

Table 6–5. Summary of AT123D Modeling Results

Final CMCOPC	Maximum Leachate Concentration, $C_{L, max}$ [a] (mg/L)	Predicted Max Groundwater Concentration[b] ($C_{gw,MAX}$) Beneath Source (mg/L)	Predicted Max Groundwater Concentration[b] ($C_{R,MAX}$) Downgradient Receptor (mg/L)	Distance to Downgradient Receptor (ft)	Observed Maximum Groundwater Concentrations[c] (mg/L)	MCL/RSL (mg/L)	Resident Adult FWCUG[d] (mg/L)	Facility-wide Background Bedrock Groundwater (mg/L)	CMCOC for Further WOE Evaluation?[e] (yes/no)
Final CMCOPCs in Soil at the Former Production Area									
Inorganic chemicals									
Arsenic	4.94E-01	1.05E-01	0.00E+00	2,480	4.50E-03	1.00E-02	5.60E-05	0.00E+00	Yes
Selenium	9.89E-02	8.85E-04	9.11E-09	2,480	ND	5.00E-02	None	0.00E+00	No
Thallium	1.32E-02	2.56E-04	0.00E+00	2,279	3.30E-04	2.00E-03	2.91E-04	0.00E+00	No
Semi-volatile Organic Compounds									
Naphthalene	1.34E-01	1.85E-02	5.03E-04	2,547	ND	1.70E-04	None	None	Yes
Phenanthrene[g]	1.40E-01	3.77E-02	0.00E+00	2,547	2.80E-03	1.20E-01	None	None	No
Final CMCOPCs in Soil at the Non-Production Area									
Inorganic chemicals									
Cadmium	4.40E-02	8.99E-04	0.00E+00	1,072	1.40E-04	5.00E-03	1.47E-03	0.00E+00	No
Cobalt	3.76E-01	1.64E-02	0.00E+00	1,274	9.30E-03	6.00E-03	7.29E-02	0.00E+00	Yes
Manganese	3.72E+01	1.68E+00	0.00E+00	1,274	2.45E+00	4.30E-01	1.58E-01	1.34E+00	Yes
Selenium	4.40E-01	3.78E-03	7.35E-06	1,072	ND	5.00E-02	None	0.00E+00	No
Semi-volatile Organic Compounds									
Naphthalene	7.91E-03	3.73E-05	1.54E-07	1,072	ND	1.70E-04	None	None	No
Final CMCOPCs in Soil at the Dry Well Area									
Inorganic chemicals									
Mercury	1.38E-01	2.70E-03	0.00E+00	1,609	ND	2.00E-03	None	0.00E+00	Yes
Final CMCOPCs in Sediment at the Drainage Ditches									
Inorganic chemicals									
Mercury	3.56E-03	3.54E-03	0.00E+00	2,478	ND	2.00E-03	None	0.00E+00	Yes
Semi-volatile Organic Compounds									
Benz(a)anthracene	8.47E-05	8.46E-05	0.00E+00	2,478	ND	1.20E-05	4.00E-06	None	Yes
Benzo(b)fluoranthene	4.03E-05	4.03E-05	0.00E+00	2,478	ND	3.40E-05	2.00E-06	None	Yes
Naphthalene	2.49E-03	2.48E-03	6.09E-07	2,478	ND	1.70E-04	None	None	Yes

Table 6–5. Summary of AT123D Modeling Results (continued)

Final CMCOPC	Maximum Leachate Concentration, $C_{L,\,max}$ [a] (mg/L)	Predicted Max Groundwater Concentration[b] ($C_{gw,MAX}$) Beneath Source (mg/L)	Predicted Max Groundwater Concentration[b] ($C_{R,MAX}$) Downgradient Receptor (mg/L)	Distance to Downgradient Receptor (ft)	Observed Maximum Groundwater Concentrations[c] (mg/L)	MCL/RSL (mg/L)	Resident Adult FWCUG[d] (mg/L)	Facility-wide Background Bedrock Groundwater (mg/L)	CMCOC for Further WOE Evaluation?[e] (yes/no)
Explosives									
Nitroguanidine	2.42E+01	2.40E+01	5.16E-01	1,274	ND	2.00E+00	None	None	Yes
PETN	8.36E-02	8.35E-02	5.75E-05	2,478	1.00E-03	1.90E-02	None	None	Yes

[a] Represents SESOIL predicted maximum leachate concentration just above the water table.

[b] The predicted concentration was estimated using the results from SESOIL and applying AT123D model.

[c] Observed groundwater concentrations were reported in the *RVAAP Facility-wide Groundwater Monitoring Program 2009 Annual Report* (EQM 2010) and sampling events through 2012.

[d] The Resident Receptor Adult FWCUG is based on a target risk of 10^{-6} and a Hazard Index of 0.1.

[e] The CMCOC was identified comparing predicted concentration in groundwater beneath the source to MCL/RSL, Resident Receptor Adult FWCUGs, and facility-wide background concentrations. A constituent is a CMCOC if its predicted concentration in groundwater exceeds all its screening criteria within 1,000 years.

[f] Maximum groundwater concentration = maximum sediment concentration divided by the distribution coefficient.

[g] Pyrene RSL was used as a surrogate for phenanthrene.

CMCOC = Contaminant migration chemical of concern.
CMCOPC = Contaminant migration chemical of potential concern.
Ft = Feet.
FWCUG = Facility-wide cleanup goal.
MCL = Maximum contaminant level.
mg/L = Milligrams per liter.
ND = Not detected.
PETN = Pentaerythritol tetranitrate.
RSL = Regional screening level.
SESOIL = Seasonal soil compartment model.
WOE = Weight of evidence.

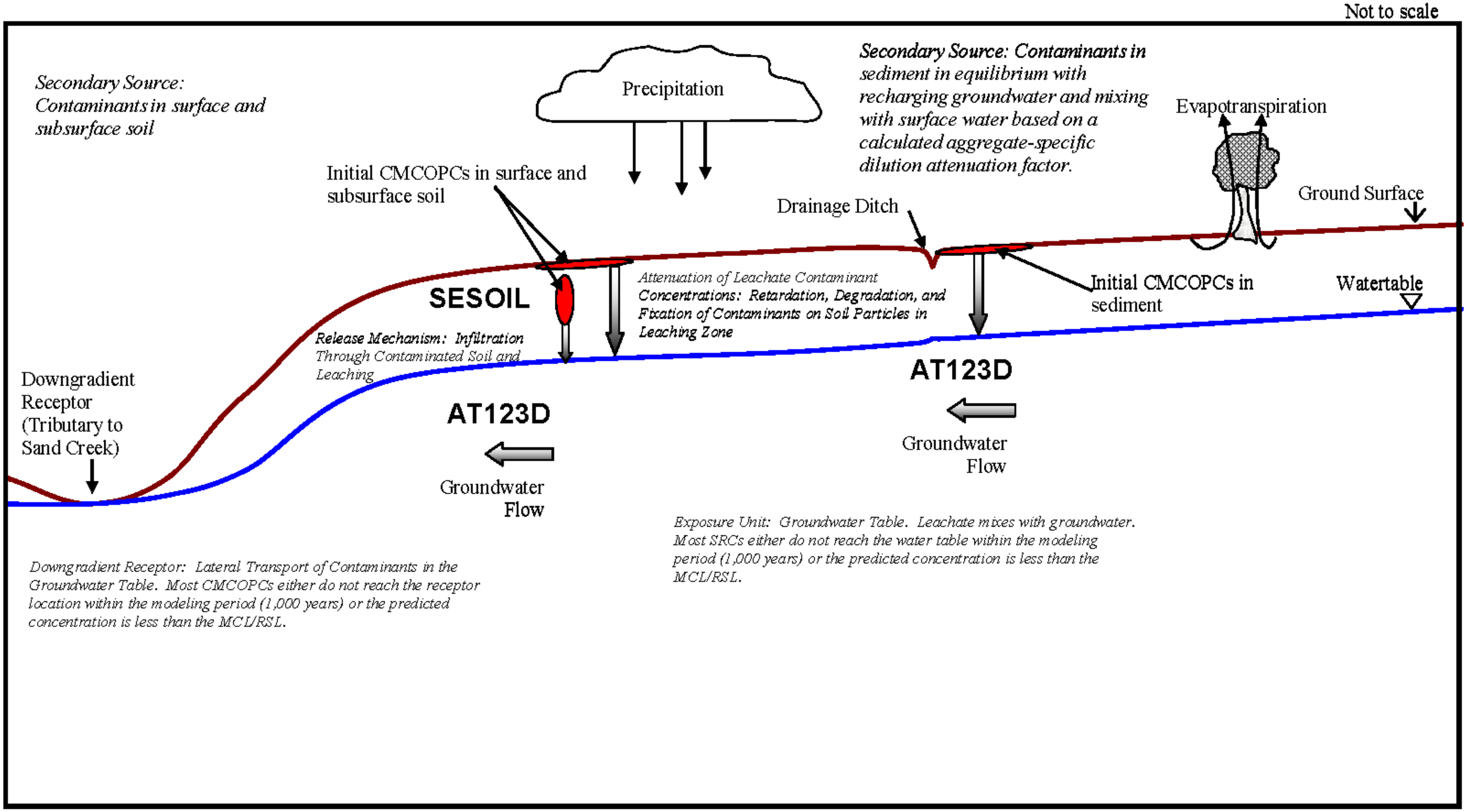

Figure 6-1. Contaminant Migration Conceptual Model

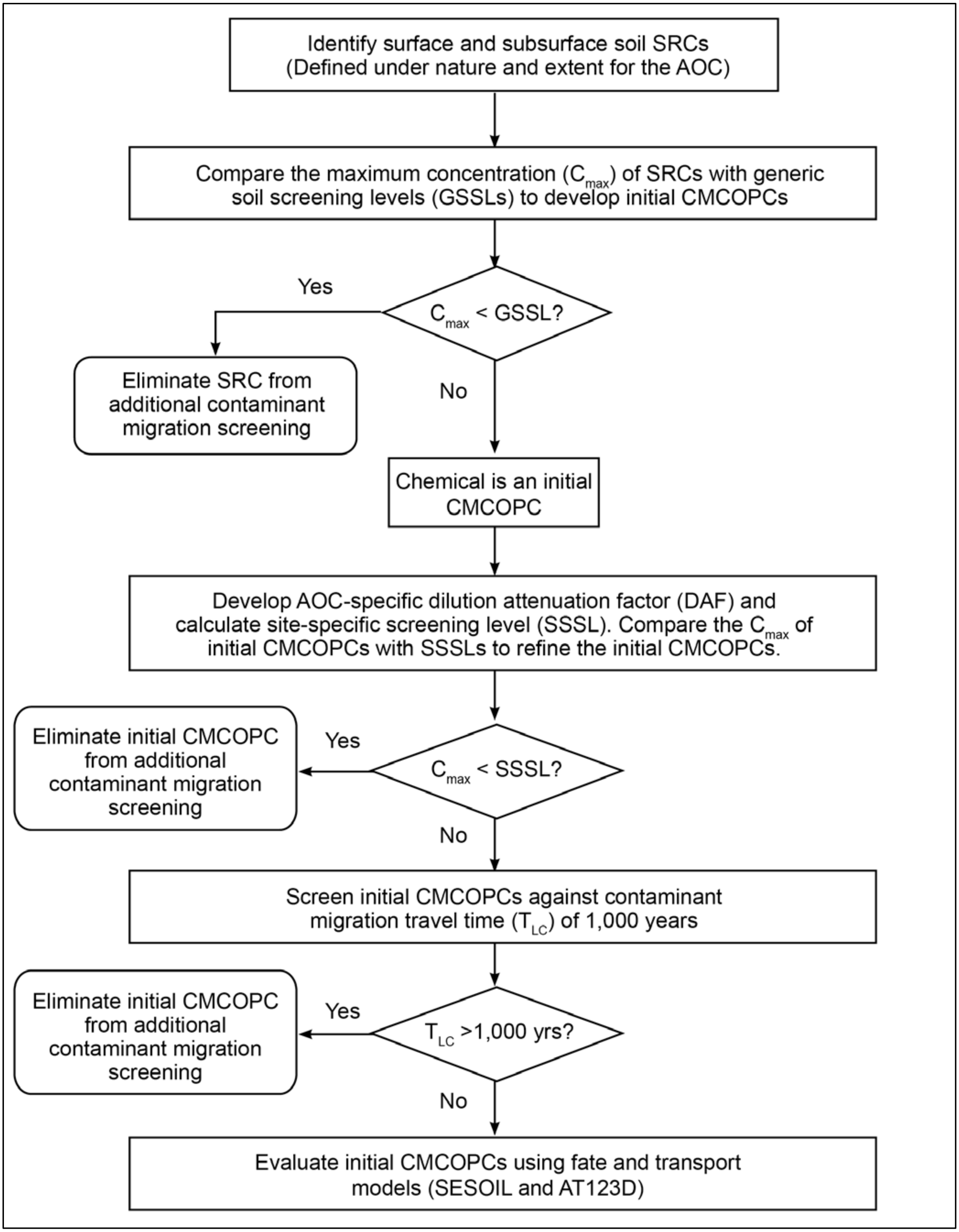

Figure 6-2. Initial CMCOPCs Identified in Soil Screening Analysis for SESOIL Evaluation

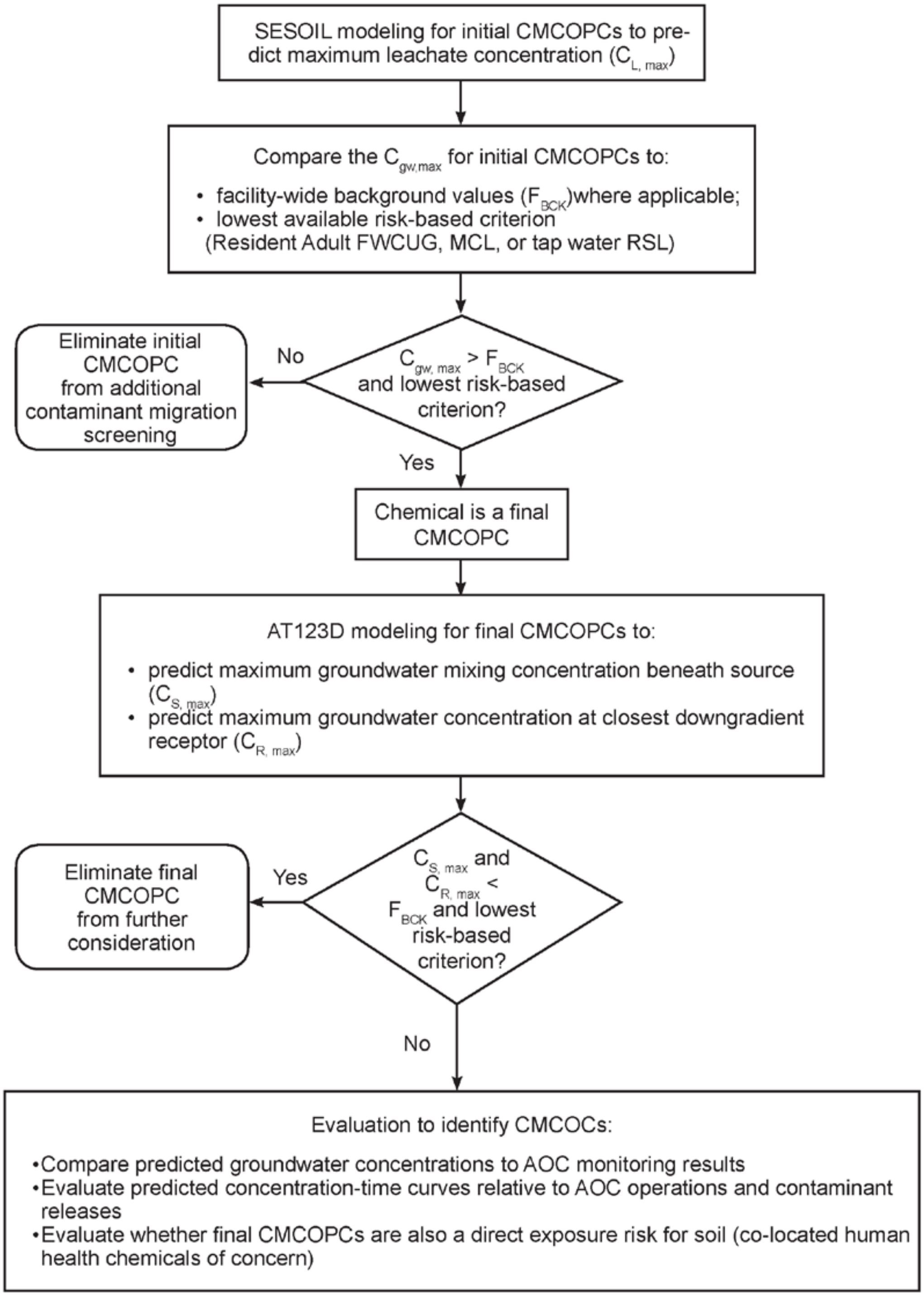

Figure 6-2. Initial CMCOPCs Identified in Soil Screening Analysis for SESOIL Evaluation (Continued)

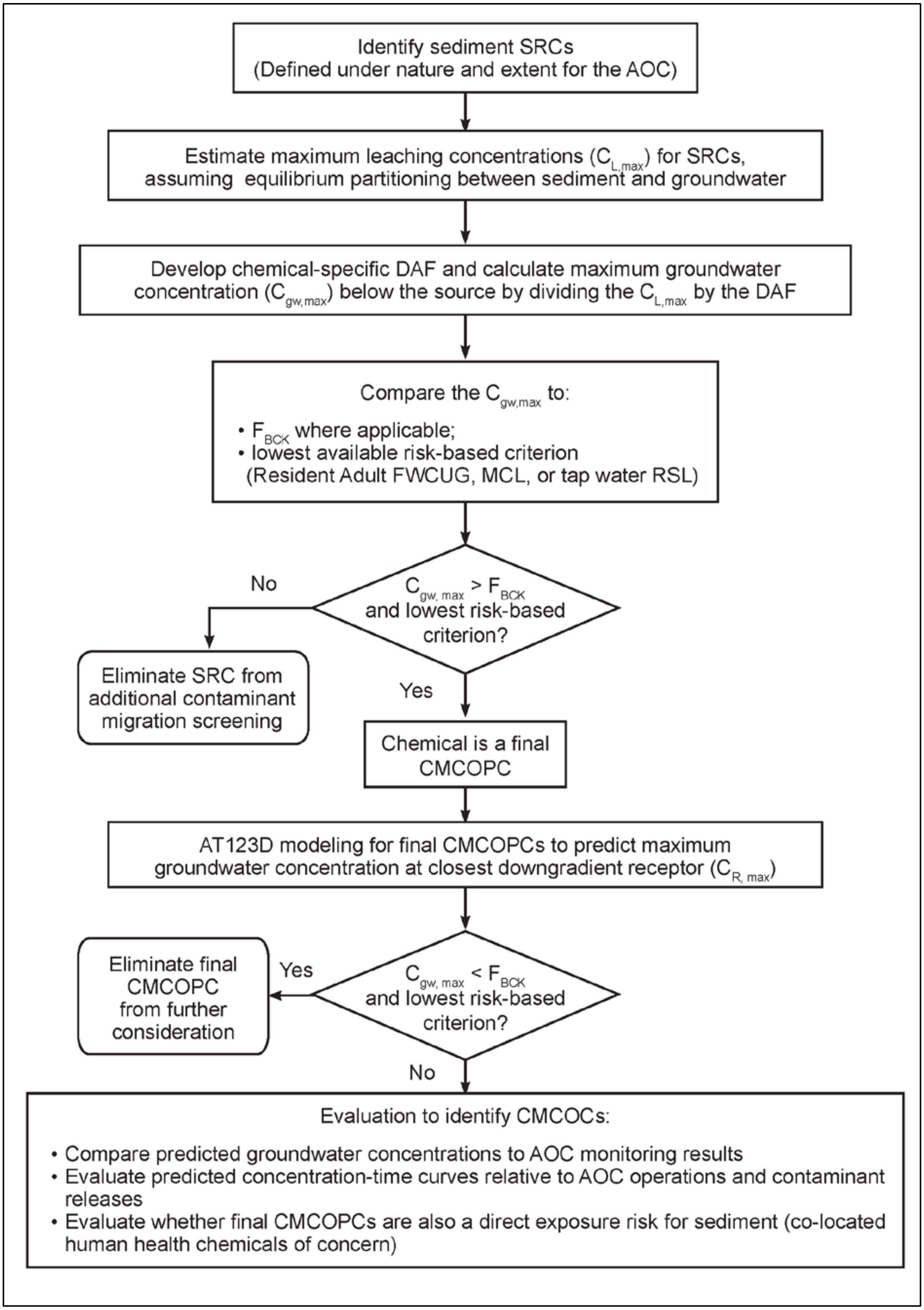

Figure 6-3. AOC Fate and Transport Modeling Approach - Sediment

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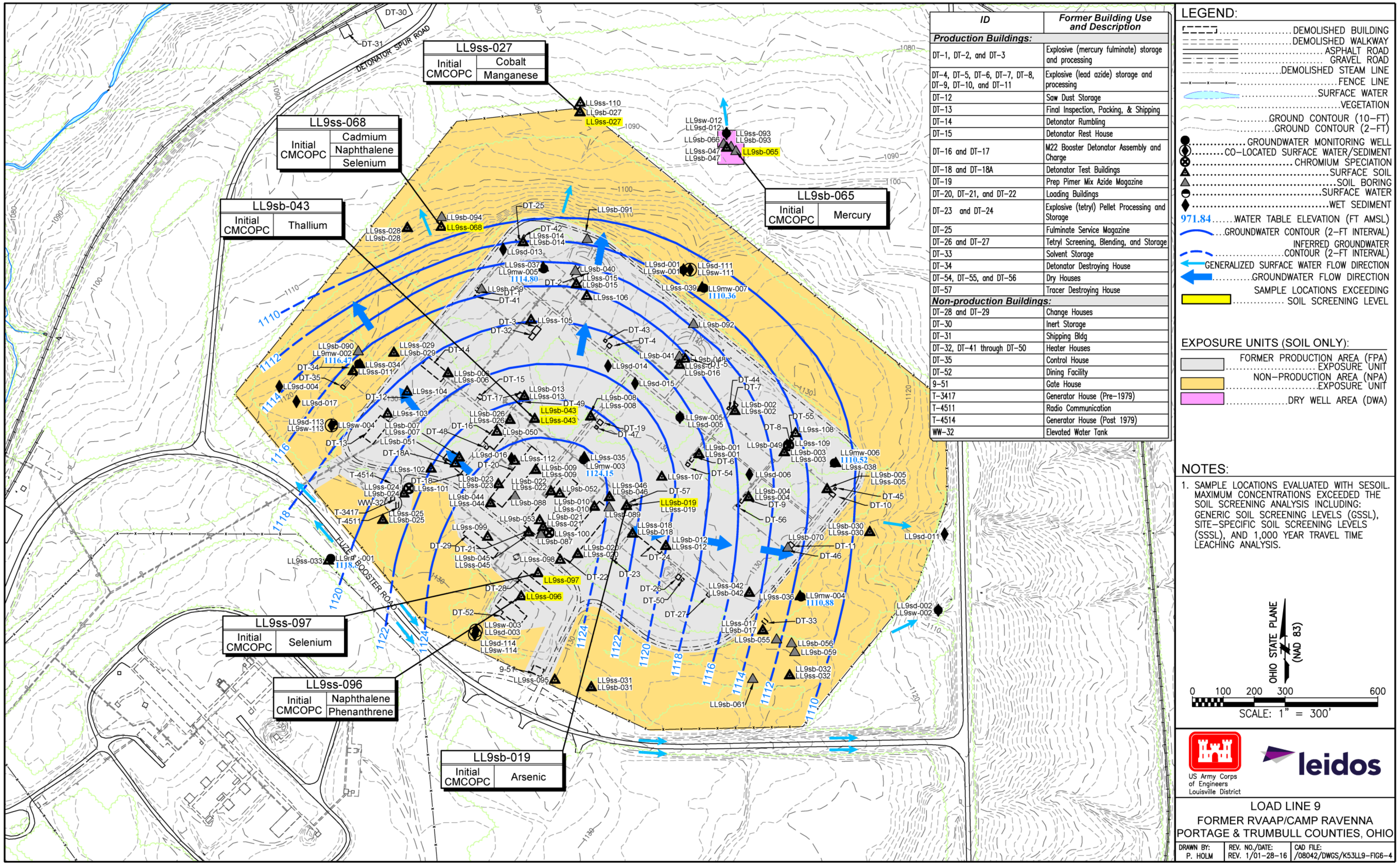


ID	Former Building Use and Description
Production Buildings:	
DT–1, DT–2, and DT–3	Explosive (mercury fulminate) storage and processing
DT–4, DT–5, DT–6, DT–7, DT–8, DT–9, DT–10, and DT–11	Explosive (lead azide) storage and processing
DT–12	Saw Dust Storage
DT–13	Final Inspection, Packing, & Shipping
DT–14	Detonator Rumbling
DT–15	Detonator Rest House
DT–16 and DT–17	M22 Booster Detonator Assembly and Charge
DT–18 and DT–18A	Detonator Test Buildings
DT–19	Prep Pimer Mix Azide Magazine
DT–20, DT–21, and DT–22	Loading Buildings
DT–23 and DT–24	Explosive (tetryl) Pellet Processing and Storage
DT–25	Fulminate Service Magazine
DT–26 and DT–27	Tetryl Screening, Blending, and Storage
DT–33	Solvent Storage
DT–34	Detonator Destroying House
DT–54, DT–55, and DT–56	Dry Houses
DT–57	Tracer Destroying House
Non-production Buildings:	
DT–28 and DT–29	Change Houses
DT–30	Inert Storage
DT–31	Shipping Bldg
DT–32, DT–41 through DT–50	Heater Houses
DT–35	Control House
DT–52	Dining Facility
9–51	Gate House
T–3417	Generator House (Pre–1979)
T–4511	Radio Communication
T–4514	Generator House (Post 1979)
WW–32	Elevated Water Tank

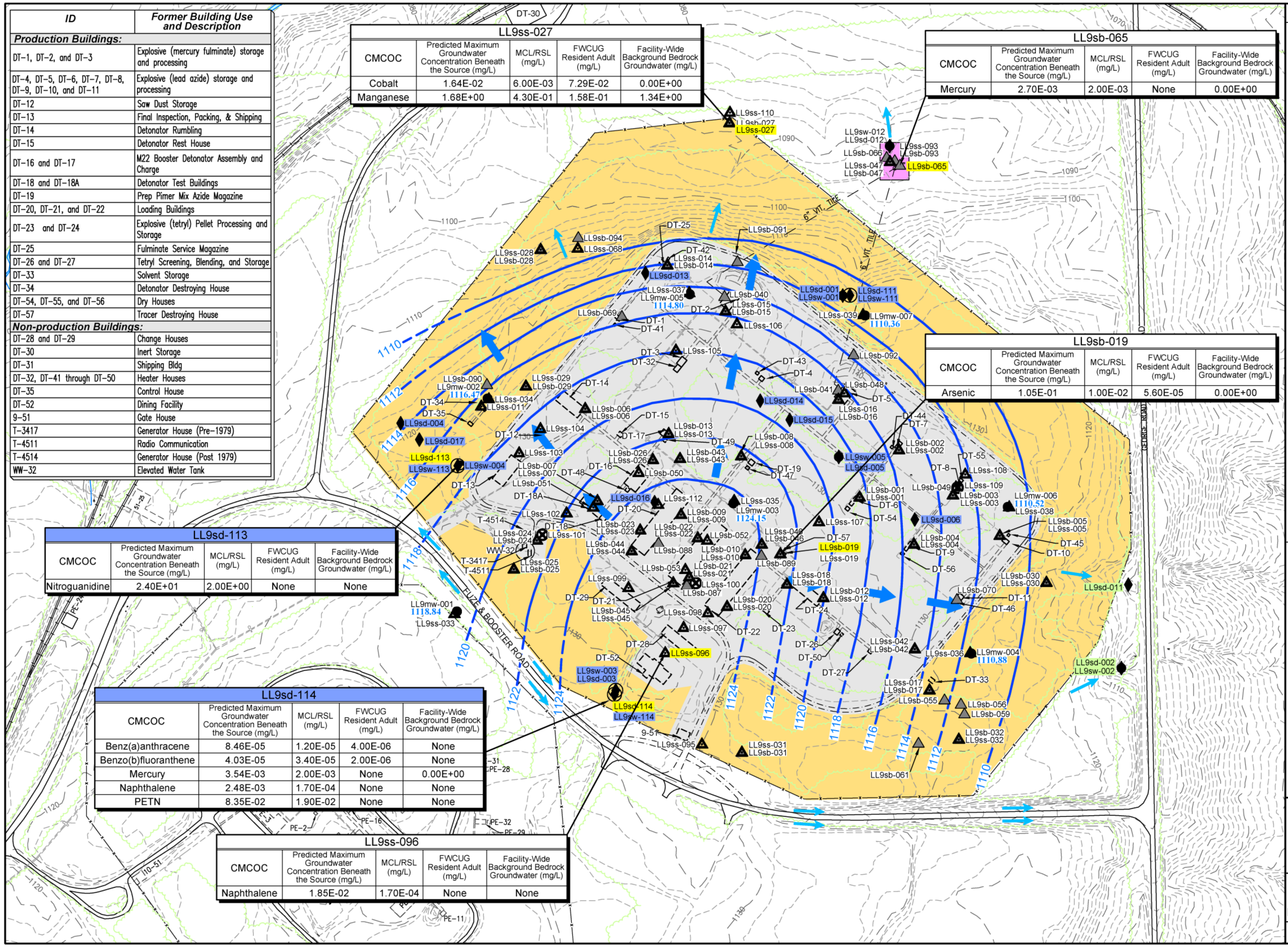
NOTES:

1. SAMPLE LOCATIONS EVALUATED WITH SESOIL. MAXIMUM CONCENTRATIONS EXCEEDED THE SOIL SCREENING ANALYSIS INCLUDING: GENERIC SOIL SCREENING LEVELS (GSSL), SITE–SPECIFIC SOIL SCREENING LEVELS (SSSL), AND 1,000 YEAR TRAVEL TIME LEACHING ANALYSIS.

LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	REV. 1/01–28–16	/08042/DWGS/K53LL9–FIG6–4

Figure 6-4. Initial CMCOPCs Identified in Soil Screening Analysis for SESOIL Evaluation



ID	Former Building Use and Description
Production Buildings:	
DT-1, DT-2, and DT-3	Explosive (mercury fulminate) storage and processing
DT-4, DT-5, DT-6, DT-7, DT-8, DT-9, DT-10, and DT-11	Explosive (lead azide) storage and processing
DT-12	Saw Dust Storage
DT-13	Final Inspection, Packing, & Shipping
DT-14	Detonator Rumbling
DT-15	Detonator Rest House
DT-16 and DT-17	M22 Booster Detonator Assembly and Charge
DT-18 and DT-18A	Detonator Test Buildings
DT-19	Prep Pimer Mix Azide Magazine
DT-20, DT-21, and DT-22	Loading Buildings
DT-23 and DT-24	Explosive (tetryl) Pellet Processing and Storage
DT-25	Fulminate Service Magazine
DT-26 and DT-27	Tetryl Screening, Blending, and Storage
DT-33	Solvent Storage
DT-34	Detonator Destroying House
DT-54, DT-55, and DT-56	Dry Houses
DT-57	Tracer Destroying House
Non-production Buildings:	
DT-28 and DT-29	Change Houses
DT-30	Inert Storage
DT-31	Shipping Bldg
DT-32, DT-41 through DT-50	Heater Houses
DT-35	Control House
DT-52	Dining Facility
9-51	Gate House
T-3417	Generator House (Pre-1979)
T-4511	Radio Communication
T-4514	Generator House (Post 1979)
WW-32	Elevated Water Tank

LL9ss-027

CMCOC	Predicted Maximum Groundwater Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG Resident Adult (mg/L)	Facility-Wide Background Bedrock Groundwater (mg/L)
Cobalt	1.64E-02	6.00E-03	7.29E-02	0.00E+00
Manganese	1.68E+00	4.30E-01	1.58E-01	1.34E+00

LL9sb-065

CMCOC	Predicted Maximum Groundwater Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG Resident Adult (mg/L)	Facility-Wide Background Bedrock Groundwater (mg/L)
Mercury	2.70E-03	2.00E-03	None	0.00E+00

LL9sb-019

CMCOC	Predicted Maximum Groundwater Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG Resident Adult (mg/L)	Facility-Wide Background Bedrock Groundwater (mg/L)
Arsenic	1.05E-01	1.00E-02	5.60E-05	0.00E+00

LL9sd-113

CMCOC	Predicted Maximum Groundwater Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG Resident Adult (mg/L)	Facility-Wide Background Bedrock Groundwater (mg/L)
Nitroguanidine	2.40E+01	2.00E+00	None	None

LL9sd-114

CMCOC	Predicted Maximum Groundwater Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG Resident Adult (mg/L)	Facility-Wide Background Bedrock Groundwater (mg/L)
Benz(a)anthracene	8.46E-05	1.20E-05	4.00E-06	None
Benzo(b)fluoranthene	4.03E-05	3.40E-05	2.00E-06	None
Mercury	3.54E-03	2.00E-03	None	0.00E+00
Naphthalene	2.48E-03	1.70E-04	None	None
PETN	8.35E-02	1.90E-02	None	None

LL9ss-096

CMCOC	Predicted Maximum Groundwater Concentration Beneath the Source (mg/L)	MCL/RSL (mg/L)	FWCUG Resident Adult (mg/L)	Facility-Wide Background Bedrock Groundwater (mg/L)
Naphthalene	1.85E-02	1.70E-04	None	None

LEGEND:

	DEMOLISHED BUILDING
	DEMOLISHED WALKWAY
	ASPHALT ROAD
	GRAVEL ROAD
	DEMOLISHED STEAM LINE
	FENCE LINE
	SURFACE WATER
	VEGETATION
	GROUND CONTOUR (10-FT)
	GROUND CONTOUR (2-FT)
●	GROUNDWATER MONITORING WELL
	CO-LOCATED SURFACE WATER/SEDIMENT
	CHROMIUM SPECIATION
▲	SURFACE SOIL
▲	SOIL BORING
	SURFACE WATER
◆	SEDIMENT
971.84	WATER TABLE ELEVATION (FT AMSL)
	GROUNDWATER CONTOUR (2-FT INTERVAL)
	INFERRED GROUNDWATER CONTOUR (2-FT INTERVAL)
←	GENERALIZED SURFACE WATER FLOW DIRECTION
←	GROUNDWATER FLOW DIRECTION
🟨	SAMPLE LOCATIONS WHERE THE AT123D PREDICTED MAXIMUM CONCENTRATION BENEATH THE SOURCE EXCEEDED SCREENING CRITERIA WITHIN 1,000 YEARS

EXPOSURE UNITS

▨	FORMER PRODUCTION AREA (FPA) EXPOSURE UNIT
🟧	NON-PRODUCTION AREA (NPA) EXPOSURE UNIT
🟪	DRY WELL AREA (DWA)
LL9sd-015	DRAINAGE DITCH SAMPLE LOCATION
LL9sd-011	OFF-AOC SAMPLE LOCATION

NOTES:

1. SAMPLE LOCATIONS EVALUATED WITH AT123D MODELING.

OHIO STATE PLANE (NAD 83)

0 100 200 300 600

SCALE: 1" = 300'

US Army Corps of Engineers Louisville District

leidos

LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	REV. 1/12-09-15	/08042/DWGS/K53LL9-FIG6-5

Figure 6-5. CMCOCs Identified for further WOE Evaluation based on AT123D Modeling

7.0 RISK ASSESSMENT

7.1 DATA EVALUATION FOR HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

The purpose of this data evaluation is to develop a set of chemical data suitable for use in the HHRA and ERA. Load Line 9 data are evaluated to establish data aggregates and to identify a list of SRCs.

7.1.1 Data Aggregates

Section 4.0 provides a summary of available data. Soil data collected at Load Line 9 were grouped (aggregated) by exposure depth (e.g., surface soil) and EU. Samples included in the risk assessment data sets for soil are listed in Tables 7-1 through 7-3. Samples included in the risk assessment data sets for sediment and surface water are listed in Tables 7-4 and 7-5. A description of the data aggregates for the media for which human and ecological receptors are potentially exposed is provided in Section 7.1.1 followed by a summary of SRCs in Section 7.1.2.

7.1.1.1 Soil Data

EUs were established at Load Line 9 as part of the data aggregation prior to the risk assessment evaluations. The EUs take into account how the areas were previously used and the extensiveness of potential contamination within a given area. In establishing EUs at Load Line 9, the area within the perimeter road is assumed to have the maximum potential contamination; therefore, that area was identified as a separate EU (i.e., FPA) from the rest of the AOC (i.e., NPA) as shown in Figure 5-1. In addition to these two EUs, the DWA was evaluated as a potential hotspot. The DWA is in the vicinity of a 6-inch well that existed approximately 190 ft north of the AOC perimeter. This area was a drainage conduit from Load Line 9. The sumps were excavated during the demolition operations conducted before the Phase I RI activities began.

Soils were aggregated by the following depth intervals:

- Surface soil with an exposure depth of 0–1 ft bgs was evaluated for the Resident Receptor (Adult and Child), Industrial Receptor, and for potential risk to ecological receptors because this layer is the most active biological zone (USACE 2003a). Table 7-1 presents the risk assessment data set for surface soil (0–1 ft bgs). For this risk assessment, discrete samples collected in March 2002 through December 2003 during the Phase I RI (MKM 2007) and March 2010 through April 2011 during the PBA08 RI were used to characterize surface soil. In October 2002, the buildings at Load Line 9 were thermally decontaminated; floor slabs and footers were removed for 20 of the buildings; and the disturbed areas were re-graded, seeded, and mulched. In 2006 and 2007, the floor slabs, foundations, and footers from the remaining 22 buildings were excavated and removed to a minimum depth of 4 ft bgs. Soil in the work areas was re-graded and vegetated in 2007 (LES 2007b). Six samples (LL9ss-048 to LL9ss-053) collected in 2003 from locations that were subsequently removed during excavation of building slabs and foundations were excluded from the risk assessments.

- Deep surface soil with an exposure depth of 0–4 ft bgs was evaluated for the National Guard Trainee. Discrete data from samples with a starting depth within this interval were used to evaluate deep surface soil for this receptor. Table 7-2 presents the risk assessment data set for deep surface soil (0–4 ft bgs).
- Subsurface soil with an exposure depth of 1–13 ft bgs was evaluated for the Resident Receptor (Adult and Child) and Industrial Receptor. Subsurface soil with an exposure depth of 4–7 ft bgs was evaluated for the National Guard Trainee. Discrete samples collected in October through December 2003 during the Phase I RI (MKM 2007) and March 2010 during the PBA08 RI with a starting depth within these intervals were used to characterize subsurface soil. Table 7-3 presents the risk assessment data sets for subsurface soil. No subsurface soil samples were collected in the NPA with a starting depth greater than 3 ft bgs due to the presence of shallow bedrock in this area.

7.1.1.2 Sediment and Surface Water Data

On-site surface water at Load Line 9 is limited to intermittent storm water runoff flowing overland to the northwestern portion of the AOC in ditches. Sediment and surface water samples were collected from the Drainage Ditches in March 2010 during the PBA08 RI, and one sample was collected from the DWA in December 2003 during the Phase I RI. These samples were used to characterize risk from exposure to chemicals in these EUs. Three surface water samples and four sediment samples collected in March 2002 through December 2003 (Phase I RI) were not used in the risk assessment because more recent (PBA08 RI) data were collected from these sample locations and are more representative of current AOC conditions. One surface water sample and six sediment samples collected in March 2002 through December 2003 (Phase I RI) were not used in the risk assessment because re-grading following building demolition in 2006 resulted in a change in drainage patterns such that these areas are no longer drainage ditches and do not contain surface water. The 2002 and 2003 data not included in the risk assessment were used in characterizing nature and extent of contamination (Section 5.0) to evaluate trends over time.

Samples included in the risk assessment data sets for surface water and sediment are listed in Tables 7-4 (surface water) and 7-5 (sediment). The small size of the surface water and sediment data sets reflects the small size of these EUs.

7.1.2 Identification of SRCs

Section 4.4 presents the statistical methods and screening criteria used to identify SRCs. The purpose of identifying SRCs is to determine the presence or absence of contamination that is above naturally occurring levels.

The 1978 Installation Assessment identified the major contaminants of the former RVAAP as TNT, composition B (a combination of TNT and RDX), sulfates, nitrates, lead styphnate, and lead azide. Additional potential contaminants at Load Line 9 based on operation history include mercury fulminate and heavy metals (lead, chromium, mercury, and arsenic) from munitions assembly activities; VOCs from former Building DT-33 that was utilized for solvent storage; PCBs from on-site transformers; and PAHs from former Buildings DT-32 and DT-41 through DT-50 that were used as a heater houses.

The SRC screen was not limited to only contaminants that may have been products of previous site use. Rather, the SRC screen followed the three steps outlined in the FWCUG Report, as summarized below, using all chemical data available:

- Background screening: MDCs of naturally occurring inorganic chemicals were compared to the facility-wide background concentrations for RVAAP, which are summarized in the FWCUG Report. Inorganic constituents detected above facility-wide background concentrations or having no background concentrations were retained as SRCs. All detected organic chemicals were retained as SRCs.
- Screening of essential human nutrients: Chemicals considered essential nutrients (e.g., calcium, chloride, iodine, iron, magnesium, potassium, phosphorous, and sodium) are an integral part of the human food supply and are often added to foods as supplements. USEPA recommends these chemicals not be evaluated provided they are: (1) present at low concentrations (i.e., only slightly above naturally occurring levels) and (2) toxic at only very high doses (i.e., much higher than those that could be associated with contact at the AOC) (USEPA 1989). Essential nutrients detected near or below their RDA/RDI-based SLs were eliminated as SRCs.
- Frequency of detection screening: in accordance with the FWCUG Report and as revised in the Final (Revised) U.S. Army Corps of Engineers RVAAP Position Paper for the Application and Use of Facility-Wide Human Health Cleanup Goals (USACE 2012b) (hereafter referred to as the Position Paper for Human Health CUGs), analytes detected in less than 5% of the samples are screened out from further consideration with the exception of explosives and propellants. A frequency-of-detection screen was included in the SRC screening for data sets having at least 20 discrete samples; however, no SRCs were screened out on this basis.

Details of the SRC screening for each exposure medium are provided in Tables G-1 through G-6 of Appendix G. The SRCs identified for Load Line 9 are summarized in Table 7-6.

7.2 HUMAN HEALTH RISK ASSESSMENT

This HHRA identifies COCs that may pose potential health risks to humans resulting from exposure to contamination at Load Line 9. This HHRA was conducted as part of the PBA08 RI and is based on the methods from the following guidance documents:

- FWHHRAM (USACE 2005b),
- FWCUG Report (USACE 2010a),
- Position Paper for Human Health CUGs (USACE 2012b), and
- Technical Memorandum (ARNG 2014).

To accomplish the goal of streamlined risk-based decision making, the FWCUG Report was developed to support risk assessments of the remaining AOCs within the former RVAAP. The FWCUG Report contains calculated FWCUGs and guidance for applying the FWCUGs to accelerate the risk assessment process. This approach takes advantage of the many risk assessment inputs and decisions that have previously been accepted by stakeholders applying the CERCLA process at the former RVAAP.

Most of the agreed upon risk assessment methodology has been documented in the FWHHRAM (USACE 2005b) and follows standard USEPA-approved risk assessment guidance. This includes the process to identify RVAAP COPCs (presented in Figure 4-6), a TR of 1E-06 and HQ of 0.1 to identify COPCs, and a TR of 1E-05 and HQ of 1 to identify COCs.

Other approaches, such as calculating the sum-of-ratios (SOR), were developed in the FWCUG Report (USACE 2010a) and Position Paper for Human Health CUGs (USACE 2012b). The Technical Memorandum (ARNG 2014) amends the risk assessment process to establish future Land Uses and applicable receptors to be evaluated in an RI.

The approach to risk-based decision making is as follows:

1. ***Develop FWCUGs*** **-** Use the risk assessment process presented in the FWHHRAM to develop FWCUGs for all COPCs identified from the facility-wide data set at RVAAP. This process has been completed in the FWCUG Report.
2. ***RI Characterization Sampling*** **-** Perform sampling and analysis to characterize an AOC and establish baseline chemical concentrations. A summary and the results of the RI characterization sampling for Load Line 9 are presented in Section 4.0 of this report.
3. ***Mapping and Data Analysis to Identify SRCs and COPCs*** – Follow the requirements specified in the FWHHRAM and the Position Paper for Human Health CUGs (USACE 2012b), perform data analysis and mapping to identify SRCs and COPCs, establish EUs, and calculate EPCs for each COPC. The results of the mapping and data analysis for Load Line 9 to identify SRCs are presented in Sections 4.0 and 5.0 of this report and are summarized in Section 7.1.
4. ***Identification of COCs*** **-** Compare EPCs to FWCUGs to determine COCs.
5. ***Address Identified COCs*** **-** Develop FS, PP, and ROD to address any COCs requiring remedy.

Identifying COPCs and COCs follows the four steps for a streamlined risk assessment established in the FWCUG Report and shown in Figure 1-3: identify media of concern, identify COPCs, present AOC Land Use and appropriate receptors, and compare to appropriate FWCUGs to identify COCs. These steps are discussed in the following subsections.

7.2.1 Identify Media of Concern

Media of concern at Load Line 9 are surface soil, subsurface soil, surface water, and sediment. Groundwater is present at this AOC and will be evaluated (including risk assessment) in a separate document, as described in Section 1.2.

7.2.2 Identify COPCs

Section 4.4 presents the statistical methods and screening criteria used to identify SRCs. COPCs are a subset of the SRCs in each exposure medium present at concentrations that indicate the potential for impacts to human receptors. The COPC screen follows the approach specified in the FWCUG Report and is summarized in this section.

To identify COPCs, the MDC of all SRCs was screened against the most stringent chemical-specific FWCUG of all RVAAP receptors at a target cancer risk level of 1E-06 and non-carcinogenic target HQ of 0.1 for the Resident Receptor (Adult and Child) and National Guard Trainee. If no FWCUGs exist for an SRC, the USEPA residential RSL (from RSL table dated June 2015) was used for this screen. No reference dose (RfD) or cancer potency factors are available for acenaphthylene, benzo(*ghi*)perylene, and phenanthrene; therefore, the RSL for pyrene was used for these PAHs (NDEP 2006).

Hexavalent chromium was detected in one of three surface soil samples collected at Load Line 9 for chromium speciation. Since hexavalent chromium was detected as part of the conservative screening approach for identifying COPCs, the FWCUG for hexavalent chromium (the more toxic of the two chromium species evaluated) was used at this stage.

Details of the COPC screening for each exposure medium are provided in Tables G-1 through G-6 of Appendix G. The COPCs identified for the media of concern at Load Line 9 are presented in Table 7-7 and are summarized below.

7.2.2.1 COPCs in Surface Soil

Surface soil (0–1 ft bgs)

- **Former Production Area.** Of the 43 chemicals detected in surface soil (0–1 ft bgs) samples at the FPA, 37 (17 inorganic chemicals, 18 SVOCs, 1 VOC, and 1 explosive) were identified as SRCs. Risk-based screening identified five inorganic chemicals (aluminum, arsenic, chromium, cobalt, and manganese) and six SVOCs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] as COPCs in surface soil (0–1 ft bgs).
- **Non-Production Area.** Of the 44 chemicals detected in surface soil (0–1 ft bgs) samples at the NPA, 35 (14 inorganic chemicals, 19 SVOCs, and 2 explosives) were identified as SRCs. Risk-based screening identified six inorganic chemicals (arsenic, cobalt, copper, lead,

manganese, and mercury) and four SVOCs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] as COPCs in surface soil (0-1 ft bgs).

- **Dry Well Area.** Of the 20 chemicals detected in shallow surface soil (0-1 ft bgs) samples at the DWA, 2 (both metals) were identified as SRCs. Risk-based screening identified only mercury as a COPC.

Deep surface soil (0–4 ft bgs)

- **Former Production Area**. Of the 44 chemicals detected in deep surface soil (0–4 ft bgs) samples at the FPA, 38 (17 inorganic chemicals, 18 SVOCs, 1 VOC, and 2 explosives) were identified as SRCs. Risk-based screening identified five inorganic chemicals (aluminum, arsenic, chromium, cobalt, and manganese) and six SVOCs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] as COPCs in deep surface soil (0-4 ft bgs).
- **Non-Production Area.** Of the 44 chemicals detected in deep surface soil (0-4 ft bgs) samples at the NPA, 35 (14 inorganic chemicals, 19 SVOCs, and 2 explosives) were identified as SRCs. Risk-based screening identified six inorganic chemicals (arsenic, cobalt, copper, lead, manganese, and mercury) and four SVOCs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] as COPCs in deep surface soil (0-4 ft bgs).
- **Dry Well Area.** Of the 21 chemicals detected in deep surface soil (0-4 ft bgs) samples at the DWA, 3 (lead, mercury, and thallium) were identified as SRCs. Risk-based screening identified only mercury as a COPC.

7.2.2.2 COPCs in Subsurface Soil

Subsurface soil (1-13 ft bgs)

- **Former Production Area.** Of the 40 chemicals detected in subsurface soil (1-13 ft bgs) samples at the FPA, 28 (11 inorganic chemicals, 15 SVOCs, and 2 explosives) were identified as SRCs. Risk-based screening identified three inorganic chemicals (arsenic, chromium, and thallium) and two SVOCs [benzo(a)pyrene, and dibenz(a,h)anthracene] as COPCs in subsurface soil (1-13 ft bgs).
- **Non-Production Area.** Of the 35 chemicals detected in subsurface soil (1-13 ft bgs) samples at the NPA, 16 (2 inorganic chemicals, 13 SVOCs, and 1 explosive) were identified as SRCs. Risk-based screening identified two SVOCs [benzo(a)pyrene and dibenz(a,h)anthracene] as COPCs.
- **Dry Well Area.** Of the 22 chemicals detected in subsurface soil (1-13 ft bgs) samples at the DWA, 3 (cadmium, lead, and mercury) were identified as SRCs. Risk-based screening identified only mercury as a COPC.

Subsurface soil (4-7 ft bgs)

- **Former Production Area.** Of the 35 chemicals detected in subsurface soil (4-7 ft bgs) samples at the FPA, 18 (6 inorganic chemicals and 12 SVOCs) were identified as SRCs. Risk-based screening identified only benzo(a)pyrene as a COPC in subsurface soil.
- **Non-Production Area.** No samples were collected in the 4-7 ft bgs interval because shallow bedrock was encountered at 1-5.5 ft bgs.
- **Dry Well Area.** Of the 22 chemicals detected in subsurface soil (4-7 ft bgs) samples at the DWA, 2 (both metals) were identified as SRCs. Risk-based screening did not identify any COPCs for this area.

7.2.2.3 COPCs in Sediment

- **Drainage Ditches.** Of the 39 chemicals detected in sediment samples at the Drainage Ditches, 24 (8 inorganic chemicals, 13 SVOCs, 1 VOC, and 2 explosives) were identified as SRCs. Risk-based screening identified one inorganic chemical (cobalt) and one SVOC [benzo(a)pyrene] as COPCs.
- **Dry Well Area.** Of the 19 chemicals detected in sediment samples at DWA, 3 (all metals) were identified as SRCs. Risk-based screening identified only mercury as a COPC.

7.2.2.4 COPCs in Surface Water

- **Drainage Ditches.** Of the 19 chemicals detected in surface water samples at the Drainage Ditches, 9 (all metals) were identified as SRCs. No COPCs were identified in Drainage Ditches surface water.
- **Dry Well Area.** Of the 13 chemicals detected in surface water samples at the DWA, 4 (3 metals and 1 explosive) were identified as SRCs. Cobalt was the only COPC identified in DWA surface water.

7.2.3 Land Use and Representative Receptors

Camp Ravenna is a controlled-access facility. Load Line 9 is located in the south-central portion of the facility and is not currently used for training. Three Land Uses for the RVAAP restoration program are specified in the Technical Memorandum (ARNG 2014) for consideration in the RI along with the following Representative Receptors:

1. Unrestricted (Residential) Land Use – Resident Receptor (Adult and Child).
2. Military Training Land Use – National Guard Trainee.
3. Commercial/Industrial Land Use – Industrial Receptor (USEPA's Composite Worker).

Unrestricted (Residential) Land Use is considered protective for all three Land Uses at Camp Ravenna. Therefore, if an AOC meets the requirements for Unrestricted (Residential) Land Use, then the AOC is also considered to have met the requirements of the other Land Uses (i.e., Commercial/Industrial and Military Training), and those other Land Uses do not require evaluation.

As stated in Paragraph 6.d of the Technical Memorandum, if an AOC fails to meet the Unrestricted (Residential) Land Use, then an FS will be completed that evaluates cleanup options for all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use]. Remedial alternatives for meeting each Land Use are to be evaluated per the current guidelines for selecting a remedy for the AOC.

7.2.4 Compare to Appropriate FWCUGs

Previous sections have outlined the process for identifying SRCs and COPCs. Comparing COPC exposure concentrations to FWCUGs and determining COCs follows guidance presented in the Position Paper for Human Health CUGs (USACE 2012b) and Technical Memorandum (ARNG 2014).

The COC determination process is as follows:

- Report all carcinogenic and non-carcinogenic based SLs for each COPC for the Representative Receptors: Unrestricted (Residential) Land Use [Resident Receptor (Adult and Child)], Military Training Land Use (National Guard Trainee), and Commercial/Industrial Land Use [Industrial Receptor (USEPA’s Composite Worker)]. SLs for the Resident Receptor (Adult and Child) and National Guard Trainee are the FWCUGs corresponding to a TR of 1E-05 and target HQ of 1. If no FWCUG is available for a COPC, the residential and industrial RSLs, adjusted to represent a TR of 1E-05 or target HQ of 1, are used for the Resident Receptor and National Guard Trainee, respectively. SLs for the Industrial Receptor are the industrial RSLs adjusted to represent a TR of 1E-05 or target HQ of 1.
- Report critical effect and target organ for each non-carcinogenic based FWCUG and RSL.
- Compare the selected FWCUG or RSL to the EPC, including an SOR.
    - For non-carcinogens, compare the EPC to the target HQ SL. Sum the ratios of EPC/SL for COPCs that affect similar target organs or do not have an identified target organ.
    - For carcinogens, compare the EPC to the TR SL. Sum the ratios of EPC/SL for all carcinogens.
- Identify the COPC as a COC for a given receptor if:
    - The EPC exceeds the most stringent SL for either the 1E-05 target cancer risk or the 1 target HQ; or
    - The SOR for all carcinogens or non-carcinogens that may affect the same organ is greater than one. Chemicals contributing at least 10% to an SOR greater than one are also considered COCs. In accordance with the Position Paper for Human Health CUGs (USACE 2012b), chemicals contributing greater than 5% but less than 10% to the SOR must be further evaluated before being eliminated as COCs.

The process for calculating FWCUGs and RSLs rearranges the cancer risk or non-cancer hazard equations to obtain a concentration that will produce a specific risk or hazard level (USEPA 1991, USACE 2010a). For example, the FWCUG for arsenic at the cancer risk level of 1E-05 for the

Resident Receptor Adult is the concentration of arsenic that produces a risk of 1E-05 when using the exposure parameters specific to the Resident Receptor Adult.

For carcinogens, risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as the increased chance of cancer above the normal background rate. In the United States, the background chance of contracting cancer is a little more than 3 in 10 for women and a little less than 5 in 10 for men, or 3E-01 to 5E-01 (American Cancer Society 2015). The calculated incremental lifetime cancer risk (ILCR) is compared to the range specified in the NCP of 10^{-6} to 10^{-4}, or 1 in a million to 1 in 10,000 exposed persons developing cancer (USEPA 1990). Cancer risks below 10^{-6} are considered acceptable; cancer risks above 10^{-4} are considered unacceptable. The range between 10^{-6} and 10^{-4} is of concern, and any decisions to address risk further in this range, either through additional study or engineered control measures, should account for the uncertainty in the risk estimates. The Ohio EPA Division of Environmental Response and Revitalization (DERR) program has adopted a human health cumulative ILCR goal within this range of 1E-05 to be used as the level of acceptable excess cancer risk and for developing remediation goals for the site. The DERR notes that the defined risk goal should be applied as a goal, recognizing the need to retain flexibility during the evaluation and selection of remedial alternatives.

In addition to developing cancer from exposure to chemicals, an individual may experience other adverse effects. The term “adverse effects” is used here to describe 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 risk associated with toxic (i.e., non-carcinogenic) chemicals is evaluated by comparing an estimated exposure (i.e., intake or dose) from AOC media to an acceptable exposure expressed as an RfD. The RfD is the threshold level below which no adverse effects are expected to occur in a population, including sensitive subpopulations. The ratio of intake over the RfD is the HQ (USEPA 1989).

The SOR is used to account for potential additive effects from exposure to multiple chemicals that can cause the same effect (e.g., cancer) or affect the same target organ. Cancer risk is assumed to be additive for all carcinogens. Non-cancer risk is assumed to be additive for chemicals with similar sites of toxicological action (i.e., target organ such as liver or critical effect such as adversely affecting the ability to reproduce). This approach compares the EPC of each COPC to the SL to determine a ratio. The sum of these individual ratios is then compared to one. The SOR method is based on the principle that a ratio greater than one represents unacceptable cumulative exposure (i.e., above FWCUGs or RSLs if adjusted for exposure to multiple COPCs), and a ratio less than or equal to one represents acceptable cumulative exposure (i.e., below FWCUGs or RSLs if adjusted for exposure to multiple COPCs). The FWCUGs for some chemical/receptor combinations are less than the background concentration. In these instances the chemical concentrations are compared to background concentrations to identify COCs. Since the background concentration is not risk-based, these chemicals are not included in the SOR calculations.

COCs identified by comparing EPCs to FWCUGs or RSLs are further evaluated in an uncertainty analysis to identify COCs requiring evaluation in the FS.

Selecting FWCUGs, calculating EPCs for comparison to the FWCUGs, and the resulting risk-based COCs are detailed in the following sections.

7.2.4.1 Selection of Appropriate FWCUGs

Unrestricted (Residential) Land Use is evaluated using FWCUGs for the Resident Receptor (Adult and Child). Military Training Land Use is evaluated using FWCUGs for the National Guard Trainee. Commercial/Industrial Land Use is evaluated using RSLs for the Industrial Receptor (USEPA's Composite Worker).

The SLs provided in Table 7-8 for the Resident Receptor (Adult and Child) and National Guard Trainee are FWCUGs corresponding to a TR of 1E-05 and target HQ of 1. If no FWCUG is available for a COPC, the residential and industrial RSLs, adjusted to represent a TR of 1E-05 or target HQ of 1 are used for the Resident Receptor and National Guard Trainee, respectively. SLs for the Industrial Receptor are the industrial RSLs adjusted to represent a TR of 1E-05 or target HQ of 1. The critical effect or target organ associated with the toxicity values used to calculate the non-cancer FWCUGs and RSLs are also provided.

Chromium Speciation

FWCUGs are available for hexavalent and trivalent chromium. Existing data at other AOCs, such as the Building 1200 and Anchor Test Area AOCs (USACE 2012c, USACE 2012d), indicate chromium exists predominantly in the trivalent state rather than the more toxic hexavalent state. The implementation of the chromium speciation process per the PBA08 SAP is discussed below.

- **Hexavalent chromium and total chromium sample collection and results -** To determine whether FWCUGs for trivalent or hexavalent chromium are most applicable to Load Line 9 and to support risk management decisions, three discrete surface soil samples were collected and analyzed for hexavalent and total chromium per the PBA08 SAP and as described in Section 5.2. Two of these samples were collected from areas previously identified as having elevated total chromium concentrations, and one was collected from an area identified as having chromium concentrations near background concentrations. Hexavalent chromium was detected one in the three speciation samples at 0.74 mg/kg. The total and hexavalent chromium results for these three samples are summarized in Table 7-9.
- **Percent hexavalent chromium in the chromium speciation samples** – As documented in the PBA08 SAP, "Chromium speciation evaluates the concentration ratio of hexavalent chromium to total chromium. This ratio will be calculated by collecting and analyzing three samples per AOC for both hexavalent chromium and total chromium." Hexavalent chromium was not detected in two of the three chromium speciation samples collected at Load Line 9. The other sample contained 3.5% hexavalent chromium. The FWCUG for hexavalent chromium is based on a cancer unit risk factor (URF) that is calculated using a chromium mixture containing 14% hexavalent chromium and 86% trivalent chromium. These sample results are below the 14% hexavalent chromium used as the basis for the cancer URF, which was used to calculate the hexavalent chromium FWCUGs.

- **Compare the concentration of hexavalent chromium detected in the chromium speciation samples to the residential RSL for hexavalent chromium** - The FWCUG for hexavalent chromium was calculated from a cancer URF based on a chromium mixture containing one seventh (14%) hexavalent chromium (USEPA 2010). The residential RSL (3 mg/kg based on a TR of 1E-05) for hexavalent chromium is specific to hexavalent chromium (i.e., it has been adjusted for the chromium mixture used in the toxicity study). The only detected concentration of hexavalent chromium in the chromium speciation samples (0.74 mg/kg) is less than 3 mg/kg, indicating hexavalent chromium is not present above the residential RSL for hexavalent chromium.
- **Compare the concentration of total chromium to the FWCUG for trivalent chromium** – After implementing the chromium speciation process specified in the PBA08 SAP, hexavalent chromium was determined to be present at a very low concentration (i.e., below the residential RSL for hexavalent chromium), and the percent hexavalent chromium is less than 14%. Therefore, hexavalent chromium is not of concern at Load Line 9, and the reported concentrations of total chromium were compared to FWCUGs and RSLs for trivalent chromium for identifying COCs at this AOC.

7.2.4.2 Exposure Point Concentrations for Comparison to FWCUGs

Soil EPCs

EPCs were calculated for each depth interval and EU using analytical results from the discrete samples presented in Tables 7-1 through 7-3. Per the FWHHRAM, the EPC is either the 95% upper confidence limit (UCL) of the mean or the MDC, whichever value is lowest. If the 95% UCL could not be determined, the EPC is the MDC.

Sediment and Surface Water EPCs

Three sediment and surface water samples collected from the Drainage Ditches in March 2010 during the PBA08 RI, and one sample collected from the DWA in December 2003 during the Phase I RI were used to characterize risk from exposure to sediment and surface water. Because of the small number of samples, each ditch and the DWA were evaluated individually, and the EPC was equal to the detected concentration in each sample.

7.2.4.3 Identification of COCs for Unrestricted (Residential) Land Use

Load Line 9 COCs for Unrestricted (Residential) Land Use, as represented by the Resident Receptor (Adult and Child), are presented below.

COCs for Surface Soil (0–1 ft bgs)

COC screening for surface soil (0-1 ft bgs) for the Resident Receptor (Adult and Child) is detailed in Tables G-7 through G-9 of Appendix G.

Mercury and several PAHs were identified as COCs for the Resident Receptor (Adult and Child), as explained below:

<u>COPCs with EPCs lower than the Resident Receptor (Adult and Child) FWCUG:</u> All aluminum, chromium, cobalt, copper, lead, manganese, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene EPCs are lower than the Resident Receptor (Adult and Child) FWCUG.

<u>COPCs with EPCs exceeding the Resident Receptor (Adult and Child) FWCUG</u>: EPCs of mercury at the NPA and arsenic and several PAHs at the FPA and NPA exceed the FWCUG.

- The EPCs for arsenic in surface soil (0–1 ft bgs) at the FPA (13 mg/kg) and NPA (10.9 mg/kg) exceed the FWCUG of 4.25 mg/kg but are below the surface soil facility-wide background concentration of 15.4 mg/kg. Because the FWCUG is less than the background concentration, the background concentration was used as the CUG for this inorganic chemical. Thus, arsenic is representative of background and is not a COC in surface soil.
- The EPC for mercury in surface soil (0–1 ft bgs) at the NPA (161 mg/kg) exceeds the FWCUG of 22.7 mg/kg. The EPC is strongly influenced by elevated mercury concentrations in seven samples collected near the former location of Building DT-34 (detonator destroying house) with concentrations ranging from 5.2–882 mg/kg. Mercury is a COC in surface soil at the NPA. The EPC for mercury (2.5 mg/kg) at the DWA is less than the FWCUG. Mercury is not a COPC at the FPA.
- The EPCs for benz(a)anthracene (2.52 mg/kg), benzo(a)pyrene (2.27 mg/kg), benzo(b)fluoranthene (3.04 mg/kg), and dibenz(a,h)anthracene (0.344 mg/kg) at the FPA exceed the FWCUGs for these PAHs. The EPCs are strongly influenced by elevated PAH concentrations in two samples, LL9ss-096 and LL9ss-097, located adjacent to the southwest and northeast sides of former Building DT-28 (change house). For example, the concentrations of benzo(a)pyrene in these samples are 15 and 1.7 mg/kg, respectively. These two samples were composed primarily of fill from building demolition (ballasts, clay pipe, bricks). These four PAHs are COCs at the FPA. The EPC for benzo(a)pyrene (0.24 mg/kg) at the NPA slightly exceeds the FWCUG of 0.221 mg/kg. The EPC is the MDC at LL9ss-068 collected in 2003. Detected benzo(a)pyrene concentrations in the other NPA samples ranged from 0.0098–0.13 mg/kg. Benzo(a)pyrene was identified as a COC at the NPA. PAHs are not COPCs at the DWA.

<u>SOR Analysis:</u> Three additional COCs were identified at the NPA based on the SOR analysis, as summarized below:

- Seven COPCs (aluminum, arsenic, chromium, cobalt, copper, manganese, and mercury) identified in surface soil have FWCUGs for non-cancer endpoints. The EPCs for aluminum, arsenic, cobalt, and manganese are less than the facility-wide background concentrations for surface soil; therefore, these metals are not included in the SOR. At the FPA and DWA only one COPC with a non-cancer endpoint is present above background concentrations; therefore, no SOR was calculated for these EUs. Two COPCs (copper and mercury) have EPCs above background concentrations at the NPA. The total SOR for these COPCs at the NPA (seven) exceeds one with mercury contributing 99% to this SOR (Table G-8). The two COPCs contributing to the SOR (copper and mercury) have different target organs. Since copper contributes only 1% to the SOR and these two chemicals have different target organs, copper is not a COC at the NPA. Mercury was previously identified as a COC at this EU.

- Eight COPCs [arsenic, cobalt, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] identified in surface soil have FWCUGs for the cancer endpoint. Chromium was evaluated as a non-carcinogen, as discussed previously. The EPCs for arsenic and cobalt are less than the facility-wide background concentrations for surface soil; therefore, these metals were not included in the SOR. An SOR was calculated for the remaining COPCs at each EU (Table G-9). The calculated SORs are greater than one. The SOR at the FPA is 15. The PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene each contribute at least 5% to the SOR. All these PAHs were previously identified as COCs for this EU; therefore, no additional COCs were identified. The SOR at the NPA is two. The PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene each contribute at least 5% to the SOR. Benzo(a)pyrene was previously identified as a COC; therefore, the SOR identifies three additional PAHs as COCs at this EU. No carcinogenic COPCs were identified at the DWA.

COCs in surface soil (0-1 ft bgs) for the Resident Receptor (Adult and Child) are summarized in Table 7-10.

COCs for Subsurface Soil (1-13 ft bgs)

COC screening for subsurface soil (1-13 ft bgs) for the Resident Receptor (Adult and Child) is detailed in Tables G-10 through G-12 of Appendix G. No COCs were identified for the Resident Receptor (Adult and Child), as explained below:

<u>COPCs with EPCs lower than the Resident Receptor (Adult and Child) FWCUG:</u> All chromium, mercury, thallium, benzo(a)pyrene, and dibenz(a,h)anthracene EPCs are lower than the Resident Receptor (Adult and Child) FWCUG.

<u>COPCs with EPCs exceeding the Resident Receptor (Adult and Child) FWCUG</u>: The arsenic EPC at the FPA exceeds the FWCUG. The EPC for arsenic in subsurface soil (1-13 ft bgs) at the FPA (15 mg/kg) exceeds the FWCUG of 4.25 mg/kg but is below the subsurface soil facility-wide background concentration of 19.8 mg/kg. Arsenic is not a COPC in subsurface soil at the NPA or DWA. Because the FWCUG is less than the background concentration, the background concentration was used as the CUG for this inorganic chemical. Thus, arsenic is representative of background and is not a COC in subsurface soil.

<u>SOR Analysis:</u> No COCs were identified based on the SOR analysis, as summarized below:

- Four COPCs (arsenic, chromium, mercury, and thallium) identified in subsurface soil have FWCUGs for non-cancer endpoints. The EPCs for arsenic, chromium, and thallium are less than the facility-wide background concentrations for subsurface soil; therefore, these metals were not included in the SOR. At the DWA only one COPC with a non-cancer endpoint is present above background concentrations; therefore, no SOR was calculated for this EU. No COPCs with non-cancer endpoints were identified in subsurface soil above background at the FPA or NPA; therefore, no SOR was calculated for these EUs.

- Three COPCs [arsenic, benzo(a)pyrene, and dibenz(a,h)anthracene] identified in subsurface soil have FWCUGs for the cancer endpoint. Chromium was evaluated as a non-carcinogen, as discussed previously. The EPC for arsenic is less than the facility-wide background concentrations for subsurface soil; therefore, this metal was not included in the SOR. An SOR was calculated for the remaining COPCs at each EU (Table G-12). The calculated SORs are less than one.

COCs for Sediment

COC screening for sediment for the Resident Receptor (Adult and Child) is detailed in Tables G-13 and G-14 of Appendix G. No COCs were identified in sediment because detected concentrations of all COPCs are lower than the FWCUGs.

SOR Analysis: No COCs were identified based on the SOR analysis, as summarized below:

- Only one COPC (cobalt at Drainage Ditches and mercury at the DWA) having a FWCUG for non-cancer endpoints was identified at each sediment EU; therefore no SOR was calculated.
- Two COPCs [cobalt and benzo(a)pyrene] identified in sediment in the Drainage Ditches have FWCUGs for the cancer endpoint. An SOR was calculated for these two chemicals for each sample (Table G-14). The calculated SORs are less than one; therefore, no COCs were identified.

COCs for Surface Water

COC screening for surface water for the Resident Receptor (Adult and Child) is detailed in Table G-15 of Appendix G. No COCs were identified in surface water because all detected concentrations of the only COPC are lower than the FWCUG.

SOR Analysis: No COCs were identified based on the SOR analysis because only one COPC (cobalt) was identified; therefore no SOR was calculated.

7.2.4.4 Identification of COCs for Commercial/Industrial Land Use

Load Line 9 COCs for Commercial/Industrial Land Use, as represented by the Industrial Receptor, are presented below.

COCs for Surface Soil (0–1 ft bgs)

COC screening for surface soil (0–1 ft bgs) for the Industrial Receptor is detailed in Tables G-16 through G-18 of Appendix G. Mercury was identified as a COC for the Industrial Receptor, as explained below:

<u>COPCs with EPCs lower than the Industrial RSL:</u> All aluminum, arsenic, chromium, cobalt, copper, lead, manganese, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene EPCs are lower than the Industrial RSLs.

<u>COPCs with EPCs exceeding the Industrial RSL</u>: The EPC for mercury in surface soil (0–1 ft bgs) at the NPA (161 mg/kg) exceeds the Industrial RSL of 40 mg/kg. The EPC is strongly influenced by elevated mercury concentrations in seven samples collected near the former location of Building DT-34 (detonator destroying house) with concentrations ranging from 5.2–882 mg/kg. Mercury is a COC in surface soil at the NPA. The EPC for mercury (2.5 mg/kg) at the DWA is less than the RSL and mercury is not a COPC at the FPA.

<u>SOR Analysis:</u> No additional COCs were identified based on the SOR analysis, as summarized below:

- Seven COPCs (aluminum, arsenic, chromium, cobalt, copper, manganese, and mercury) identified in surface soil have RSLs for non-cancer endpoints. The EPCs for aluminum, arsenic, cobalt, and manganese are less than the facility-wide background concentrations for surface soil; therefore, these metals were not included in the SOR. At the FPA and DWA only one COPC with a non-cancer endpoint is present above background concentrations; therefore, no SOR was calculated for these EUs. Two COPCs (copper and mercury) have EPCs above background concentrations at the NPA. The total SOR for these COPCs at the NPA (four) exceeds one with mercury contributing 100% to this SOR (Table G-17). The two COPCs contributing to this SOR (copper and mercury) have different target organs. Since copper contributes less than 1% to the SOR and these two chemicals have different target organs, copper is not a COC at the NPA. Mercury was previously identified as a COC at this EU.
- Eight COPCs [arsenic, cobalt, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] identified in surface soil have RSLs for the cancer endpoint. Chromium was evaluated as a non-carcinogen, as discussed previously. The EPCs for arsenic and cobalt are less than the facility-wide background concentrations for surface soil; therefore, these metals were not included in the SOR. An SOR was calculated for the remaining COPCs at each EU (Table G-18). The calculated SORs are less than or equal to one; therefore, no additional COCs were identified. No carcinogenic COPCs were identified at the DWA.

COCs for Subsurface Soil (1-13 ft bgs)

COC screening for subsurface soil (1-13 ft bgs) for the Industrial Receptor is detailed in Tables G-19 through G-21 of Appendix G. No COCs were identified for the Industrial Receptor, as explained below:

<u>COPCs with EPCs lower than the Industrial RSL:</u> All arsenic, chromium, mercury, thallium, benzo(a)pyrene, and dibenz(a,h)anthracene EPCs are lower than the Industrial RSL.

<u>SOR Analysis:</u> No COCs were identified based on the SOR analysis, as summarized below:

- Four COPCs (arsenic, chromium, mercury, and thallium) identified in subsurface soil have RSLs for non-cancer endpoints. The EPCs for arsenic, chromium, and thallium are less than the facility-wide background concentrations for subsurface soil; therefore, these metals were not included in the SOR. At the DWA only one COPC with a non-cancer endpoint is present above background concentrations; therefore, no SOR was calculated for this EU. No COPCs with non-cancer endpoints were identified in subsurface soil above background at the FPA or NPA; therefore, no SOR was calculated for these EUs.
- Three COPCs [arsenic, benzo(a)pyrene, and dibenz(a,h)anthracene] identified in subsurface soil have RSLs for the cancer endpoint. Chromium was evaluated as a non-carcinogen, as discussed previously. The EPC for arsenic is less than the facility-wide background concentrations for subsurface soil; therefore, this metal was not included in the SOR. An SOR was calculated for the remaining COPCs at each EU (Table G-21). The calculated SORs are less than one.

COCs for Sediment and Surface Water

Industrial RSLs are not available for sediment or surface water. As noted in Section 7.2.4.3, all COPCs in sediment and surface water are at concentrations less than Resident Receptor (Adult and Child) FWCUGs.

7.2.4.5 <u>Identification of COCs for Military Training Land Use</u>

Load Line 9 COCs for Military Training Land Use, as represented by the National Guard Trainee are presented below.

COCs for Deep Surface Soil (0-4 ft bgs)

COC screening for deep surface soil (0-4 ft bgs) for the National Guard Trainee is detailed in Tables G-22 through G-24 of Appendix G. No COCs were identified for the National Guard Trainee, as explained below:

<u>COPCs with EPCs lower than the National Guard Trainee FWCUG:</u> All aluminum, arsenic, chromium, cobalt, copper, lead, manganese, mercury, benz(a)anthracene, benzo(a)pyrene,

benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene EPCs are lower than the National Guard Trainee FWCUG.

SOR Analysis: No additional COCs were identified based on the SOR analysis, as summarized below:

- Seven COPCs (aluminum, arsenic, chromium, cobalt, copper, manganese, and mercury) identified in deep surface soil (0-4 ft bgs) have FWCUGs for non-cancer endpoints. The EPCs for aluminum, arsenic, cobalt, and manganese are less than the facility-wide background concentrations for surface soil; therefore, these metals were not included in the SOR. At the FPA and DWA only one COPC with a non-cancer endpoint is present above background concentrations; therefore, no SOR was calculated for these EUs. Two COPCs (copper and mercury) have EPCs above background concentrations at the NPA. The total SOR for these COPCs is less than one.
- Eight COPCs [arsenic, cobalt, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] identified in deep surface soil (0-4 ft bgs) have FWCUGs for the cancer endpoint. Chromium was evaluated as a non-carcinogen, as discussed previously. The EPCs for arsenic and cobalt are less than the facility-wide background concentrations for surface soil; therefore, these metals were not included in the SOR. An SOR was calculated for the remaining COPCs at each EU (Table G-24). The calculated SORs are less than one.

COCs for Subsurface Soil (4-7 ft bgs)

COC screening for subsurface soil (4-7 ft bgs) for the National Guard Trainee is detailed in Table G-25 of Appendix G. No COCs were identified for the National Guard Trainee, as explained below:

COPCs with EPCs lower than the National Guard Trainee FWCUG: Benzo(a)pyrene was the only COPC identified in subsurface soil (4-7 ft bgs). The EPC of this chemical was lower than the National Guard Trainee FWCUG.

SOR Analysis: Only one COPC was identified in subsurface soil (4-7 ft bgs); therefore, no SOR was calculated.

COCs for Sediment

COC screening for sediment for the National Guard Trainee is detailed in Tables G-26 and G-27 of Appendix G. No COCs were identified in sediment because all detected concentrations of all COPCs are lower than the FWCUGs.

SOR Analysis: No COCs were identified based on the SOR analysis, as summarized below:

- Only one COPC (cobalt at Drainage Ditches and mercury at the DWA) having a FWCUG for non-cancer endpoints was identified at each sediment EU; therefore, no SOR was calculated.

- Two COPCs [cobalt and benzo(a)pyrene] identified in sediment in the Drainage Ditches have FWCUGs for the cancer endpoint. An SOR was calculated for these two chemicals for each sample (Table G-27). The calculated SORs are less than one; therefore, no COCs were identified.

COCs for Surface Water

COC screening for surface water for the National Guard Trainee is detailed in Table G-28 in Appendix G. No COCs were identified in surface water because all detected concentrations of the only COPC are lower than the FWCUG.

SOR Analysis: No COCs were identified based on the SOR analysis because only one COPC (cobalt) was identified; therefore no SOR was calculated.

7.2.5 Uncertainty Assessment

The sources of uncertainty, as well as the potential bias they impart to the risk assessment (i.e., whether conservatism is increased or decreased) and approaches for minimizing their impact on the conclusions of the RI, are briefly discussed below.

7.2.5.1 Uncertainty in Estimating Potential Exposure

Sources of uncertainty in estimating potential human exposure include sampling and analysis limitations, comparison to background concentrations to identify SRCs, and estimation of EPCs.

Sampling Limitations. Uncertainties arise from limits on the media sampled, the total number and specific locations that can be sampled, and the parameters chosen for analysis to characterize the AOC. A total of 75 surface soil (0-1 ft bgs) samples were available for the HHRA. Samples were collected from areas biased toward areas anticipated to have the highest level of potential contamination (i.e., around former buildings) to delineate potential sources. The results of surface soil sampling were used to efficiently guide selection of locations for subsurface soil sampling with a bias toward the areas of highest potential contamination.

Analytical Limitations. Uncertainty is associated with the chemical concentrations detected and reported by the analytical laboratory. The quality of the analytical data used in the risk assessment was maximized and uncertainty was minimized by implementing QA/QC procedures that specify how samples are selected and handled; however, sampling errors, laboratory analysis errors, and data analysis errors can occur. Beyond the potential for errors, there is normal variability in analytical results.

Some current analytical methods are limited in their ability to achieve detection limits at or below risk-based SLs. Under these circumstances, it is uncertain whether the true concentration is above or below the SLs that are protective of human health. When analytes have a mixture of detected and non-detected concentrations, EPC calculations may be affected by these detection limits. Risks may be overestimated as a result of some sample concentrations being reported as non-detected at the MDL, when the actual concentration may be much smaller than the MDL. Risks may also be underestimated if some analytes that were not detected in any sample were removed from the COPC list. If the concentrations of these analytes are below the MDL but are above the SL, the risk from these analytes would not be included in the risk assessment results.

One of the three chromium speciation samples collected in March 2010 had a reported hexavalent chromium concentration (33 mg/kg) that was greater than the total chromium concentration (22.8 mg/kg) in the same sample. Since it is not possible for hexavalent chromium to make up more than 100% of the total chromium in a sample, this result was assumed to be an analytical error and the location was re-sampled in October 2010. The analytical results of the re-sampling reported the same total chromium concentration (21.4 mg/kg) as the original sample but a much lower hexavalent chromium concentration (0.74 mg/kg). The results of the October 2010 sample are more similar to the other two March 2010 samples which were both non-detected for hexavalent chromium and reflected activities at Load Line 9 where hexavalent chromium was not used.

Identifying SRCs. Part of determining SRCs is to identify chemicals detected above the established RVAAP facility-wide background concentrations. This screen does not account for the potential sources of chemicals, and background values are only available for inorganic chemicals.

Uncertainty associated with screening against background results from statistical limitations and natural variation in background concentrations. Because of this variation, inorganic chemical concentrations below the background concentration are likely representative of background conditions. Inorganic chemical concentrations above the background concentration may be above background concentrations or may reflect natural variation. This is especially true for measured concentrations close to the background concentration.

At Load Line 9, 14 inorganic chemicals (aluminum, antimony, arsenic, barium, beryllium, chromium, cobalt, copper, lead, manganese, nickel, selenium, thallium, and zinc) had MDCs in surface and/or subsurface soil that were one to two times the background concentration. The consequences of carrying most of these inorganic chemicals forward as SRCs, even if they are actually representative of background concentrations, is negligible because they are not toxic at near-background concentration levels. By contrast, naturally occurring (background) arsenic and manganese in soil exceed risk-based CUGs. Therefore, the consequence of identifying arsenic or manganese as an SRC if it is, in fact, representative of the background concentration, can have a significant impact on the conclusions of the risk assessment. The EPCs of these two metals are less than background concentrations.

Organic chemicals are not screened against background concentrations even though some organic compounds are present in the environment as a result of natural or human activities not related to the CERCLA releases at the AOC. For example, PAHs are present in the environment as a result of burning fossil fuels and as a component of road dust, vehicle exhaust, tire wear particles, pavement, and slag used as railroad ballast and fill. Samples collected near roadways or parking areas may represent normal "urban" sources of PAHs. These issues represent significant sources of uncertainty at sites where low levels of PAHs are found over large areas of the AOC. At Load Line 9, PAHs were detected across the AOC (i.e., in 17 of 19 surface soil samples analyzed for SVOCs), generally at low (less than or very close to FWCUGs) concentrations in all areas except at sample locations LL9ss-096 and LL9ss-097, which included debris from the demolition of Building DT-28 (change house) and where concentrations were up to 10 times the FWCUGs.

Detected concentrations were generally less than or very close to Resident Receptor (Adult and Child) FWCUGs in all but surface soil (0-1 ft bgs) sample locations as described below using benzo(a)pyrene concentrations as an example of the PAHs:

- The surface soil (0-1 ft bgs) EPC of benzo(a)pyrene in the FPA (2.27 mg/kg) exceeds the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg by an order of magnitude. This EPC is strongly influenced by the concentrations reported in samples LL9ss-096 (15 mg/kg with a field duplicate result of 8.5 mg/kg) and LL9ss-097 (1.7 mg/kg). Both of these samples were collected near the former Building DT-28 (change house). The material in these boring samples were composed primarily of fill (ballasts, clay pipe, gravel, and bricks). Borings were terminated at 1 ft bgs due to auger refusal. Benzo(a)pyrene in the other 17 samples analyzed for SVOCs at the FPA ranged from non-detect to 0.11 mg/kg.
- The surface soil (0-1 ft bgs) EPC of benzo(a)pyrene in the NPA (0.24 mg/kg) barely exceeds the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg. This EPC is the MDC from sample LL9ss-068 collected in 2003 to characterize an area downgradient of the FPA; it is located in wooded area where surface debris (glass, metal, and other rubbish) were found. Sample LL9sb-094 was collected in 2010 to confirm contamination found in LL9ss-068. The benzo(a)pyrene concentration in sample LL9sb-094 was 0.0098 mg/kg.

Although no background concentrations for PAHs were established for RVAAP, the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b), which established background concentrations for inorganics, included a characterization of naturally occurring background metal concentrations in surface and subsurface soil at Camp Ravenna using samples from outside the process areas. Surface soil samples were collected at 15 locations on the eastern half of Camp Ravenna. These background locations were chosen using aerial photographs and site visits with the concurrence of Ohio EPA and USACE to reflect areas not impacted by RVAAP activities and establish background values that are unaffected by any human activity. The background locations were situated upgradient and generally upwind of known or suspected contaminant sources.

Background sampling was conducted in April and May 1998. All background samples were analyzed for TAL metals, cyanide, and SVOCs. Two of the background samples were also analyzed for VOCs and pesticides/PCBs. The background soil sampling effort established concentrations for naturally occurring metals in soil at RVAAP.

In establishing background concentrations for naturally occurring metals, data were screened to identify outliers in the inorganic chemical results. Ohio EPA guidance (Comment Resolution Meeting, December 2, 1998) called for using upper and lower cutoff limits based on quartiles to identify outliers. The upper cutoff limit is the third quartile (75th percentile) plus one and a half times the interquartile range. All results that exceeded the upper cutoff limit were examined to determine if the results should be used in establishing background concentrations for naturally occurring metals. Outliers were removed so that background values would most nearly represent natural conditions and exclude human disturbance whether from RVAAP or pre-RVAAP activities.

Statistical outliers were identified in 5 surface soil and 15 subsurface soil samples. All analytical results for four of these samples [BKGss-011(b)-0794-SO, BKGss-012(b)-0795-SO, BKGss-015(b)-0798-SO, and BKGss-005(b)-0788-SO] were removed from the surface soil background data set.

The primary reason for eliminating these four samples from the surface soil background data set was that PAHs were elevated and these sampling locations were near pre-existing homes or farms and could have been influenced by activities/materials associated with those structures (e.g., burning wood and fossil fuels, vehicle exhaust, or building materials such as slag used as fill or tar paper and shingles). The other 11 outlier samples were not excluded from the background calculations primarily because no SVOCs were detected in those samples and thus the outliers did not appear to be associated with human activities.

Concentrations of PAHs in surface soil at Camp Ravenna associated with pre-RVAAP anthropogenic sources calculated from the 15 RVAAP background surface soil samples are shown in Table 7-11. Since the purpose here is to identify PAH levels associated with anthropogenic activities unrelated to CERCLA releases from operations at RVAAP, it is appropriate to include all 15 background samples in these calculations. The following criteria were used per the method used in establishing the background concentrations for naturally occurring metals (USACE 2001b):

- For analytes with a frequency of detection greater than 50%, a distribution (determined using the Shapiro-Wilk test) that is neither normal nor log-normal, and a sample size of 59 or less, the maximum result represents the nonparametric 95% upper tolerance limit and was identified as the background concentration for naturally occurring metals. These conditions apply to four of the PAHs detected in background samples [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and chrysene].
- For analytes with a frequency of detection between 0 and 50% with a sample size of 15, the maximum result represents the 99th percentile value and was identified as the background concentration for naturally occurring metals. These conditions apply to the remainder of the PAHs detected in background samples.

These results demonstrate the large variability in environmental concentrations of PAHs. For example, benzo(a)pyrene was detected in 8 of 15 background surface soil samples at concentrations ranging from 0.058–3.7 mg/kg.

Other studies of environmental concentrations of PAHs in Ohio soils show similar variability. For example, in the environmental study of three locations in Cuyahoga County performed for Ohio EPA (Weston 2012), PAHs were detected in only 1 of 36 surface soil samples with a reported concentration of benzo(a)pyrene of 1.33 mg/kg. Aerial photographs indicate this sample was collected near an old road or trail, but no other sources of PAHs are apparent.

In addition to these RVAAP and Cuyahoga County studies, numerous other environmental studies have been conducted that examine environmental levels of PAHs in rural and urban surface soil (e.g., ATSDR 1995, Bradley et al. 1994, IEPA 2005, MADEP 2002, and Teaf et al. 2008). Reported minimum, maximum, and 95th percentile concentrations of benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene from numerous studies are shown in Table 7-12. These studies further demonstrate the high variability in environmental levels of PAHs within a single study area and among multiple studies.

The lack of established RVAAP background concentrations for identifying SRCs for PAHs is a source of uncertainty. Evaluating potential RVAAP process-related sources and other common anthropogenic (non-CERCLA) sources using available PAH environmental data minimizes the impact of this uncertainty on the conclusions of the RI (see Section 7.2.6).

Exposure Point Concentrations. Generally, the 95% UCL on the arithmetic mean was adopted as the EPC for discrete sample results and is considered to represent a conservative estimate of the average concentration. This imparts a small but intentional conservative bias to the risk assessment, provided the sampling captured the most highly contaminated areas. Thus, representative EPCs for the EUs were calculated from discrete data based on the assumption that the samples collected from the EUs were truly random samples. This assumption is not true for Load Line 9 where sample locations were biased to identify areas of highest contaminant concentrations. Therefore, EPCs generated from these data are likely to represent an upper bound of potential exposure concentrations.

In addition to calculating EPCs for each EU, individual discrete sample results above FWCUGs or RSLs are evaluated to identify whether potential hot spots are present as a result of specific source areas.

The EPCs of arsenic, lead, manganese, and benzo(a)pyrene are less than FWCUGs or RSLs but the MDCs exceed CUGs at Load Line 9 for one or more receptors at the surface soil locations described below.

Arsenic: The MDC of arsenic in surface soil at Load Line 9 was 24 mg/kg at sample location LL9ss-015 near the former Building DT-2 (fulminate mix house) in the FPA. The only other arsenic concentration greater than 19.8 mg/kg was at LL9ss-023 (21 mg/kg) near former Building DT-20 (loading building). The reported concentrations in 46 of 48 samples are less than the subsurface soil background concentration of 19.8 mg/kg. The RVAAP background concentration for arsenic in surface soil is 15.4 mg/kg and in subsurface soil is 19.8 mg/kg. Mixing soil during building demolition and re-grading activities likely resulted in mixing surface soil into the subsurface, thus blurring the distinction between surface and subsurface background concentrations. As noted previously, other studies indicate arsenic may be naturally occurring in Ohio soils at greater than 20 mg/kg. For example, an environmental study of three locations in Cuyahoga County performed for Ohio EPA (Weston 2012) showed arsenic ranged from 4.6-25.2 mg/kg (22.9 mg/kg excluding statistical outliers) in surface soil (0–2 ft bgs) and 5.3-34.8 mg/kg (22.6 mg/kg excluding statistical outliers) in subsurface soil (2–4 ft bgs). Based on this evaluation, arsenic does not represent a hot spot and is not identified as a COC.

Lead: The MDC of lead in surface soil at Load Line 9 was 1,330 mg/kg at sample location LL9ss-011 near the former Building DT-34 (detonator destroying house) in the NPA. The reported concentrations in the other 47 surface soil samples are less than the residential RSL of 400 mg/kg. This elevated lead concentration is co-located with the maximum mercury concentration and may be a result of lead azide used in detonators. Based on these data, lead may represent a hot spot along with mercury and is identified as a COC for this location.

Manganese: The MDC of manganese in surface soil at Load Line 9 was 3,800 mg/kg at sample location LL9ss-027 in the NPA. The only other manganese concentration greater than 3,030 mg/kg was at LL9ss-097 (3,240 mg/kg) near the former Building DT-28 (change house). The reported concentrations in the remaining 46 of 48 samples are less than the subsurface soil background concentration of 3,030 mg/kg. The RVAAP background concentration for manganese in surface soil is 1,450 mg/kg and 3,030 mg/kg in subsurface soil. Mixing soil during building demolition and re-grading activities likely resulted in mixing surface soil into the subsurface, thus blurring the distinction between surface and subsurface background concentrations. There is no known source of manganese at Load Line 9 other than the crushed slag used for fill as well as gravel roads and parking areas. Based on these data, manganese does not represent a hot spot and is not identified as a COC.

Benzo(a)pyrene: The EPC of benzo(a)pyrene (2.27 mg/kg) at the FPA exceeds the FWCUG for the Resident Receptor (Adult and Child) of 0.221 but is less than the Industrial RSL (2.9 mg/kg) and the FWCUG for the National Guard Trainee (4.77 mg/kg). The MDC of benzo(a)pyrene (15 mg/kg) at sample location LL9ss-096 near former Building DT-29 (change house) exceeds the Industrial and National Guard Trainee CUGs. While no source of PAHs could be identified in this area beyond the nearby gravel road, the concentration of 15 mg/kg exceeds the concentrations normally associated with roads and vehicle traffic; therefore, this location was identified as a hot spot and benzo(a)pyrene is identified as a COC for all three receptors.

The EPC of benzo(a)pyrene (0.24 mg/kg) at the NPA exceeds the FWCUG for the Resident Receptor (Adult and Child) of 0.221 mg/kg. This EPC is the MDC of benzo(a)pyrene at sample location LL9ss-068. The reported concentration of benzo(a)pyrene in all other samples collected from the NPA ranged from non-detect to 0.13 mg/kg and are less than the FWCUG. No activities took place at this location and no source of PAHs could be identified. The concentration of 0.24 mg/kg is comparable to PAH concentrations reported in RVAAP background soil samples and is indicative of atmospheric deposition from sources such as vehicle traffic. Based on these data, this location was not identified as a hot spot and benzo(a)pyrene is not identified as a COC for the NPA.

7.2.5.2 Uncertainty in Use of FWCUGs and RSLs

Sources of uncertainty in the FWCUGs used to identify COCs include selecting appropriate receptors and exposure parameters, exposure models, and toxicity values used in calculating FWCUGs and RSLs.

Selection of Representative Receptors. Camp Ravenna is a controlled-access facility. Load Line 9 is located in the south-central portion of the facility and is not currently used for training. While residential Land Use is unlikely, an evaluation using Resident Receptor (Adult and Child) FWCUGs is included to provide an Unrestricted (Residential) Land Use evaluation. As stated in Paragraph 6.d of the Technical Memorandum, if an AOC fails to meet the Unrestricted (Residential) Land Use, then all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use] will be evaluated.

Exposure Parameters and Exposure Models. For each primary exposure pathway included in the FWCUGs and RSLs, assumptions are made concerning the exposure parameters (e.g., amount of contaminated media a receptor can be exposed to and intake rates for different routes of exposure) and the routes of exposure. Most exposure parameters have been selected so that errors occur on the side of human health protection. When several of these upper-bound values are combined in estimating exposure for any one pathway, the resulting risks can be in excess of the 99th percentile and outside of the range that may be reasonably expected. Therefore, consistently selecting upper-bound parameters generally leads to overestimation of the potential risk.

Toxicity Values. The toxicity of chemicals is under constant study and values change from time to time. The toxicity values used in calculating the FWCUGs were the most recent values available at the time of those calculations (September 2008). These values are designed to be conservative and provide an upper-bound estimate of risk.

The toxicity and mobility of many inorganic chemicals in the environment depends on the chemical species present. Two important examples are arsenic and chromium. The toxicity values used in developing FWCUGs are for inorganic arsenic; however, these values do not distinguish between arsenite and arsenate. Chromium is generally present in the environment as either the trivalent (Cr+3) or hexavalent (Cr+6) species, with the trivalent form generally being more stable and therefore more common. FWCUGs are available for hexavalent and trivalent chromium. Trivalent chromium has not been shown to be carcinogenic. It is an essential micronutrient but can also be toxic at high doses (i.e., above the RfD used to calculate the FWCUG). FWCUGs for trivalent chromium are based on non-cancerous effects. Hexavalent chromium is much more toxic than trivalent chromium. It is classified as a “known human carcinogen” and may also cause non-cancerous effects. The cancer URF for hexavalent chromium published in USEPA’s Integrated Risk Information System (IRIS) is based on epidemiological data on lung cancer in workers associated with chromate production. Workers in the chromate industry are exposed to trivalent and hexavalent compounds of chromium. The cancer mortality in the study used to establish the URF was assumed to be due to hexavalent chromium. It was further assumed that hexavalent chromium constituted no less than one seventh of the total chromium in air that the workers were exposed to. As noted in IRIS, the assumption that the ratio of hexavalent to trivalent chromium was 1:6 in this study may lead to a sevenfold underestimation of risk when using this URF to evaluate exposure to hexavalent chromium alone.

To avoid underestimating risk, selecting the FWCUG for chromium includes a step that compares the maximum concentration of hexavalent chromium detected in chromium speciation samples to the residential RSL for hexavalent chromium of 3 mg/kg. Concentrations of hexavalent chromium in chromium speciation samples that are less than or equal to 3 mg/kg indicate that hexavalent chromium is not present above hexavalent chromium FWCUGs and supports using trivalent chromium FWCUGs for evaluating total chromium. Using speciation samples to identify the appropriate FWCUG minimizes the associated uncertainty.

FWCUGs and RSLs Below Background Concentrations. One purpose of the HHRA process is to identify COCs and CUGs for evaluating remedial alternatives for remediating residual contamination that has resulted from process operations at the AOC. The FWCUGs and RSLs are risk-based values. In some cases, natural or anthropogenic background concentrations, unrelated to process operations, exceed the risk-based FWCUGs and RSLs. For naturally occurring inorganic chemicals this problem is addressed by using the background concentration as the CUG. This introduces uncertainty in the chosen CUG because there is uncertainty in assigning a specific value to background, which can be highly variable.

No background concentrations are available for organic chemicals, although PAHs are often present in the environment from natural and anthropogenic sources and regulatory standards are often much lower than environmental levels of PAHs in urban and rural surface soil, especially near areas of vehicle traffic (e.g., roads and parking areas). Given their frequent presence in environmental media, and especially in areas influenced by vehicle exhaust and tire particles, it is important to compare risk-based cleanup levels with typical environmental concentrations before utilizing unrealistically low cleanup targets. Numerous studies have been conducted that examine ambient levels of PAHs in rural and urban surface soil (ATSDR 1995, Bradley et al. 1994, MADEP 2002, and Teaf et al. 2008). These studies indicate that given the multitude of non-point mobile sources for PAHs, it is not uncommon for ambient concentrations to exceed health-based regulatory recommendations. Some states have begun to consider ambient anthropogenic levels by establishing minimum SLs based on environmental studies. For example, the New York State Department of Environmental Conservation has established a minimum soil cleanup objective of 1 mg/kg for benz(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene and 0.1 mg/kg for dibenz(a,h)anthracene, based on the 95th percentile concentrations of these PAHs in rural areas near roads (NYSDEC 2006).

7.2.5.3 Uncertainty in the Identification of COCs

All of the sources of uncertainty described in the previous sections potentially impact the identification of COCs. The exposure and toxicity values used to calculate FWCUGs and RSLs as well as the approach for identifying SRCs, COPCs, and ultimately COCs based on the FWCUGs and RSLs were designed to ensure overestimation, rather than underestimation, of potential risk. The uncertainty assessment attempts to put the identified COCs in perspective to facilitate informed risk management decisions for the AOC.

The SOR is used to account for the potential additive effects from exposure to multiple chemicals that can cause the same effect or affect the same target organ. Cancer risk is assumed to be additive for all carcinogens. Non-cancer risk is assumed to be additive for chemicals with similar sites of toxicological action. In the event that any combination of COPCs results in synergistic effects, risk might be underestimated. Conversely, the assumption of additivity would overestimate risk if a combination of COPCs acted antagonistically. It is unclear whether the potential for chemical interaction has been inadvertently understated or overstated. It seems unlikely that the potential for chemical interaction contributes significant uncertainty to the conclusions of the risk assessment.

7.2.6 Identification of COCs for Potential Remediation

COCs were identified in Section 7.2.4 as any COPC having an EPC greater than an applicable FWCUG or RSL or contributing more than 5–10% to an SOR greater than one. For inorganic chemicals with FWCUGs or RSLs below background concentrations, the background concentration was used as the point of comparison. The TR for the FWCUGs and RSLs used to identify COCs is 1E-05 per the Ohio EPA DERR program, which has adopted a human health cumulative ILCR goal of 1E-05 to be used as the level of acceptable excess cancer risk and for developing site remediation goals.

The results of the COC screening (Section 7.2.4) are combined with the results of the uncertainty assessment (Section 7.2.5) to identify COCs to be carried forward for potential remediation.

Lead, mercury, and four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] were identified as COCs to be carried forward for potential remediation as described below:

- Lead and mercury are COCs to be carried forward for potential remediation at the NPA in the area of the former detonator destroying house (DT-34) for all three Land Uses. The EPC for mercury in surface soil (0-1 ft bgs) at the NPA (161 mg/kg) exceeds the Resident Receptor (Adult and Child) FWCUG of 22.7 mg/kg and the Industrial RSL of 40 mg/kg. The EPC is strongly influenced by elevated mercury concentrations in the seven samples collected near the former location of Building DT-34 with concentrations ranging from 5.2–882 mg/kg. No FWCUGs are available for lead. The residential [for Resident Receptor (Adult and Child)] RSL (400 mg/kg) and industrial (for Industrial Receptor and National Guard Trainee) RSLs (800 mg/kg) are used for comparison. The EPC for lead in surface soil (0-1 ft bgs) at the NPA (239 mg/kg) is less than the residential RSL of 400 mg/kg and industrial RSL of 800 mg/kg; however, the MDC of 1,330 mg/kg was co-located with the maximum mercury concentration at sample LL9ss-011. Elevated levels of lead and mercury may be present in this area as a result of lead azide and mercury fulminate used in detonators. Based on these data, lead and mercury appear to represent a hot spot and are identified as COCs for potential remediation in the area of the former detonator destroying house (DT-34) for all three Land Uses.
- The PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were identified as COCs to be carried forward for potential remediation at the FPA in the area of the former change house (DT-28) for the Unrestricted (Residential) Land Use. The EPCs for benz(a)anthracene (2.52 mg/kg), benzo(a)pyrene (2.27 mg/kg), benzo(b)fluoranthene (3.04 mg/kg), and dibenz(a,h)anthracene (0.344 mg/kg) at the FPA exceed the Resident Receptor (Adult and Child) FWCUGs for these PAHs. The EPCs are strongly influenced by elevated PAH concentrations in two samples: LL9ss-096 and LL9ss-097 located adjacent to the southwest and northeast sides of former Building DT-28 (change house). These two samples were composed primarily of fill from building demolition

(ballasts, clay pipe, bricks). Concentrations across the rest of the FPA are less than Residential Receptor (Adult and Child) FWCUGs. The MDC of benzo(a)pyrene (15 mg/kg) at sample location LL9ss-096 exceeds the Industrial RSL (2.9 mg/kg) and National Guard Trainee FWCUG (4.77 mg/kg). While no source of PAHs could be identified in this area beyond the nearby gravel road, the concentration of 15 mg/kg exceeds the concentrations normally associated with roads and vehicle traffic; therefore, this location was identified as a possible hot spot and benzo(a)pyrene is identified as a COC for potential remediation for all three Land Uses.

- The EPC of benzo(a)pyrene (0.24 mg/kg) at the NPA exceeds the FWCUG for the Resident Receptor (Adult and Child) of 0.221 mg/kg. The EPCs of all other PAHs at the NPA are less than FWCUGs; however, benz(a)anthracene, benzo(b)fluoranthene, and dibenz(a,h)anthracene each contribute more than 5% to the SOR. The EPC is the MDC of benzo(a)pyrene at sample location LL9ss-068. The reported concentration of benzo(a)pyrene in all other samples collected from the NPA ranged from non-detect to 0.13 mg/kg and are less than the Resident Receptor (Adult and Child) FWCUG. No activities took place at this location where surface debris (glass, metal, and other rubbish) was found but no source of PAHs could be identified. The concentration of 0.24 mg/kg is comparable to benzo(a)pyrene concentrations reported in RVAAP background soil samples and is indicative of atmospheric deposition from sources such as vehicle traffic. Based on these data, this location was not identified as a hot spot and these PAHs were not identified as COCs for potential remediation at the NPA.

7.2.7 Summary of HHRA

This HHRA documents COCs that may pose potential health risk to human receptors resulting from exposure to contamination at Load Line 9. This HHRA was conducted as part of the RI and was based on the streamlined approach described in the FWCUG Report (USACE 2010a), Position Paper for Human Health FWCUGs (USACE 2012b), and Technical Memorandum (ARNG 2014). The components of the risk assessment (receptors, exposure media, EPCs, and results) are summarized below.

Receptors. RVAAP is a controlled-access facility. Load Line 9 is located in the south-central portion of the facility and is not currently used for training. Three Land Uses for the RVAAP restoration program are specified in the Technical Memorandum (ARNG 2014) for consideration in the RI along with their Representative Receptors. Unrestricted (Residential) Land Use [Resident Receptor (Adult and Child)] is considered protective for all three Land Uses at Camp Ravenna. Therefore, if an AOC meets the requirements for Unrestricted (Residential) Land Use, then the AOC is also considered to have met the requirements of the other Land Uses (i.e., Commercial/Industrial and Military Training). Commercial/Industrial Land Use [Industrial Receptor] is considered protective of all uses other than Residential. Military Training Land Use is represented by the National Guard Trainee. All three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use] are evaluated in this HHRA.

Exposure Media. Media of concern at Load Line 9 are surface soil, subsurface soil, surface water, and sediment. Soil data associated with Load Line 9 were aggregated into surface and subsurface soil at the FPA, NPA, and DWA.

Estimation of EPCs. The EPCs for soil were calculated from the results of all of the discrete samples collected from a given depth interval at each EU. The EPC was either the 95% UCL of the mean or the MDC, whichever value is lowest. The limited number of sediment and surface water samples were evaluated individually (i.e., the number of samples was too small to calculate 95% UCLs).

Results of Human Health Risk Assessment. Lead, mercury, and four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] were identified as COCs to be carried forward for potential remediation. Lead and mercury are COCs to be carried forward for potential remediation at the NPA at sample location LL9ss-011, which is in the area of the former detonator destroying house (DT-34) for all three Land Uses. Elevated levels of lead and mercury may be present in this area as a result of lead azide and mercury fulminate used in detonators. The PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were identified as COCs to be carried forward for potential remediation at the FPA at sample locations LL9ss-096 and LL9ss-097, which are in the area of the former change house (DT-28), for Unrestricted (Residential) Land Use. Additionally, benzo(a)pyrene was identified as a COC in this area to be carried forward for potential remediation for Industrial and Military Training Land Uses.

No COCs were identified for any media or receptors in the DWA. No COCs were identified in sediment or surface water. COCs identified for potential remediation at Load Line 9 are summarized in Table 7-13.

7.3 ECOLOGICAL RISK ASSESSMENT

7.3.1 Introduction

The ERA presented in this RI/FS Report follows a unified approach of methods integrating Army, Ohio EPA, and USEPA guidance. This ERA approach is consistent with the general approach by these agencies and primarily follows the Level I Scoping ERA, Level II Screening ERA, and Level III Baseline ERA outlined in the *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008), with specific application of components from the FWERWP, *Risk Assessment Handbook Volume II: Environmental Evaluation* (USACE 2010b), and *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997). The process implemented in this RI/FS Report combines these guidance documents to meet requirements of the Ohio EPA and Army, while following previously accepted methods established for RVAAP. This unified approach resulted from coordination between USACE and Ohio EPA during the summer of 2011.

7.3.1.1 Scope and Objective

Load Line 9 contains habitat that supports ecological receptors. The predominantly terrestrial habitat has known chemical contamination (MKM 2007). Habitat types and an assessment of the ecological resources found at Load Line 9 are presented in subsequent subsections. Additionally, the results of the historical ERA [termed a SERA performed as part of the Phase I RI documented in the *Report for the Phase I Remedial Investigation at Load Line 9* (MKM 2007)] and the PBA08 RI are provided to determine whether a qualitative ERA (Level I) is sufficient, based on the quality of the habitat and the presence of contamination, or whether a more rigorous ERA (Level II or III) should be conducted.

7.3.2 Level I: Scoping Level Ecological Risk Assessment

The ERA method for Level I follows guidance documents listed in Section 7.3.1. Level I is intended to evaluate if the AOC had past releases or the potential for current contamination and if there are important ecological resources on or near the AOC.

The following two questions should be answered when the Level I ERA is complete:

1. **Are current or past releases suspected at the AOC?** Current or past releases are determined by evidence that chemical contaminants or COPECs are present.
2. **Are important ecological resources present at or in the locality of the AOC?** Important ecological resources are defined in the *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008) and *Technical Document for Ecological Risk Assessment: Process for Developing Management Goals* (BTAG 2005).

If an AOC has contaminants but lacks important ecological resources, the ERA process can stop at Level I. Contamination and important ecological resources must both be present to proceed to a Level II Screening Level ERA.

7.3.2.1 AOC Description and Land Use

Load Line 9 is approximately 69 acres. The habitat is mostly field, shrubland, and forest and is large enough to completely support cover and food for small birds and mammals that typically require approximately 1 acre of habitat (USEPA 1993). The habitat area at Load Line 9 represents 0.32% of the 21,683 acres at Camp Ravenna.

Future use at Load Line 9 is anticipated to be within the Military Training and Commercial/Industrial Land Use scenarios.

7.3.2.2 Evidence of Historical Chemical Contamination

The 1978 Installation Assessment identified the major contaminants of the former RVAAP to be TNT, composition B (a combination of TNT and RDX), sulfates, nitrates, lead styphnate, and lead azide. Additional potential contaminants at Load Line 9 based on operation history include mercury fulminate and heavy metals (lead, chromium, mercury, and arsenic) from munitions assembly activities; VOCs from former Building DT-33 that was utilized for solvent storage; PCBs from on-site transformers; and PAHs from former Buildings DT-32 and DT-41 through DT-50 that were used as heater houses.

The goal of the historical ERA (MKM 2007) was to identify COPECs in soil, sediment, and surface water for Load Line 9. Bioaccumulative compounds were identified and HQs based on food chain models were calculated in the Phase I RI (MKM 2007); this will be discussed if the PBA08 ERA continues to Level III. The Phase I RI followed instructions presented in the *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2003) and included the first two of six steps listed in Figure III of the FWERWP (USACE 2003a). These two steps identified evaluation procedures which were used to determine AOC-related COPECs. First, the MDC of each chemical was compared to its respective facility-wide background concentration. Chemicals were not considered COPECs if the MDC was below the background concentration. For all chemicals detected above background concentrations, the MDC was compared to an ESV. The hierarchy of screening values was based on the guidance included in the FWERWP and *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2003). In addition to the ESV comparison, it was determined if the chemical was a persistent, bioaccumulative, and toxic (PBT) compound. For sediment, chemicals were also compared with the Ohio Sediment Reference Value (SRV). Chemicals were retained as COPECs if they exceeded background concentrations and the ESV, if the chemical exceeded background concentrations and had no toxicity information, or if the chemical was considered a PBT compound.

Groundwater was not included in the historical ERA. As explained in Section 3.2.2 of the FWERWP, groundwater is not considered an exposure medium to ecological receptors because these receptors are unlikely to contact groundwater greater than 5 ft bgs. As discussed in Section 3.4.2, initial depths to groundwater at Load Line 9 encountered during well installation varied from 10–23.4 ft bgs.

The historical ERA tables are provided as Appendix Tables H-1, H-2, and H-3 and include the following applicable components to the Level I assessment:

- Frequency of detection,
- Minimum concentration,
- MDC,
- Mean concentration,
- Average of positive detects,
- Sample of maximum detect,
- Background concentration,
- Comparison of MDC to background (SRC determination),
- SRVs (sediment only),
- SLs (ESVs),
- HQ (MDC/ESV ratio),
- PBT compound identification (soil and surface water only),
- COPEC determination, and
- COPEC rationale.

Historical COPECs for Deep Surface Soil. The historical ERA conducted as part of the Phase I RI reported 44 chemicals in deep surface soil (0-4 ft bgs) at Load Line 9 (MKM 2007). Of the 44 chemicals detected, 4 chemicals (calcium, magnesium, potassium, and sodium) were essential nutrients and were excluded from the COPEC screen. A total of 15 inorganic chemicals and 22 organic chemicals were determined to be SRCs because they exceeded background concentrations or did not have an associated background concentration for comparison. A total of 12 inorganic chemicals (aluminum, arsenic, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, vanadium, and zinc) were identified as COPECs because their concentrations were above ESVs (Table 7-14). Four chemicals (dibenzofuran, nitrocellulose, nitroguanidine, and RDX) were identified as COPECs due to a lack of ESVs. One COPEC that exceeded its ESV (mercury) was also a PBT compound. Appendix Table H-1 presents the Phase I RI ecological screening for deep surface soil (0-4 ft bgs) at Load Line 9.

Historical COPECs for Sediment. The historical ERA conducted as part of the Phase I RI reported 40 chemicals in sediment (MKM 2007). Of the 40 chemicals detected, 4 chemicals (calcium, magnesium, potassium, and sodium) were essential nutrients and were excluded from the COPEC screen (Appendix Table H-2). A total of 4 inorganic chemicals and 18 organic chemicals were determined to be SRCs because they exceeded background concentrations and the SRV or did not have an associated background concentration for comparison. Of the 22 SRCs, 2 inorganic chemicals (lead and mercury) and 2 organic chemicals [bis(2-ethylhexyl)phthalate and dibenz(a,h)anthracene] exceeded the ESVs and were identified as COPECs (Table 7-14). In addition, two inorganic chemicals (beryllium and selenium) and one organic chemical (nitrocellulose) were selected as COPECs because they did not have an ESV.

Historical COPECs for Surface Water. The historical ERA conducted as part of the Phase I RI reported 20 chemicals in surface water at Load Line 9 (MKM 2007). Of the 20 chemicals detected, 4 chemicals (calcium, magnesium, potassium, and sodium) were essential nutrients and were excluded from the COPEC screen (Appendix Table H-3). The 15 inorganic chemicals and 1 organic chemical were determined to be SRCs because they exceeded background concentrations or did not have an associated background concentration for comparison. Of the 16 SRCs, 6 inorganic chemicals (aluminum, copper, iron, lead, mercury, and zinc) exceeded the ESVs and were identified as COPECs (Table 7-14). In addition, one inorganic chemical (manganese) and one organic chemical (nitrocellulose) were selected as COPECs because they did not have an ESV. One COPEC that exceeded its ESV (mercury) was also a PBT compound.

Summary of Historical ERA. As explained previously, a historical ERA was performed to determine COPECs at Load Line 9 in deep surface soil (0-4 ft bgs), sediment, and surface water and compute ratios of MDCs to ESVs (Appendix Tables H-1 through H-3). Table 7-14 summarizes the COPECs by media. Based on the identified COPECs, ecological risk in all three media was predicted in the historical investigation, and an additional investigation was recommended for Load Line 9 (MKM 2007).

7.3.2.3 Ecological Significance

Sources of data and information about the ecological resources at Load Line 9 include the *Integrated Natural Resources Management Plan* (OHARNG 2014) (herein referred to as the INRMP), previous characterization work (e.g., the Phase I RI), and visits to Load Line 9 conducted for the PBA08 RI.

One of the two key questions to answer in the Level I Scoping ERA is whether there are ecologically important and especially ecologically significant resources at Load Line 9. Ecological importance is defined as a place or resource that exhibits unique, special, or other attributes that makes it of great value. Ecological significance is defined as an important resource found at an AOC, or in its vicinity, that is subject to contaminant exposure.

The underlying basis for this distinction can be found in the *Ecological Significance and Selection of Candidate Assessment Endpoints* (USEPA 1996a), and is stated as follows:

> "A critical element in the ERA process requires distinguishing important environmental responses to chemical releases from those that are inconsequential to the ecosystem in which the site resides: in other words, determining the ecological significance of past, current, or projected site-related effects."

Important places and resources identified by the Army and Ohio EPA (Appendix Table H-4) include wetlands, terrestrial areas used for breeding by large or dense aggregations of animals, habitat known to be used by threatened or endangered species, state land designated for wildlife or game management, locally important ecological places, and state parks. The Army and Ohio EPA collectively recognize 17 important places and resources. The Army recognizes an additional 16 important places (BTAG 2005), and the Ohio EPA recognizes another 6 important places (Ohio EPA 2008). In total, there are 39 important places. Presence or absence of an ecologically important place can be determined by comparing environmental facts and characteristics of Load Line 9 with each of the important places and resources listed in Appendix Table H-4.

Presence of an important ecological resource or place and proximity to contamination at an AOC makes a resource ecologically significant. Thus, any important places and resources listed in Appendix Table H-4 are elevated to ecologically significant when present on the AOC and there is exposure to contaminants. For all 39 important places and resources, it is relatively clear the ecological place or resource is present or absent on the AOC; therefore, the decision process is objective. If no important or significant resource is present at an AOC, the evaluation will not proceed to Level II, regardless of the presence of contamination. Instead, the Level I Scoping ERA would acknowledge that there are important ecological places, but that those resources are not ecologically significant, and no further evaluation is required.

Management Goals for the AOC. Regardless of whether the evaluation is concluded at Level I or continues to Level II, there is another level of environmental protection for Load Line 9 through the natural resource management goals expressed in the INRMP (OHARNG 2014). The OHARNG manages the ecological and natural resources at Camp Ravenna to maintain or enhance the current integrity of the natural resources and ecosystems at the facility. Natural resource management activities in place at Camp Ravenna may also be applicable to any degradation noted from contamination.

Some natural resource management goals of OHARNG (listed in Appendix Table H-5) benefit Load Line 9. For example, Goal 1 states that natural resources need to be managed in a compatible way with the military mission, and Goal 5 requires the Army to sustain usable training lands and native natural resources by implementing a natural resource management plan which incorporates invasive species management and utilizes native species mixes for revegetation after ground disturbance activities. These management goals help detect minor degradation (whether from training activities or historical contamination). While the applicability of the remaining 10 management goals to Load Line 9 varies, all of the management goals are intended to monitor, maintain, or enhance the facility's natural resources and its ecosystem. Though these goals are for managing all types of resources at and near Load Line 9, they do not affect the decisions concerning the presence or absence of important or significant ecological places or resources at Load Line 9.

Important Places and Resources. Ecological importance means a place or resource that exhibits a unique, special, or other attribute that makes it of great value. Examples of important places and resources include wetlands, terrestrial areas used for breeding by large or dense aggregations of animals, and habitat of state-listed or federally listed species. An important resource becomes significant when found on an AOC and there is contaminant exposure. There is no important/significant ecological resource at Load Line 9 (Appendix Table H-4).

Terrestrial Resources. Load Line 9 is dominated by terrestrial resources, as described below.

Habitat Descriptions and Species. The INRMP and Leidos scientist visits indicate Load Line 9 consists of two predominant vegetation types (Figure 7-1 and Photographs 7-1 and 7-2). The AOC is dominated by dry, mid-successional, cold-deciduous shrubland in the center of the area and red maple (*Acer rubrum*) successional forest along the boundary of the AOC (Photograph 7-2). This characterization was originally established by a vegetation study using aerial photography and field verification (USACE 1999) and was later used in the INRMP (OHARNG 2008).

During a field survey on May 20, 2010 at Load Line 9, Leidos scientists determined there have been changes in vegetation at the AOC, including (1) a decrease of dry, mid-successional, cold-deciduous, shrubland; (2) an increase in the red maple (*Acer rubrum*) successional forest; and (3) emergence of a new dry, early-successional, herbaceous field.

The dry shrubland habitat is located in the interior of Load Line 9 (Photograph 7-2). The decrease in dry shrubland habitat is attributable in part to conversion to dry, herbaceous field habitat (following demolition activities) and plant succession (as small trees have invaded areas that were dominated by shrubland). Conversion to dry, herbaceous field habitat has occurred in the central part of the AOC, while succession to forest habitat has occurred primarily between the AOC boundary and the roadway that encircles the old load line, with small forested areas inside the road loop. Many of the shrub species are colonial and spread by vegetative propagation. Common species include various willows

(*Salix* spp.), gray dogwood (*Cornus racemosa*), black locust (*Robinia pseudoacacia*), quaking aspen (*Populus tremuloides*), autumn olive (*Elaeagnus umbellata*), blackberry (*Rubus allegheniensis*), hawthorn (*Crataegus* spp.), and multiflora rose (*Rosa multiflora*).

Photograph 7-1. Herbaceous Field in Foreground and Red Maple Forest in Background (May 20, 2008)

Photograph 7-2. Shrubland and Herbaceous Field in Foreground and Red Maple Forest in Background (May 20, 2008)

The increase in forested area is attributable primarily to plant succession, as saplings in the shrubland habitat grow into more mature trees and other tree species colonize the habitat. The area of red maple successional forest at the AOC has approximately doubled since the vegetation study and field verification (USACE 1999). The increase in forest habitat has occurred primarily between the AOC boundary and the roadway that encircles the old load line, but small patches of young forest are scattered in the central part of the AOC. The dominant species is red maple (*Acer rubrum*), with a mix of quaking aspen (*Populus tremuloides*), black cherry (*Prunus serotina*), and black locust (*Robinia pseudoacacia*). The forest includes small open areas and an understory that result in multi-story vegetation that provides various layers of vegetation for foraging height preferences of birds, mammals, insects, and other organisms.

The dry, herbaceous field habitat is largely located in the central part of the AOC, inside the roadway that encircles the old load line. Demolition activities associated with removing buildings and other infrastructure have cleared much of the shrubland that was formerly present at the AOC. Dominant plants include an assortment of grasses, forbs, and seedlings of trees and shrubs. Common species include tall fescue (*Festuca arundinacea*), reed canary grass (*Phalaris arundinacea*), several species of goldenrod (*Solidago* spp.), clasping-leaf dogbane (*Apocynum cannabinum*), yarrow (*Achillea millefolium*), bedstraw (*Galium* spp.), gray dogwood (*Cornus racemosa*), blackberry (*Rubus allegheniensis*), autumn olive (*Elaeagnus umbellata*), and multiflora rose (*Rosa multiflora*).

Based on May 2008 and May 2010 observations (Photographs 7-1 and 7-2), Leidos scientists assessed the habitats at Load Line 9 to be healthy and functioning. Functional habitat was determined by noting the absence of large bare spots and dead vegetation or other obvious visual signs of an unhealthy ecosystem. Additional habitat photographs are provided in Appendix H.

Threatened and Endangered and Other Rare Species. The northern long-eared bat (*Myotis septentrionalis*; federally threatened) exists at Camp Ravenna. There are no other federally listed species and no critical habitat on Camp Ravenna. Load Line 9 has not been previously surveyed for rare, threatened, or endangered species; however, there have been no known sightings of rare, threatened, or endangered species at the AOC (OHARNG 2014).

Other Terrestrial Resources. While there are no other known important terrestrial places and resources (Appendix Table H-4), there are other resources at or near Load Line 9 (e.g., vegetation, animals) that interact in their ecosystems and support nutrient cycling and energy flow. For example, wildlife such as wild turkey (*Meleagris gallopavo*) and white-tailed deer (*Odocoileus virginianus*) could use the area. The INRMP provides information about species and habitat surveys at Camp Ravenna (e.g., timber and ecological succession) (OHARNG 2014). There are no other reported surveys of habitats and wildlife at Load Line 9 beyond those summarized in the INRNP (OHARNG 2014).

Aquatic Resources. Load Line 9 has few aquatic resources. Although there are no ponds, streams, or wetlands identified, there are ditches that drain Load Line 9.

Habitat Descriptions and Species. As noted, there is only one type of known aquatic resource at Load Line 9. Surface water flows intermittently in small drainage ditches bordering the roads and former walkways. During most of the year, there is no water in the drainage ditches. Surface water samples could only be collected after a heavy rain event and snowmelt during the PBA08 RI. Precipitation data from Camp Ravenna are provided in Section 3.5. The storm frequency is 35 days per year, and precipitation occurs 154 days per year.

Leidos scientists evaluated three drainage ditches (Drainage Points 111, 113, and 114) (Figure 7-1) during the May 2010 field survey. These three ditches are relatively shallow, short in length, and their traces disappear in the forest. The ditches have shown varying amounts of water present following heavy rains at the AOC. Although water has been present in all three drainage ditches, the ditches are not sufficient to create and maintain aquatic habitat at Load Line 9. No aquatic life was observed in the ditches during the AOC visit.

Wetlands. A wetland survey has not been conducted at Load Line 9; however, Leidos scientists found no evidence of a wetland during the field survey conducted in May 2010. In addition, there are no wetlands identified for Load Line 9 in the INRMP (OHARNG 2014).

Threatened and Endangered and Other Rare Species. The northern long-eared bat (*Myotis septentrionalis*; federally threatened) exists at Camp Ravenna. There are no other federally listed species and no critical habitat on Camp Ravenna. Load Line 9 has not been previously surveyed for rare, threatened, or endangered species; however, there have been no known sightings of rare, threatened, or endangered species at the AOC (OHARNG 2014).

Other Aquatic Resources. There are no other known aquatic resources (Appendix Table H-4) at or near Load Line 9 (e.g., aquatic vegetation, animals). There are no other reported surveys of habitats and wildlife at the AOC beyond those summarized in the INRMP (OHARNG 2014). The nearest biological and water quality sampling station (stream) is approximately 1,100 ft away, and there is no connecting stream to the AOC.

Ecosystem and Landscape Roles and Relationships. There are four spatial areas to evaluate to assess the ecosystem and landscape roles and relationships at Load Line 9: the AOC, the vicinity of the AOC, the entire Camp Ravenna, and the ecoregion of northeastern Ohio. Information about the AOC (as a spatial area) is provided in previous sections about terrestrial and aquatic resources.

Vicinity of the AOC. Five vegetation communities border Load Line 9 (Figure 7-1), including herbaceous field, shrubland, and forest communities similar to the vegetation observed at the AOC. There are no apparent differences in habitat quality of these plant communities inside or outside of the AOC. The types and qualities of habitat are not unique to Load Line 9 and can be found at many other areas at Camp Ravenna.

The nearest stream is a tributary to Sand Creek approximately 1,100 ft to the north-northwest. There are no known wetlands in Load Line 9 (Figure 7-1). However, there are small wetlands near the AOC. Two small wetlands are approximately 100 and 150 ft southeast of AOC. Other wetlands are located northeast and southwest of the AOC, more than 500 ft from the AOC boundary. By definition, a wetland is considered an important ecological resource (BTAG 2005); however, wetlands are located far enough from the AOC that they are unlikely to be impacted by contamination present at Load Line 9. There is no known connection between Load Line 9 and any off-site wetlands.

The closest recorded occurrence of a rare species [northern blue-eyed grass (*Sisyrinchium montanum*)] was located approximately 1,600 ft northeast of the AOC (Table 7-15) (OHARNG 2014); it is a state potentially threatened species. The next closest recorded rare species include the Eastern box turtle [(*Terrapene carolina*); state species of concern], located approximately 1,700 ft southwest of the AOC; butternut (*Juglans cinerea*), a federal species of concern located approximately 2,950 ft northeast of the AOC; and the Stenonema mayfly [(*Stenonema ithica*), a state species of concern] located approximately 3,000 ft northeast of the AOC. No beaver dams, 100-year floodplains, or biological and water quality stations (stream or pond) are in or near the AOC.

Table 7-15 summarizes the geographical relationships of various ecological resources in the vicinity of the AOC. Only wetlands are found in the vicinity of the AOC; the majority of the nearest resources are more than 1,100 ft away.

The Entire Camp Ravenna. Load Line 9, considered a medium-sized (approximately 69 acres) AOC, represents 0.32% of the total area of Camp Ravenna (21,683 acres). There are approximately 3,510 acres of forest type FU4 [*Acer rubrum* successional forest (red maple)] at Camp Ravenna, based on the INRMP map (OHARNG 2008); this represents 16.2% of the habitat at RVAAP. There are approximately 2,050 acres of forest type HU1 [dry early-successional herbaceous field (e.g., goldenrod)] (OHARNG 2014), representing 9.5% of the habitat at RVAAP. There are approximately 2,900 acres of habitat type SU1 [dry mid-successional cold-deciduous shrubland (e.g., gray dogwood and northern arrowwood)] (OHARNG 2014), representing 13.4% of the habitat at Camp Ravenna. These types of resources are abundant and are not unique to Load Line 9.

Ecoregion. In the area surrounding Camp Ravenna, forests occupy a high percentage of the terrain. Ohio’s forests cover approximately 8,000,000 acres or 30% of the state (USDA 2009). The Erie/Ontario Drift and Lake Plain ecoregion (USEPA 2011) is located in the northeastern part of Ohio, and both contain communities of red maple successional forest; dry, early-successional, herbaceous field (e.g., goldenrod and blackberry); and dry mid-successional cold-deciduous shrubland (e.g., gray dogwood and northern arrowwood). The Erie/Ontario Drift and Lake Plain ecoregion exhibits rolling to level terrain formed by lacustrine and low lime drift deposits. Lakes, wetlands, and swampy streams occur where stream networks converge or where the land is flat and clayey (USEPA 2011). The U.S. Forest Service has a Forest Inventory Data Online tool that was queried for the forest types in the surrounding counties in or near RVAAP (USFS 2011). In 2009, approximately 138,840 acres of forest type FU4 was found throughout northwestern Ohio in Cuyahoga, Geauga, Mahoning, Portage, Stark, Summit, and Trumbull counties that surround RVAAP (USFS 2011). The herbaceous field and shrubland was not individually found in this query because it is not classified as a main group of trees in the forest inventory data tool. However, herbaceous field (HU1) and shrubland (SU1) are common across the ecoregion (USDA 2011). The vegetation communities at Load Line 9 are also found in the surrounding counties in the ecoregion of northeastern Ohio.

In summary, the current vegetation types of red maple successional forest; dry, early-successional, herbaceous field (e.g., goldenrod and blackberry); and dry, mid-successional, cold-deciduous, shrubland (e.g., gray dogwood and northern arrowwood) are found in the vicinity of Load Line 9. The forest type, herbaceous field and shrubland are in abundance at Camp Ravenna and the larger surrounding local ecoregion. There is no known unique resource at Load Line 9 that cannot be found in the immediate vicinity of the AOC, Camp Ravenna, and in the large part of the ecoregion of northeastern Ohio.

7.3.2.4 Evaluation of Historical Chemical Contamination and Ecological Significance

Based on the historical ESV screening, 16 soil, 7 sediment, and 8 surface water COPECs were identified at Load Line 9. These COPECs are listed on Table 7-14. Section 7.3.2.3 provides information about the lack of important/significant ecological resources at the AOC. There are no known wetlands, federal- or state-listed species, or other important/significant ecological resources, as defined by the Army and Ohio EPA. Section 7.3.2.6 summarizes the chemicals and resources to demonstrate there is contamination but no important/significant ecological resources at Load Line 9.

7.3.2.5 Evaluation of Chemical Contamination

This section provides information about methods and results of the analysis of current and historical chemical contamination.

The SL approach to evaluate sample results from the PBA08 RI followed a similar approach to that used in the historical ERA. Section 5.3 details chemical concentration data. The PBA08 RI included collecting discrete deep surface soil (0-4 ft bgs), sediment, and surface water samples. Some locations were different from the historical sample locations, and some were co-located with previous samples (Figures 5-2 through 5-9).

As discussed in Section 7.1, the soil data within the geographic area of Load Line 9 were subdivided into two EUs: FPA and NPA. The FPA includes the area inside the perimeter road and all former buildings and operational areas. The NPA includes two distinct areas: the area outside the FPA to the fence line, and the soil in the DWA. The DWA is the 100 by 125 ft area around the former well that existed approximately 190 ft north of the AOC perimeter (Figure 2-1). The sediment and surface water samples were divided into two spatial aggregates: the Drainage Ditches and DWA. This ERA uses updated SRVs (Appendix Table H-6) and ESVs that follow the revised *Guidance for conducting Ecological Risk Assessments* (Ohio EPA 2008), as provided in Appendix Tables H-7, H-8, and H-9.

The MDC of each chemical is compared to its respective facility-wide background concentration. Sediment concentrations were also compared to the SRV. Chemicals are not considered site-related if the MDC is below the background concentration or SRV (sediment only). For all chemicals detected above background concentrations, the MDC is compared to the chemical-specific ESV. The hierarchy of ESVs is based on the information found in the Ohio EPA risk assessment guidance (Ohio EPA 2008) and FWERWP (USACE 2003a). In addition to the ESV comparison, it was determined if the chemical is a PBT compound. A chemical is retained as a COPEC if it exceeds its background concentration (and SRV for sediment) and the ESV, if the chemical exceeds its background concentration (and SRV for sediment) and had no toxicity information, or if the chemical is considered a PBT compound. MDC to ESV ratios are used to determine the integrated COPECs; the MDCs used are those from the combined current and historical data sets.

A ratio greater than one suggests a possible environmental consequence. Any chemicals with ratios greater than one are identified as integrated COPECs.

Based on comment resolution with Ohio EPA in July 2014, the selection of integrated COPECs for surface water was modified to include two screens. Along with comparing the MDC to the ESV, Ohio EPA requested the average concentration also be compared to the ESV. In the former, the preferred ESV is the Ohio EPA Outside Mixing Zone Maximum (OMZM) when available, whereas in the latter, the preferred ESV is the Ohio EPA Outside Mixing Zone Average (OMZA). However, there is only one surface water sample for the DWA at Load Line 9, so average concentrations are not available to compare against the OMZA. As a result, for the DWA at Load Line 9, the MDC was compared against both the OMZA and the OMZM.

Integrated COPECs for Deep Surface Soil (0–4 ft) at the FPA. During the PBA08 RI, 44 chemicals were detected in deep surface soil at the FPA. Five chemicals (calcium, iron, magnesium, potassium, and sodium) were essential nutrients and were excluded as SRCs. A total of 17 inorganic chemicals and 21 organic chemicals were determined to be SRCs because they exceeded background concentrations or did not have an associated background concentration for comparison. Of the 38 SRCs, 12 inorganic chemicals (aluminum, antimony, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, selenium, and zinc) and 4 organic chemicals [benz(a)anthracene, benzo(a)pyrene, chrysene, and naphthalene] exceeded the ESVs and were identified as integrated COPECs (Table 7-16). In addition, two organic chemicals (nitrocellulose and tetryl) were selected as integrated COPECs because they do not have an ESV. One COPEC that exceeded its ESV (mercury) was also a PBT compound. Table 7-16 shows the calculated ratio of MDC to ESV for each integrated COPEC. Appendix Table H-10 presents the details of the ESV comparisons for deep surface soil at the FPA.

Most of the inorganic COPECs reported in the historical ERA (Table 7-14) for soil are also identified in this ERA for the FPA. The historical ERA (MKM 2007) identified three inorganic COPECs (iron, nickel, and vanadium) that are not integrated COPECs for the FPA. Iron was considered an essential nutrient in the new data set (Appendix Table H-10); nickel was below the new (higher) ESV (Ohio EPA 2008); and vanadium was below its background concentration. Three new integrated inorganic COPECs (antimony, cadmium, and cobalt) were identified in the FPA due to detections above the new (lower) ESVs (Ohio EPA 2008). Six organic chemicals were identified as integrated COPECs in this ERA. Nitrocellulose is the only organic chemical identified as a COPEC in both the historical ERA and this ERA. The historical ERA (MKM 2007) identified three organic COPECs (dibenzofuran, nitroguanidine, and RDX) that are not integrated COPECs for the FPA. Dibenzofuran and nitroguanidine were not detected in FPA soil, and the single historical RDX detection was eliminated from the PBA08 RI data set because it was located under a building slab that was subsequently demolished to 4 ft bgs and filled with soil. Five new integrated COPECs [benz(a)anthracene, benzo(a)pyrene, chrysene, naphthalene, and tetryl] were identified due to detections of these organic chemicals in samples collected during the PBA08 RI.

Integrated COPECs for Deep Surface Soil (0-4 ft bgs) at the NPA. During the PBA08 RI, 44 chemicals were detected in deep surface soil at the NPA. Five chemicals (calcium, iron, magnesium, potassium, and sodium) were essential nutrients and were excluded as SRCs. A total of 14 inorganic chemicals and 21 organic chemicals were determined to be SRCs because they either exceeded their background concentrations or did not have an associated background concentration for comparison. Of the 25 SRCs, 9 inorganic chemicals (antimony, cadmium, cobalt, copper, lead, manganese, mercury, selenium, and zinc) exceeded the ESVs and are identified as integrated COPECs (Table 7-17). In addition, three organic chemicals (nitrocellulose, nitroguanidine, and dibenzofuran) were selected as integrated COPECs because they do not have an ESV. One COPEC that exceeded its ESV (mercury) was also a PBT compound. Table 7-17 shows the calculated ratio of MDC to ESV for each integrated COPEC. Appendix Table H-11 presents the details of the ESV comparisons for deep surface soil at the NPA.

Some of the inorganic COPECs reported in the historical ERA (Table 7-14) for soil are also identified in this ERA for the NPA. The historical ERA (MKM 2007) identified six inorganic COPECs (aluminum, arsenic, chromium, iron, nickel, and vanadium) that are not integrated COPECs for the NPA. Arsenic in the NPA samples was not detected above its ESV; aluminum, chromium, and vanadium were below their background concentration; iron was considered an essential nutrient in the new data set (Appendix Table H-11); and nickel was below the new (higher) ESV (Ohio EPA 2008). Three new integrated inorganic COPECs (antimony, cadmium, and cobalt) were identified in the NPA due to detections above the new (lower) ESVs (Ohio EPA 2008). With the exception of RDX, all of the inorganic COPECs reported in the historical ERA (Table 7-14) for soil are also identified in this ERA for the NPA. The single historical RDX sample was detected in the FPA and was not included in the NPA data set for the PBA08 RI.

Integrated COPECs for Sediment at the Drainage Ditches. During the PBA08 RI, 39 chemicals were detected in sediment at the Drainage Ditches. Five chemicals (calcium, iron, magnesium, potassium, and sodium) were essential nutrients and were excluded as SRCs. A total of 2 inorganic chemicals and 16 organic chemicals were determined to be SRCs because they either exceeded their background concentrations or did not have an associated background concentration for comparison. Of the 18 SRCs, 1 inorganic chemical (mercury) and 1 organic chemical (benzenemethanol) exceeded the ESVs and are identified as integrated COPECs (Table 7-18). In addition, one inorganic chemical (beryllium) and two organic chemicals (nitroguanidine and PETN) were selected as integrated COPECs because they do not have an ESV. One COPEC that exceeded its ESV (mercury) was also a PBT compound. Table 7-18 shows the calculated ratio of MDC to ESV for each integrated COPEC. Appendix Table H-12 presents the details of the ESV comparisons for sediment at the Drainage Ditches.

Two of the inorganic COPECs (beryllium and mercury) reported in the historical ERA (Table 7-14) for sediment were also identified in this ERA for the Drainage Ditches. The historical ERA (MKM 2007) identified two inorganic COPECs (lead and selenium) and three organic COPECs [bis(2-ethylhexyl)phthalate, dibenz(a,h)anthracene, and nitrocellulose] that are not integrated COPECs for the Drainage Ditches. Lead and selenium were below their background concentrations or the SRV (Appendix Table H-12). Bis(2-ethylhexyl)phthalate, dibenz(a,h)anthracene, and nitrocellulose were not detected in the Drainage Ditch samples. Three new integrated COPECs (nitroguanidine, PETN, and benzenemethanol) were identified in the PBA08 RI.

Integrated COPECs for Sediment at the DWA. During the PBA08 RI, 19 chemicals were detected in sediment at the DWA. Four chemicals (calcium, iron, magnesium, and potassium) were essential nutrients and were excluded as SRCs. Two inorganic chemicals were determined to be SRCs because they exceeded their background concentrations. Both of these inorganic chemicals (beryllium and mercury) exceeded the ESVs and are identified as integrated COPECs (Table 7-19). One COPEC that exceeded its ESV (mercury) was also a PBT compound. Table 7-19 shows the calculated ratio of MDC to ESV for each integrated COPEC. Appendix Table H-13 presents the details of the ESV comparisons for sediment at the DWA.

Two of the inorganic COPECs (beryllium and mercury) reported in the historical ERA (Table 7-14) for sediment are also identified in this ERA for the DWA. The historical ERA (MKM 2007) identified two inorganic COPECs (lead and selenium) and three organic COPECs [bis(2-ethylhexyl)phthalate, dibenz(a,h)anthracene, and nitrocellulose] that are not integrated COPECs for the DWA. Lead and selenium were below their background concentrations and/or SRVs (Appendix Table H-13). Bis(2-ethylhexyl)phthalate, dibenz(a,h)anthracene, and nitrocellulose were not detected in the DWA samples.

Integrated COPECs for Surface Water at the Drainage Ditches. During the PBA08 RI, 19 chemicals were detected in surface water at the Drainage Ditches. Five chemicals (calcium, iron, magnesium, potassium, and sodium) were essential nutrients and were excluded as SRCs. Nine inorganic chemicals were determined to be SRCs because they either exceeded their background concentrations or did not have an associated background concentration for comparison. Of the nine SRCs, one inorganic chemical (mercury) exceeded the ESV and is identified as an integrated COPEC (Table 7-20). Mercury is also a PBT compound. Table 7-20 shows the calculated ratio of MDC to ESV for mercury. Appendix Table H-14 presents the details of the ESV comparisons for surface water at the Drainage Ditches based on the MDC. This comparison, consistent with all previously submitted PBA08 ERAs, used the OMZM, when available, as the ESV.

For the OMZA comparison, of the nine SRCs, one inorganic chemical (mercury) is identified as an integrated COPEC because it is a PBT compound (Table 7-21). Table 7-21 shows the calculated ratio of the average detected concentration to the ESV for mercury. Appendix Table H-15 presents details of the ESV comparisons for surface water at the Drainage Ditches based on the average detected concentration.

The historical ERA (MKM 2007) identified seven inorganic COPECs (aluminum, copper, iron, lead, manganese, mercury, and zinc) and one organic COPEC (nitrocellulose) for surface water (Table 7-14). One of the inorganic COPECs (mercury) reported in the historical ERA for surface water is also identified in this ERA for the Drainage Ditches based on MDC and average comparisons. Aluminum, manganese, and zinc were below their associated background concentration; lead was below its ESV; iron was considered an essential nutrient; and copper and nitrocellulose were not detected in the Drainage Ditch samples. Therefore, these chemicals are not considered integrated COPECs for surface water in the Drainage Ditches.

Integrated COPECs for Surface Water at the DWA. During the PBA08 RI, 13 chemicals were detected in surface water at the DWA. Five chemicals (calcium, iron, magnesium, potassium, and sodium) were essential nutrients and were excluded as SRCs. Three inorganic chemicals and one organic chemical were determined to be SRCs because they exceeded their background concentrations or did not have an associated background concentration for comparison. Of the four SRCs, one inorganic chemical (mercury) is identified as an integrated COPEC because it is a PBT compound (Table 7-22). In addition, one organic chemical (nitrocellulose) was selected as an integrated COPEC because it does not have an ESV. Table 7-22 shows the calculated ratio of MDC to ESV for each integrated COPEC. Appendix Table H-16 presents the details of the ESV comparisons for surface water at the DWA.

For the OMZA comparison, of the four SRCs, one inorganic chemical (mercury) was identified as an integrated COPEC because it is a PBT compound (Table 7-23). In addition, one organic chemical (nitrocellulose) was selected as an integrated COPEC because it does not have an ESV. Table 7-23 shows the calculated ratio of the average detected concentration to the ESV for each integrated COPEC. Appendix Table H-17 presents the details of the ESV comparisons for surface water at the DWA based on the average detected concentration.

The historical ERA (MKM 2007) identified seven inorganic COPECs (aluminum, copper, iron, lead, manganese, mercury, and zinc) and one organic COPEC (nitrocellulose) for surface water (Table 7-14). One inorganic COPEC (mercury) and one organic COPEC (nitrocellulose) reported in the historical ERA for surface water are also identified in this ERA for the DWA based on MDC and average comparisons. Aluminum, manganese, and zinc were below their associated background concentration; lead was below its ESV; iron was considered an essential nutrient; and copper was not detected in the PBA08 RI samples. Therefore, these chemicals are not considered integrated COPECs for surface water in the DWA.

Summary of ERA Findings. At Load Line 9, there are 18 integrated COPECs identified in deep surface soil at the FPA: aluminum, antimony, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, selenium, zinc, nitrocellulose, tetryl, benz(a)anthracene, benzo(a)pyrene, chrysene, and naphthalene. In deep surface soil in the NPA, there are 12 integrated COPECs: antimony, cadmium, cobalt, copper, lead, manganese, mercury, selenium, zinc, nitrocellulose, nitroguanidine, and dibenzofuran. In the Drainage Ditches, there are five integrated COPECs in sediment (beryllium, mercury, nitroguanidine, PETN, and benzenemethanol) and one integrated

COPEC in surface water (mercury). In the DWA, there are two integrated COPECs in sediment (beryllium and mercury) and two integrated COPECs in surface water (mercury and nitrocellulose).

7.3.2.6 Summary and Recommendations of Scoping Level Ecological Risk Assessment

At Load Line 9, there were 18 integrated COPECs identified in deep surface soil at the FPA, 12 integrated COPECs in deep surface soil at the NPA, 5 integrated COPECs in sediment at the Drainage Ditches, 2 integrated COPECs in sediment at the DWA, 1 integrated COPEC in surface water at the Drainage Ditches, and 2 integrated COPECs in surface water at the DWA. These COPECs consist of inorganic chemicals, explosives, propellants, and SVOCs.

The information in Section 7.3.2.3 regarding ecological resources at Load Line 9 was compared to the list of important ecological places and resources (Appendix Table H-4). None of the 39 important places were present, and there is nothing ecologically significant at Load Line 9. Environmental management goals and objectives of OHARNG are applicable to Load Line 9, as presented in Appendix Table H-5. Some of the management goals benefit Load Line 9, including Goal 1, which requires management of natural resources to be compatible with military mission, and Goal 5, which requires the Army to sustain usable training lands and native natural resources by implementing a natural resource management plan which incorporates invasive species management and utilizes native species mixes for revegetation after ground disturbance activities.

Load Line 9 is approximately 69 acres and is vegetated with: (1) dry, early-successional, herbaceous field; (2) dry, mid-successional, cold-deciduous, shrubland; and (3) red maple successional forest. These same types of habitats are found adjacent to the AOC and elsewhere at Camp Ravenna (OHARNG 2014). These habitats are also found in the larger, local ecoregion that surrounds Camp Ravenna (USFS 2011). Thus, there is no known unique resource at Load Line 9.

Although there is contamination at Load Line 9, the AOC has no known important/significant ecological places or resources. Consequently, the ERA can conclude with a Level I Scoping Level ERA that no further action is necessary to be protective of important ecological receptors at Load Line 9.

7.3.3 Conclusions

There is chemical contamination present at Load Line 9: there were 18 integrated COPECs identified in deep surface soil at the FPA, 12 integrated COPECs in deep surface soil at the NPA, 5 integrated COPECs in sediment at the Drainage Ditches, 2 integrated COPECs in sediment at the DWA, 1 integrated COPEC in surface water at the Drainage Ditches, and 2 integrated COPECs in surface water at the DWA. There are no important/significant ecological resources in the Load Line 9 habitat according to the Army and Ohio EPA list of important places and resources. Further, the vegetation types are found elsewhere near the AOC, at RVAAP, and in the ecoregion. Consequently, the Level I Scoping Level Risk Assessment concluded that no further action is necessary to be protective of ecological resources.

Table 7–1. Risk Assessment Data Set for Surface Soil (0-1 ft bgs) Discrete Samples

Station	Sample ID	Date	Depth (ft bgs)
Former Production Area			
LL9sb-087	LL9sb-087-5437-SO	3/8/2010	0 - 1
LL9sb-088	LL9sb-088-5441-SO	3/8/2010	0 - 1
LL9sb-089	LL9sb-089-5445-SO	3/8/2010	0 - 1
LL9sb-091	LL9sb-091-5453-SO	3/9/2010	0 - 1
LL9sb-092	LL9sb-092-5457-SO	3/9/2010	0 - 1
LL9ss-001	LL9ss-001-0001-SO	3/11/2002	0 - 1
LL9ss-002	LL9ss-002-0001-SO	12/4/2003	0 - 1
LL9ss-003	LL9ss-003-0001-SO	3/11/2002	0 - 1
LL9ss-004	LL9ss-004-0001-SO	12/4/2003	0 - 1
LL9ss-005	LL9ss-005-0001-SO	3/11/2002	0 - 1
LL9ss-006	LL9ss-006-0001-SO	12/11/2003	0 - 1
LL9ss-007	LL9ss-007-0001-SO	3/11/2002	0 - 1
LL9ss-008	LL9ss-008-0001-SO	12/10/2003	0 - 1
LL9ss-009	LL9ss-009-0001-SO	3/11/2002	0 - 1
LL9ss-010	LL9ss-010-0001-SO	12/8/2003	0 - 1
LL9ss-012	LL9ss-012-0001-SO	12/10/2003	0 - 1
LL9ss-013	LL9ss-013-0001-SO	12/10/2003	0 - 1
LL9ss-014	LL9ss-014-0001-SO	12/11/2003	0 - 1
LL9ss-015	LL9ss-015-0001-SO	12/11/2003	0 - 1
LL9ss-016	LL9ss-016-0001-SO	12/11/2003	0 - 1
LL9ss-018	LL9ss-018-0001-SO	12/10/2003	0 - 1
LL9ss-019	LL9ss-019-0001-SO	12/11/2003	0 - 1
LL9ss-020	LL9ss-020-0001-SO	12/8/2003	0 - 1
LL9ss-021	LL9ss-021-0001-SO	12/8/2003	0 - 1
LL9ss-022	LL9ss-022-0001-SO	12/10/2003	0 - 1
LL9ss-023	LL9ss-023-0001-SO	12/8/2003	0 - 1
LL9ss-024	LL9ss-024-0001-SO	12/10/2003	0 - 1
LL9ss-026	LL9ss-026-0001-SO	12/10/2003	0 - 1
LL9ss-035	LL9ss-035-0001-SO	11/11/2003	0 - 1
LL9ss-037	LL9ss-037-0001-SO	11/11/2003	0 - 1
LL9ss-038	LL9ss-038-0001-SO	11/11/2003	0 - 1
LL9ss-042	LL9ss-042-0001-SO	11/6/2003	0 - 1
LL9ss-043	LL9ss-043-0001-SO	11/6/2003	0 - 1
LL9ss-044	LL9ss-044-0001-SO	11/6/2003	0 - 1
LL9ss-045	LL9ss-045-0001-SO	11/6/2003	0 - 1
LL9ss-046	LL9ss-046-0001-SO	11/6/2003	0 - 1
LL9ss-096	LL9ss-096-5474-SO	3/1/2010	0 - 1
LL9ss-097	LL9ss-097-5475-SO	3/1/2010	0 - 1
LL9ss-098	LL9ss-098-5476-SO	3/1/2010	0 - 1
LL9ss-099	LL9ss-099-5477-SO	3/2/2010	0 - 1
LL9ss-102	LL9ss-102-5480-SO	3/2/2010	0 - 1
LL9ss-103	LL9ss-103-5481-SO	3/2/2010	0 - 1
LL9ss-104	LL9ss-104-5482-SO	3/2/2010	0 - 1
LL9ss-105	LL9ss-105-5483-SO	3/2/2010	0 - 1
LL9ss-106	LL9ss-106-5484-SO	3/2/2010	0 - 1
LL9ss-107	LL9ss-107-5485-SO	3/2/2010	0 - 1
LL9ss-108	LL9ss-108-5486-SO	3/2/2010	0 - 1
LL9ss-112	LL9ss-112-5470-SO	3/9/2010	0 - 1
LL9ss-100[a]	LL9ss-100-5478-SO	3/1/2010	0 - 1
LL9ss-101[a]	LL9ss-101-5807-SO	10/18/2010	0 - 1
LL9ss-109[a]	LL9ss-109-5487-SO	3/1/2010	0 - 1

Table 7–1. Risk Assessment Data Set for Surface Soil (0-1 ft bgs) Discrete Samples (continued)

Station	Sample ID	Date	Depth (ft bgs)
Non-Production Area			
LL9sb-090	LL9sb-090-5449-SO	3/9/2010	0 - 1
LL9sb-094	LL9sb-094-5465-SO	3/9/2010	0 - 1
LL9ss-011	LL9ss-011-0001-SO	3/11/2002	0 - 1
LL9ss-017	LL9ss-017-0001-SO	12/4/2003	0 - 1
LL9ss-025	LL9ss-025-0001-SO	12/10/2003	0 - 1
LL9ss-027	LL9ss-027-0001-SO	12/4/2003	0 - 1
LL9ss-028	LL9ss-028-0001-SO	12/4/2003	0 - 1
LL9ss-029	LL9ss-029-0001-SO	12/4/2003	0 - 1
LL9ss-030	LL9ss-030-0001-SO	12/4/2003	0 - 1
LL9ss-031	LL9ss-031-0001-SO	12/4/2003	0 - 1
LL9ss-032	LL9ss-032-0001-SO	12/4/2003	0 - 1
LL9ss-034	LL9ss-034-0001-SO	11/11/2003	0 - 1
LL9ss-036	LL9ss-036-0001-SO	11/11/2003	0 - 1
LL9ss-039	LL9ss-039-0001-SO	11/11/2003	0 - 1
LL9ss-068	LL9ss-068-0001-SO	12/12/2003	0 - 1
LL9ss-095	LL9ss-095-5473-SO	3/2/2010	0 - 1
LL9ss-110	LL9ss-110-5488-SO	3/2/2010	0 - 1
LL9ss-131	LL9ss-131-5865-SO	4/26/2011	0 - 1
LL9ss-132	LL9ss-132-5866-SO	4/26/2011	0 - 1
LL9ss-133	LL9ss-133-5867-SO	4/26/2011	0 - 1
LL9ss-134	LL9ss-134-5868-SO	4/26/2011	0 - 1
LL9ss-135	LL9ss-135-5869-SO	4/26/2011	0 - 1
Dry Well Area			
LL9sb-093	LL9sb-093-5461-SO	3/9/2010	0 - 1
LL9ss-047	LL9ss-047-0001-SO	11/6/2003	0 - 1

[a] Chromium speciation samples used to evaluate the presence of hexavalent chromium.
bgs = Below ground surface.
ft = Feet.
ID = Identification.

Table 7–2. Risk Assessment Data Set for Deep Surface Soil (0-4 ft bgs) Discrete Samples

Station	Sample ID	Date	Depth[a] (ft bgs)
Former Production Area			
LL9sb-087	LL9sb-087-5437-SO	3/8/2010	0 - 1
LL9sb-088	LL9sb-088-5441-SO	3/8/2010	0 - 1
LL9sb-089	LL9sb-089-5445-SO	3/8/2010	0 - 1
LL9sb-091	LL9sb-091-5453-SO	3/9/2010	0 - 1
LL9sb-092	LL9sb-092-5457-SO	3/9/2010	0 - 1
LL9ss-001	LL9ss-001-0001-SO	3/11/2002	0 - 1
LL9ss-002	LL9ss-002-0001-SO	12/4/2003	0 - 1
LL9ss-003	LL9ss-003-0001-SO	3/11/2002	0 - 1
LL9ss-004	LL9ss-004-0001-SO	12/4/2003	0 - 1
LL9ss-005	LL9ss-005-0001-SO	3/11/2002	0 - 1
LL9ss-006	LL9ss-006-0001-SO	12/11/2003	0 - 1
LL9ss-007	LL9ss-007-0001-SO	3/11/2002	0 - 1
LL9ss-008	LL9ss-008-0001-SO	12/10/2003	0 - 1
LL9ss-009	LL9ss-009-0001-SO	3/11/2002	0 - 1
LL9ss-010	LL9ss-010-0001-SO	12/8/2003	0 - 1
LL9ss-012	LL9ss-012-0001-SO	12/10/2003	0 - 1
LL9ss-013	LL9ss-013-0001-SO	12/10/2003	0 - 1
LL9ss-014	LL9ss-014-0001-SO	12/11/2003	0 - 1
LL9ss-015	LL9ss-015-0001-SO	12/11/2003	0 - 1
LL9ss-016	LL9ss-016-0001-SO	12/11/2003	0 - 1
LL9ss-018	LL9ss-018-0001-SO	12/10/2003	0 - 1
LL9ss-019	LL9ss-019-0001-SO	12/11/2003	0 - 1
LL9ss-020	LL9ss-020-0001-SO	12/8/2003	0 - 1
LL9ss-021	LL9ss-021-0001-SO	12/8/2003	0 - 1
LL9ss-022	LL9ss-022-0001-SO	12/10/2003	0 - 1
LL9ss-023	LL9ss-023-0001-SO	12/8/2003	0 - 1
LL9ss-024	LL9ss-024-0001-SO	12/10/2003	0 - 1
LL9ss-026	LL9ss-026-0001-SO	12/10/2003	0 - 1
LL9ss-035	LL9ss-035-0001-SO	11/11/2003	0 - 1
LL9ss-037	LL9ss-037-0001-SO	11/11/2003	0 - 1
LL9ss-038	LL9ss-038-0001-SO	11/11/2003	0 - 1
LL9ss-042	LL9ss-042-0001-SO	11/6/2003	0 - 1
LL9ss-043	LL9ss-043-0001-SO	11/6/2003	0 - 1
LL9ss-044	LL9ss-044-0001-SO	11/6/2003	0 - 1
LL9ss-045	LL9ss-045-0001-SO	11/6/2003	0 - 1
LL9ss-046	LL9ss-046-0001-SO	11/6/2003	0 - 1
LL9ss-096	LL9ss-096-5474-SO	3/1/2010	0 - 1
LL9ss-097	LL9ss-097-5475-SO	3/1/2010	0 - 1
LL9ss-098	LL9ss-098-5476-SO	3/1/2010	0 - 1
LL9ss-099	LL9ss-099-5477-SO	3/2/2010	0 - 1
LL9ss-102	LL9ss-102-5480-SO	3/2/2010	0 - 1
LL9ss-103	LL9ss-103-5481-SO	3/2/2010	0 - 1
LL9ss-104	LL9ss-104-5482-SO	3/2/2010	0 - 1
LL9ss-105	LL9ss-105-5483-SO	3/2/2010	0 - 1
LL9ss-106	LL9ss-106-5484-SO	3/2/2010	0 - 1
LL9ss-107	LL9ss-107-5485-SO	3/2/2010	0 - 1
LL9ss-108	LL9ss-108-5486-SO	3/2/2010	0 - 1
LL9ss-112	LL9ss-112-5470-SO	3/9/2010	0 - 1
LL9ss-100[b]	LL9ss-100-5478-SO	3/1/2010	0 - 1
LL9ss-101[b]	LL9ss-101-5807-SO	10/18/2010	0 - 1
LL9ss-109[b]	LL9ss-109-5487-SO	3/1/2010	0 - 1

Table 7–2. Risk Assessment Data Set for Deep Surface Soil (0-4 ft bgs) Discrete Samples (continued)

Station	Sample ID	Date	Depth[a] (ft bgs)
LL9sb-001	LL9sb-001-0001-SO	12/4/2003	1 - 3
LL9sb-002	LL9sb-002-0001-SO	12/4/2003	1 - 3
LL9sb-003	LL9sb-003-0001-SO	12/4/2003	1 - 3
LL9sb-004	LL9sb-004-0001-SO	12/4/2003	1 - 3
LL9sb-005	LL9sb-005-0001-SO	12/4/2003	1 - 3
LL9sb-006	LL9sb-006-0001-SO	12/11/2003	1 - 2
LL9sb-007	LL9sb-007-0001-SO	12/8/2003	1 - 3
LL9sb-008	LL9sb-008-0001-SO	12/10/2003	1 - 3
LL9sb-009	LL9sb-009-0001-SO	12/8/2003	1 - 3
LL9sb-010	LL9sb-010-0001-SO	12/8/2003	1 - 2.5
LL9sb-012	LL9sb-012-0001-SO	12/10/2003	1 - 3
LL9sb-013	LL9sb-013-0001-SO	12/10/2003	1 - 3
LL9sb-014	LL9sb-014-0001-SO	12/11/2003	1 - 3
LL9sb-015	LL9sb-015-0001-SO	12/11/2003	1 - 3
LL9sb-016	LL9sb-016-0001-SO	12/11/2003	1 - 3
LL9sb-018	LL9sb-018-0001-SO	12/10/2003	1 - 3
LL9sb-019	LL9sb-019-0001-SO	12/11/2003	1 - 3
LL9sb-020	LL9sb-020-0001-SO	12/8/2003	1 - 3
LL9sb-021	LL9sb-021-0001-SO	12/8/2003	1 - 3
LL9sb-022	LL9sb-022-0001-SO	12/10/2003	1 - 3
LL9sb-023	LL9sb-023-0001-SO	12/8/2003	1 - 3
LL9sb-024	LL9sb-024-0001-SO	12/10/2003	1 - 3
LL9sb-026	LL9sb-026-0001-SO	12/10/2003	1 - 3
LL9sb-087	LL9sb-087-5438-SO	3/8/2010	1 - 4
LL9sb-088	LL9sb-088-5442-SO	3/8/2010	1 - 4
LL9sb-089	LL9sb-089-5446-SO	3/8/2010	1 - 4
LL9sb-091	LL9sb-091-5454-SO	3/9/2010	1 - 4
LL9sb-092	LL9sb-092-5458-SO	3/9/2010	1 - 4
Non-Production Area			
LL9sb-090	LL9sb-090-5449-SO	3/9/2010	0 - 1
LL9sb-094	LL9sb-094-5465-SO	3/9/2010	0 - 1
LL9ss-011	LL9ss-011-0001-SO	3/11/2002	0 - 1
LL9ss-017	LL9ss-017-0001-SO	12/4/2003	0 - 1
LL9ss-025	LL9ss-025-0001-SO	12/10/2003	0 - 1
LL9ss-027	LL9ss-027-0001-SO	12/4/2003	0 - 1
LL9ss-028	LL9ss-028-0001-SO	12/4/2003	0 - 1
LL9ss-029	LL9ss-029-0001-SO	12/4/2003	0 - 1
LL9ss-030	LL9ss-030-0001-SO	12/4/2003	0 - 1
LL9ss-031	LL9ss-031-0001-SO	12/4/2003	0 - 1
LL9ss-032	LL9ss-032-0001-SO	12/4/2003	0 - 1
LL9ss-034	LL9ss-034-0001-SO	11/11/2003	0 - 1
LL9ss-036	LL9ss-036-0001-SO	11/11/2003	0 - 1
LL9ss-039	LL9ss-039-0001-SO	11/11/2003	0 - 1
LL9ss-068	LL9ss-068-0001-SO	12/12/2003	0 - 1
LL9ss-095	LL9ss-095-5473-SO	3/2/2010	0 - 1
LL9ss-110	LL9ss-110-5488-SO	3/2/2010	0 - 1
LL9ss-131	LL9ss-131-5865-SO	4/26/2011	0 - 1
LL9ss-132	LL9ss-132-5866-SO	4/26/2011	0 - 1
LL9ss-133	LL9ss-133-5867-SO	4/26/2011	0 - 1
LL9ss-134	LL9ss-134-5868-SO	4/26/2011	0 - 1
LL9ss-135	LL9ss-135-5869-SO	4/26/2011	0 - 1
LL9sb-017	LL9sb-017-0001-SO	12/4/2003	1 - 3

1 **Table 7–2. Risk Assessment Data Set for Deep Surface Soil (0-4 ft bgs) Discrete Samples (continued)**

Station	Sample ID	Date	Depth[a] (ft bgs)
LL9sb-025	LL9sb-025-0001-SO	12/10/2003	1 - 3
LL9sb-027	LL9sb-027-0001-SO	12/4/2003	1 - 3
LL9sb-028	LL9sb-028-0001-SO	12/4/2003	1 - 3
LL9sb-029	LL9sb-029-0001-SO	12/4/2003	1 - 3
LL9sb-030	LL9sb-030-0001-SO	12/4/2003	1 - 3
LL9sb-031	LL9sb-031-0001-SO	12/4/2003	1 - 3
LL9sb-032	LL9sb-032-0001-SO	12/4/2003	1 - 3
LL9sb-061	LL9sb-061-0001-SO	11/5/2003	1 - 3
LL9sb-090	LL9sb-090-5450-SO	3/9/2010	1 - 3.5
LL9sb-055	LL9sb-055-0001-SO	11/5/2003	1.5 - 3.5
LL9sb-056	LL9sb-056-0001-SO	11/5/2003	2 - 4
LL9sb-059	LL9sb-059-0001-SO	11/5/2003	3 - 5
Dry Well Area			
LL9sb-093	LL9sb-093-5461-SO	3/9/2010	0 - 1
LL9ss-047	LL9ss-047-0001-SO	11/6/2003	0 - 1
LL9sb-093	LL9sb-093-5462-SO	3/9/2010	1 - 4
LL9sb-047	LL9sb-047-0001-SO	11/6/2003	3 - 5
LL9sb-065	LL9sb-065-0001-SO	11/6/2003	3 - 5

[a] Samples were assigned to depth intervals based on starting depth. For example a sample collected from 3-5 ft bgs is included in the 0-4 ft deep surface soil interval.

[b] Chromium speciation samples used to evaluate the presence of hexavalent chromium.

bgs = Below ground surface.

ft = Feet.

ID = Identification.

Table 7–3. Risk Assessment Data Set for Subsurface Soil Discrete Samples

Station	Sample ID	Date	Depth[a] (ft bgs)
Former Production Area			
Subsurface Soil (4-7 ft bgs)			
LL9sb-046	LL9sb-046-0001-SO	11/6/2003	4 - 6
LL9sb-087	LL9sb-087-5439-SO	3/8/2010	4 - 7
LL9sb-088	LL9sb-088-5443-SO	3/8/2010	4 - 6
LL9sb-089	LL9sb-089-5447-SO	3/8/2010	4 - 7
LL9sb-091	LL9sb-091-5455-SO	3/9/2010	4 - 6
LL9sb-092	LL9sb-092-5459-SO	3/9/2010	4 - 6
LL9sb-040	LL9sb-040-0001-SO	10/27/2003	6 - 7
LL9sb-070	LL9sb-070-0001-SO	10/27/2003	6 - 7
LL9sb-041	LL9sb-041-0001-SO	10/27/2003	6.5 - 7.5
LL9sb-069	LL9sb-069-0001-SO	10/27/2003	6.5 - 7.5
Subsurface Soil (1-13 ft bgs)			
LL9sb-001	LL9sb-001-0001-SO	12/4/2003	1 - 3
LL9sb-002	LL9sb-002-0001-SO	12/4/2003	1 - 3
LL9sb-003	LL9sb-003-0001-SO	12/4/2003	1 - 3
LL9sb-004	LL9sb-004-0001-SO	12/4/2003	1 - 3
LL9sb-005	LL9sb-005-0001-SO	12/4/2003	1 - 3
LL9sb-006	LL9sb-006-0001-SO	12/11/2003	1 - 2
LL9sb-007	LL9sb-007-0001-SO	12/8/2003	1 - 3
LL9sb-008	LL9sb-008-0001-SO	12/10/2003	1 - 3
LL9sb-009	LL9sb-009-0001-SO	12/8/2003	1 - 3
LL9sb-010	LL9sb-010-0001-SO	12/8/2003	1 - 2.5
LL9sb-012	LL9sb-012-0001-SO	12/10/2003	1 - 3
LL9sb-013	LL9sb-013-0001-SO	12/10/2003	1 - 3
LL9sb-014	LL9sb-014-0001-SO	12/11/2003	1 - 3
LL9sb-015	LL9sb-015-0001-SO	12/11/2003	1 - 3
LL9sb-016	LL9sb-016-0001-SO	12/11/2003	1 - 3
LL9sb-018	LL9sb-018-0001-SO	12/10/2003	1 - 3
LL9sb-019	LL9sb-019-0001-SO	12/11/2003	1 - 3
LL9sb-020	LL9sb-020-0001-SO	12/8/2003	1 - 3
LL9sb-021	LL9sb-021-0001-SO	12/8/2003	1 - 3
LL9sb-022	LL9sb-022-0001-SO	12/10/2003	1 - 3
LL9sb-023	LL9sb-023-0001-SO	12/8/2003	1 - 3
LL9sb-024	LL9sb-024-0001-SO	12/10/2003	1 - 3
LL9sb-026	LL9sb-026-0001-SO	12/10/2003	1 - 3
LL9sb-087	LL9sb-087-5438-SO	3/8/2010	1 - 4
LL9sb-088	LL9sb-088-5442-SO	3/8/2010	1 - 4
LL9sb-089	LL9sb-089-5446-SO	3/8/2010	1 - 4
LL9sb-091	LL9sb-091-5454-SO	3/9/2010	1 - 4
LL9sb-092	LL9sb-092-5458-SO	3/9/2010	1 - 4
LL9sb-046	LL9sb-046-0001-SO	11/6/2003	4 - 6
LL9sb-087	LL9sb-087-5439-SO	3/8/2010	4 - 7
LL9sb-088	LL9sb-088-5443-SO	3/8/2010	4 - 6
LL9sb-089	LL9sb-089-5447-SO	3/8/2010	4 - 7
LL9sb-091	LL9sb-091-5455-SO	3/9/2010	4 - 6
LL9sb-092	LL9sb-092-5459-SO	3/9/2010	4 - 6
LL9sb-040	LL9sb-040-0001-SO	10/27/2003	6 - 7
LL9sb-070	LL9sb-070-0001-SO	10/27/2003	6 - 7
LL9sb-041	LL9sb-041-0001-SO	10/27/2003	6.5 - 7.5
LL9sb-069	LL9sb-069-0001-SO	10/27/2003	6.5 - 7.5
LL9sb-089	LL9sb-089-5448-SO	3/8/2010	7 - 13

Table 7-3. Risk Assessment Data Set for Subsurface Soil Discrete Samples (continued)

Station	Sample ID	Date	Depth[a] (ft bgs)
LL9sb-042	LL9sb-042-0001-SO	11/6/2003	8 - 10
LL9sb-044	LL9sb-044-0001-SO	11/6/2003	8 - 10
LL9sb-045	LL9sb-045-0001-SO	11/6/2003	8 - 10
LL9sb-043	LL9sb-043-0001-SO	11/6/2003	9 - 11
Non-Production Area			
Subsurface Soil (4-7 ft bgs)			
None[b]			
Subsurface Soil (1-13 ft bgs)			
LL9sb-017	LL9sb-017-0001-SO	12/4/2003	1 - 3
LL9sb-025	LL9sb-025-0001-SO	12/10/2003	1 - 3
LL9sb-027	LL9sb-027-0001-SO	12/4/2003	1 - 3
LL9sb-028	LL9sb-028-0001-SO	12/4/2003	1 - 3
LL9sb-029	LL9sb-029-0001-SO	12/4/2003	1 - 3
LL9sb-030	LL9sb-030-0001-SO	12/4/2003	1 - 3
LL9sb-031	LL9sb-031-0001-SO	12/4/2003	1 - 3
LL9sb-032	LL9sb-032-0001-SO	12/4/2003	1 - 3
LL9sb-061	LL9sb-061-0001-SO	11/5/2003	1 - 3
LL9sb-090	LL9sb-090-5450-SO	3/9/2010	1 - 3.5
LL9sb-055	LL9sb-055-0001-SO	11/5/2003	1.5 - 3.5
LL9sb-056	LL9sb-056-0001-SO	11/5/2003	2 - 4
LL9sb-059	LL9sb-059-0001-SO	11/5/2003	3 - 5
Dry Well Area			
Subsurface Soil (4-7 ft bgs)			
LL9sb-093	LL9sb-093-5463-SO	3/9/2010	4 - 4.8
LL9sb-066	LL9sb-066-0001-SO	11/6/2003	5 - 7
Subsurface Soil (1-13 ft bgs)			
LL9sb-093	LL9sb-093-5462-SO	3/9/2010	1 - 4
LL9sb-047	LL9sb-047-0001-SO	11/6/2003	3 - 5
LL9sb-065	LL9sb-065-0001-SO	11/6/2003	3 - 5
LL9sb-093	LL9sb-093-5463-SO	3/9/2010	4 - 4.8
LL9sb-066	LL9sb-066-0001-SO	11/6/2003	5 - 7

[a] Samples were assigned to depth intervals based on starting depth. For example a sample collected from 3-5 ft bgs is included in the 0-4 ft deep surface soil interval.

[b] No samples collected in the 4-7 ft bgs interval because shallow bedrock was encountered at 1-5.5 ft bgs.

bgs = Below ground surface.
ft = Feet.
ID = Identification.

Table 7–4. Risk Assessment Data Set for Surface Water

Station	Sample ID	Date
Drainage Ditches		
LL9sw-111	LL9sw-111-5489-SW	2/18/2010
LL9sw-113	LL9sw-113-5491-SW	3/9/2010
LL9sw-114	LL9sw-114-5492-SW	3/9/2010
Dry Well Area		
LL9sw-012	LL9sw-012-0001-SW	12/9/2003

ID = Identification.

Table 7–5. Risk Assessment Data Set for Sediment

Station	Sample ID	Date	Depth (ft bgs)
Drainage Ditches			
LL9sd-111	LL9sd-111-5469-SD	2/18/2010	0 - 0.5
LL9sd-113	LL9sd-113-5471-SD	2/18/2010	0 - 0.5
LL9sd-114	LL9sd-114-5472-SD	2/18/2010	0 - 0.5
Dry Well Area			
LL9sd-012	LL9sd-012-0001-SD	12/9/2003	0 - 1

bgs = Below ground surface.
ft = Feet.
ID = Identification.

Table 7–6. Summary of SRCs

SRC	Surface Soil (0-1 ft bgs)			Deep Surface Soil (0-4 ft bgs)			Subsurface Soil[a] (4-7 ft bgs)		Subsurface Soil (1-13 ft bgs)			Sediment		Surface Water	
	FPA	**NPA**	**DWA**	**FPA**	**NPA**	**DWA**	**FPA**	**DWA**	**FPA**	**NPA**	**DWA**	**Ditches**	**DWA**	**Ditches**	**DWA**
Metals															
Aluminum	X	--	--	X	--	--	--	--	--	--	--	--	--	--	--
Antimony	X	X	--	X	X	--	--	--	X	--	--	X	--	--	--
Arsenic	X	X	--	X	X	--	--	--	X	--	--	--	--	--	--
Barium	X	X	--	X	X	--	X	--	X	--	--	--	--	--	--
Beryllium	X	--	--	X	--	--	X	--	X	--	--	X	X	X	--
Cadmium	X	X	--	X	X	--	X	X	X	X	X	X	--	X	--
Chromium	X	--	--	X	--	--	--	--	X	--	--	--	--	X	--
Cobalt	X	X	--	X	X	--	--	--	--	--	--	X	--	X	--
Copper	X	X	--	X	X	--	--	--	--	--	--	--	--	--	--
Lead	X	X	--	X	X	X	X	--	X	--	X	X	--	X	X
Manganese	X	X	--	X	X	--	--	--	--	--	--	--	--	--	--
Mercury	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Nickel	X	X	--	X	X	--	--	--	--	--	--	X	X	X	X
Selenium	X	X	--	X	X	--	--	--	--	--	--	--	--	--	--
Silver	X	X	--	X	X	--	X	--	X	--	--	X	--	--	--
Thallium	X	X	X	X	X	X	--	--	X	--	--	--	--	--	--
Vanadium	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--
Zinc	X	X	--	X	X	--	--	--	X	--	--	--	--	X	--
Explosives															
Nitrocellulose	X	X	--	X	X	--	--	--	X	X	--	--	--	--	X
Nitroguanidine	--	X	--	--	X	--	--	--	--	--	--	X	--	--	--
PETN	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--
Tetryl	--	--	--	X	--	--	--	--	X	--	--	--	--	--	--
SVOCs															
Acenaphthene	X	X	--	X	X	--	--	--	X	X	--	--	--	--	--
Acenaphthylene	X	X	--	X	X	--	--	--	--	--	--	--	--	--	--
Anthracene	X	X	--	X	X	--	--	--	X	X	--	--	--	--	--
Benz(a)anthracene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--

Table 7-6. Summary of SRCs (continued)

SRC	Surface Soil (0-1 ft bgs)			Deep Surface Soil (0-4 ft bgs)			Subsurface Soil[a] (4-7 ft bgs)		Subsurface Soil (1-13 ft bgs)			Sediment		Surface Water	
	FPA	**NPA**	**DWA**	**FPA**	**NPA**	**DWA**	**FPA**	**DWA**	**FPA**	**NPA**	**DWA**	**Ditches**	**DWA**	**Ditches**	**DWA**
Benzenemethanol	--	--	--	--	--	--	--	--	--	--	--	X	--	--	--
Benzo(a)pyrene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--
Benzo(b)fluoranthene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--
Benzo(*ghi*)perylene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--
Benzo(k)fluoranthene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--
Bis(2-ethylhexyl)phthalate	X	X	--	X	X	--	--	--	--	--	--	--	--	--	--
Chrysene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--
Di-n-butyl phthalate	--	--	--	--	--	--	X	--	X	--	--	--	--	--	--
Dibenz(a,h)anthracene	X	X	--	X	X	--	X	--	X	X	--	--	--	--	--
Dibenzofuran	--	X	--	--	X	--	--	--	--	--	--	--	--	--	--
Fluoranthene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--
Fluorene	X	X	--	X	X	--	--	--	X	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--
2-Methylnaphthalene	X	X	--	X	X	--	--	--	--	--	--	X	--	--	--
Naphthalene	X	X	--	X	X	--	--	--	--	--	--	X	--	--	--
Phenanthrene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--
Pyrene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--
VOCs															
Toluene	X	--	--	X	--	--	--	--	--	--	--	X	--	--	--

[a] No samples were collected from this depth interval at the NPA because bedrock was encountered at 1-5.5 ft bgs.

bgs = Below ground surface.
DWA = Dry Well Area.
FPA = Former Production Area.
ft = Feet.
NPA = Non-Production Area.
PETN = Pentaerythritol tetranitrate.
SRC = Site-related Contaminant.
SVOC = Semi-Volatile Organic Chemical.
VOC = Volatile Organic Chemical.
X = Chemical is an SRC in this medium.
-- = Chemical is not a COPC in this medium.

Table 7–7. Summary of COPCs

	Surface Soil (0-1 ft bgs)			**Deep Surface Soil (0-4 ft bgs)**			**Subsurface Soil[a] (4-7 ft bgs)**		**Subsurface Soil (1-13 ft bgs)**			**Sediment**		**Surface Water**	
COPC	**FPA**	**NPA**	**DWA**	**FPA**	**NPA**	**DWA**	**FPA**	**DWA**	**FPA**	**NPA**	**DWA**	**Ditches**	**DWA**	**Ditches**	**DWA**
Metals															
Aluminum	X	--	--	X	--	--	--	--	--	--	--	--	--	--	--
Arsenic	X	X	--	X	X	--	--	--	X	--	--	--	--	--	--
Chromium	X	--	--	X	--	--	--	--	X	--	--	--	--	--	--
Cobalt	X	X	--	X	X	--	--	--	--	--	--	X	--	X	--
Copper	--	X	--	--	X	--	--	--	--	--	--	--	--	--	--
Lead	--	X	--	--	X	--	--	--	--	--	--	--	--	--	--
Manganese	X	X	--	X	X	--	--	--	--	--	--	--	--	--	--
Mercury	--	X	X	--	X	X	--	--	--	--	X	--	X	--	--
Thallium	--	--	--	--	--	--	--	--	X	--	--	--	--	--	--
SVOCs															
Benz(a)anthracene	X	X	--	X	X	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	X	X	--	X	X	--	X	--	X	X	--	X	--	--	--
Benzo(b)fluoranthene	X	X	--	X	X	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	X	--	--	X	--	--	--	--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	X	X	--	X	X	--	--	--	X	X	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	X	--	--	X	--	--	--	--	--	--	--	--	--	--	--

[a] No samples were collected from this depth interval at the NPA.

bgs = Below ground surface.
COPC = Chemical of Potential Concern.
DWA = Dry Well Area.
FPA = Former Production Area.
ft = Feet.
NPA = Non-Production Area.
SVOC = Semi-Volatile Organic Chemical.
VOC = Volatile Organic Chemical.
X = Chemical is a COPC in this medium.
-- = Chemical is not a COPC in this medium or depth interval.

Table 7–8. Screening Levels Corresponding to an HQ of 1 and TR of 1E-05

COPC	Critical Effect or Target Organ	Screening Level					
		Resident Receptor[a] FWCUG		Industrial Receptor RSL		NGT Receptor FWCUG	
		HQ=1	TR=1E-05	H =1	TR=1E-05	HQ=1	TR=1E-05
Soil and Sediment (mg/kg)							
Aluminum	Neurotoxicity in offspring	73,798	--	1,100,000	--	34,960	--
Arsenic	Skin	20.2	4.25[b]	480	30	1,140	27.8
Chromium, trivalent	NOAEL	81,473	--	1,800,000	--	1,000,000	--
Cobalt[c]	NS	1,313	8,030	350	19,000	140	70.3
Copper	GI, kidney, liver	3,106	--	47,000	--	253,680	--
Lead	--	400[d]	--	800	--	800[d]	--
Manganese	CNS	2,927	--	26,000	--	351[b]	--
Mercury	Hand tremor, memory disturbance	22.7	--	40	--	1,722	--
Thallium	CNS, lung, heart, kidney, liver	6.12	--	12	--	477	--
Benz(a)anthracene	NA	--	2.21	--	29	--	47.7
Benzo(a)pyrene	NA	--	0.221	--	2.9	--	4.77
Benzo(b)fluoranthene	NA	--	2.21	--	29	--	47.7
Benzo(k)fluoranthene	NA	--	22.1	--	290	--	477
Dibenz(a,h)anthracene	NA	--	0.221	--	2.9	--	4.77
Indeno(1,2,3-cd)pyrene	NA	--	2.21	--	29	--	47.7
Surface Water (mg/L)							
Cobalt	NS	0.006[e]	--	NA	NA	0.006[e]	--

[a] Resident Receptor FWCUGs are the smaller of the Adult or Child values for each COPC and endpoint (non-cancer and cancer).

[b] Risk-based FWCUG is less than the background screening values for arsenic in surface soil (15.4 mg/kg), subsurface soil (19.8 mg/kg) and sediment (19.5 mg/kg) and for manganese in surface soil (1,450 mg/kg), subsurface soil (3030 mg/kg), and sediment (1950 mg/kg).

[c] No FWCUGs are available for cobalt in sediment. The sediment and surface soil FWCUGs are the same for these receptors; therefore, cobalt concentrations were compared to the FWCUG for soil for the identification of COCs in sediment.

[d] No FWCUG is available for lead; the RSL is used. No endpoint is specified for this screening level.

[e] No FWCUG is available for cobalt. Value is the U.S. Environmental Protection Agency (USEPA) tap water RSL.

CNS = Central nervous system.
COPC = Chemical of potential concern.
FWCUG = Facility-wide cleanup goal.
HQ = Hazard quotient.
mg/L = Milligrams per liter.
NA = Not applicable.
NGT = National Guard Trainee.
NOAEL = No observed adverse effect level.
NS = Not specified.
RSL = Regional screening level.
TR = Target risk.
-- = No value available.

Table 7–9. Total and Hexavalent Chromium Soil Sample Results

Discrete Sample Location	Total Chromium (mg/kg)	Hexavalent Chromium (mg/kg)
LL9ss-100	18	ND
LL9ss-101	21.4	0.74J
LL9ss-109	10.2	ND

J = estimated concentration.
mg/kg = Milligrams per kilogram.
ND = Not detected.

Table 7–10. COCs Identified for Surface Soil Using EPC Comparison at Load Line 9

COC	Exposure Unit	EPC Surface Soil (0-1 ft bgs)	Resident Receptor (Adult and Child) FWCUG	Industrial RSL	EPC Deep Surface Soil (0-4 ft bgs)	National Guard Trainee FWCUG
Mercury	**NPA**	**161**	**22.7**	**40**	92.5	1722
Benz(a)anthracene	**FPA**	**2.52**	**2.21**	29	1.91	47.7
	NPA	0.23[a]			0.23	
Benzo(a)pyrene	**FPA**	**2.27**	**0.221**	2.9	1.72	4.77
	NPA	**0.24**			0.24	
Benzo(b)fluoranthene	**FPA**	**3.04**	**2.21**	29	2.3	47.7
	NPA	0.24[a]			0.24	
Dibenz(a,h)anthracene	**FPA**	**0.344**	**0.221**	2.9	0.26	4.77
	NPA	0.064[a]			0.038	

[a] EPC is less than FWCUG and RSL values for all receptors. Chemical is identified as a COC based on contribution to sum-of-ratios.
Bold and shaded = EPC exceeds shaded FWCUG or RSL and chemical is identified as a COC for this exposure unit and receptor.
All concentrations are mg/kg.
bgs = Below ground surface.
COC = Chemical of concern.
EPC = Exposure point concentration = 95% upper confidence limit (UCL) on the mean or maximum detected concentration (MDC) if the 95% UCL exceeds the MDC.
FPA = Former production area.
Ft = Feet.
FWCUG = Facility-wide cleanup goal at a target risk of 1E-05 or target hazard quotient of 1.
NPA = Non-production area.
RSL = Regional screening level at a target risk of 1E-05 or target hazard quotient of 1.

Table 7–11. Environmental Concentrations of PAHs Measured in Background Surface Soil Samples at RVAAP

Analyte	% Detects		Reported Concentration (mg/kg)	
			Minimum	Maximum
Acenaphthene	1/15	7%	0.88	0.88
Acenaphthylene	1/15	7%	0.07	0.07
Anthracene	2/15	13%	0.12	1
Benz(a)anthracene	10/15	67%	0.044	4.1
Benzo(a)pyrene	8/15	53%	0.058	3.7
Benzo(b)fluoranthene	10/15	67%	0.062	4.8
Benzo(*ghi*)perylene	6/15	40%	0.046	1.3
Benzo(k)fluoranthene	6/15	40%	0.053	2.6
Chrysene	10/15	67%	0.057	4
Dibenz(a,h)anthracene	2/15	13%	0.11	0.37
Indeno(1,2,3-cd)pyrene	5/15	33%	0.054	1.5

mg/kg = Milligrams per kilogram.

Table 7–12. Baseline Levels of Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, and Dibenz(a,h)anthracene in Soil from Various Data Sets

Study	Number of Samples	Geometric Mean or Median	Minimum	95th Percentile[a]	Maximum
Benz(a)anthracene					
CA/T Project[b]	872	0.33	0.045	19	250
LSPA Project[b]	490	0.563	ND	--	796
Watertown[b]	17	0.411	0.021	6.04	6.05
Worcester[b]	68	--	ND	3.8	15
New England[c]	62	0.672	ND	1.86	15
Illinois[d] Urban	--	--	--	1.8	--
Illinois[d] Rural	--	--	--	0.72	--
ATSDR[e] Urban	--	--	0.169	--	59
ATSDR[e] Rural	--	--	0.005	--	0.02
ATSDR[e] Agricultural	--	--	0.056	--	0.11
NYSDEC Rural Near Roads[f]	28	--	ND	1.2	2.9
NYSDEC Rural Distant Roads[f]	118	--	ND	0.16	2.6
Benzo(a)pyrene					
CA/T Project[b]	873	0.3	0.031	17	230
LSPA Project[b]	489	0.44	ND	--	222
Watertown[b]	17	0.95	0.6	4.77	6.08
Worcester[b]	67	--	ND	3.3	9.7
New England[c]	62	0.686	ND	1.82	13
Illinois[d] Urban	--	--	--	2.1	--
Illinois[d] Rural	--	--	--	0.98	--
ATSDR[e] Urban	--	--	0.165	--	0.22
ATSDR[e] Rural	--	--	0.002	--	1.3
ATSDR[e] Agricultural	--	--	0.0046	--	0.9
NYSDEC Rural Near Roads[f]	28	--	ND	1.1	2.4
NYSDEC Rural Distant Roads[f]	118	--	ND	0.12	3.4
Benzo(b)fluoranthene					
CA/T Project[b]	873	0.68	0.045	18	270
LSPA Project[b]	486	--	ND	--	250
Watertown[b]	17	1.4	0.6	6.79	7.08
Worcester[b]	--	--	--	--	--
New England[c]	62	0.722	ND	1.97	12

Table 7-12. Baseline Levels of Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, and Dibenz(a,h)anthracene in Soil from Various Data Sets (continued)

Study	Number of Samples	Geometric Mean or Median	Minimum	95th Percentile[a]	Maximum
Illinois[d] Urban	--	--	--	2	--
Illinois[d] Rural	--	--	--	0.7	--
ATSDR[e] Urban	--	--	15	--	62
ATSDR[e] Rural	--	--	0.02	--	0.03
ATSDR[e] Agricultural	--	--	0.058	--	0.22
NYSDEC Rural Near Roads[f]	28	--	ND	1.2	3.3
NYSDEC Rural Distant Roads[f]	118	--	ND	0.36	4.6
Dibenz(a,h)anthracene					
CA/T Project[b]	866	0.17	0.045	2.1	39
LSPA Project[b]	--	--	--	--	--
Watertown[b]	17	0.195	0.155	0.604	0.64
Worcester[b]	68	--	ND	--	1.6
New England[c]	62	0.245	ND	--	2.9
Illinois[d] Urban	--	--	--	0.42	--
Illinois[d] Rural	--	--	--	0.15	--
ATSDR[e]	--	--	--	--	--
NYSDEC Rural Near Roads[f]	28	--	--	--	--
NYSDEC Rural Distant Roads[f]	118	--	ND	ND	0.23

[a] Lognormal 95th percentile value for all studies except: (1) New England value is 95% upper confidence limit and (2) NYSDEC values are distribution-free 95th percentile.

[b] Data reported by Massachusetts Department of Environmental Protection (MADEP 2002).

CA/T = Data collected by Mass Highway Department as part of the Central Artery/Tunnel (CA/T) project.

LSPA = Preliminary data compiled by the Massachusetts Licensed Site professional Association (LSPA) from background data submitted by its members in 2001. Water Town and Worcester Site-specific background samples.

[c] Data from three New England locations from Bradley et al. 1994.

[d] Background concentrations of polycyclic aromatic hydrocarbons in Illinois metropolitan statistical areas (urban) and non-metropolitan statistical areas (rural) as reported by Illinois EPA (IEPA 2005).

[e] Generic background data published by the Agency for Toxic Substances and Disease Registry in PAHs August 1995.

[f] Distribution-free 95th percentile values for near roads (less than 10 ft from roads and pavement) and not near roads (more than 15 ft from roads and pavement) from New York State Brownfield Cleanup program Development of Soil Cleanup Objectives Technical Support Document (September 2006), Appendix D.

ND = Not detected.

-- = No value reported for this source.

Table 7–13. COCs in Surface Soil for Potential Remediation at Load Line 9

COC	EU or Sample Location	EPC or Sample Concentration	FWCUG or RSL		
			Resident Receptor (Adult and Child)	**Industrial Receptor**	**National Guard Trainee**
Lead	**NPA**	**239 (159)**	400	800	800
	DT-34 (Detonator Destroying House)				
	LL9ss-011	1330			
Mercury	**NPA**	**161 (114)**	**22.7**	**40**	1722
	DT-34 (Detonator Destroying House)				
	LL9ss-011	882			
	LL9ss-131	65			
	LL9ss-132	280			
	LL9ss-133	520			
Benz(a)anthracene	**FPA**	**2.52 (1.91)**	**2.21**	29	47.7
	DT-28 (Change House)				
	LL9ss-096	17			
	LL9ss-097	1			
Benzo(a)pyrene	**FPA**	**2.27 (1.72)**	**0.221**	**2.9**	**4.77**
	DT-28 (Change House)				
	LL9ss-096	15			
	LL9ss-097	1.7			
Benzo(b)fluoranthene	**FPA**	**3.04 (2.3)**	**2.21**	29	47.7
	DT-28 (Change House)				
	LL9ss-096	20			
	LL9ss-097	2.4			
Dibenz(a,h)anthracene	**FPA**	**0.344 (0.26)**	**0.221**	2.9	4.77
	DT-28 (Change House)				
	LL9ss-096	2.2			
	LL9ss-097	0.36			

All concentrations are mg/kg.

Bold and shaded = EPC or sample concentration exceeds shaded FWCUG or RSL and chemical is identified as a COC for this location and receptor.

COC = Chemical of concern.

EPC = Exposure point concentration = 95% upper confidence limit (UCL) on the mean or maximum detected concentration if the 95% UCL exceeds the MDC. Value in (parenthesis) is the EPC for the 0-4 ft bgs deep surface soil exposure depth.

EU = Exposure unit.

FPA = Former production area.

FWCUG = Facility-wide cleanup goal at a target risk of 1E-05 or target hazard quotient of 1.

NPA = Non-production area.

RSL = Regional screening level at a target risk of 1E-05 or target hazard quotient of 1.

Table 7–14. Summary of Historical COPECs per the Phase I RI

Group	COPEC	Deep Surface Soil	Sediment	Surface Water
Inorganic chemicals	Aluminum	X	--	X
	Arsenic	X	--	--
	Beryllium	--	X	--
	Chromium	X	--	--
	Copper	X	--	X
	Iron	X	--	X
	Lead	X	X	X
	Manganese	X	--	X
	Mercury	X	X	X
	Nickel	X	--	--
	Selenium	X	X	--
	Vanadium	X	--	--
	Zinc	X	--	X
SVOCs	Bis(2-ethylhexyl)phthalate	--	X	--
	Dibenz(a,h)anthracene	--	X	--
	Dibenzofuran	X	--	--
Explosives	Nitroguanidine	X	--	--
	RDX	X	--	--
Propellants	Nitrocellulose	X	X	X

Adapted from the Report for the Phase I Remedial Investigation at Load Line 9 (MKM 2007).
COPEC = Chemical of potential ecological concern.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
SVOC = Semi-volatile organic compound.
-- = Chemical not identified as a COPEC in this data set.
X = Quantitative COPEC, exceeds ecological screening value (ESV), does not have an ESV, or is a persistent, bioaccumulative, and toxic (PBT) compound.

Table 7–15. Survey of Proximity to the AOC of Various Ecological Resources

Natural Resource	Inside Habitat Area	Near the AOC	Distances to Nearest Resources and Comments[a]
Wetlands (Planning Level Survey and Jurisdictional)	Not surveyed, none known	Near south, southeast, and northeast boundaries	Two small wetlands 100 ft and 150 ft southeast along George Road
Rare species	No known sightings	None	1,600 ft northeast 1,700 ft southwest 2,950 ft northeast 3,000 ft northeast (See text for species names)
Beaver dams	None	None	1,400 ft west
100-year floodplain	None	None	1,100 ft north
Stream sampling[b]	None	None	Approximately 1,100 ft north-northwest
Pond sampling[b]	None	None	4,100 ft southeast

[a] Measurements of distance and direction are taken from the nearest boundary of the AOC to the resource being measured.
[b] Stream and pond sampling refers to *Facility-Wide Biological and Water Quality Study 2003* (USACE 2005a).
AOC = Area of Concern.
ft = Feet.

Table 7–16. Summary of Integrated COPECs for Deep Surface Soil at the Former Production Area

COPEC	MDC (mg/kg)	ESV (mg/kg)	Ratio of MDC to ESV	Comments
Aluminum	20,000	50	400	Second highest ratio at about 400x
Antimony	1.2	0.27	4.4	None
Arsenic	32	18	1.8	None
Cadmium	2.9	0.36	8.1	None
Chromium	110	26	4.2	None
Cobalt	17	13	1.3	None
Copper	31	28	1.1	None
Lead	320	11	29.1	None
Manganese	3,240	220	14.7	None
Mercury	1.3	0.00051	2,549	Highest ratio at about 2,549x; PBT compound
Selenium	1.4	0.52	2.7	None
Zinc	228	46	5.0	None
Nitrocellulose	1.8	No ESV	--	None
Tetryl	0.011	No ESV	--	None
Benz(a)anthracene	17	5.21	3.3	None
Benzo(a)pyrene	15	1.52	9.9	None
Chrysene	17	4.73	3.6	None
Naphthalene	0.92	0.0994	9.3	None

Table excludes nutrients.
COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
MDC = Maximum detected concentration.
mg/kg = Milligrams per kilogram.
PBT = Persistent, bioaccumulative, and Toxic.
x = Multiplier.
-- = Not applicable, no ESV is available for comparison.

Table 7–17. Summary of Integrated COPECs for Deep Surface Soil at the Non-Production Area

COPEC	MDC (mg/kg)	ESV (mg/kg)	Ratio of MDC to ESV	Comments
Antimony	1.4	0.27	5.2	None
Cadmium	2.7	0.36	7.5	None
Cobalt	18	13	1.4	None
Copper	1,240	28	44.3	None
Lead	1,330	11	120.9	Second highest ratio at about 121x
Manganese	3,800	220	17.3	None
Mercury	882	0.00051	> 1,000,000	Highest ratio greater than 1,000,000x, PBT compound
Selenium	1.8	0.52	3.5	None
Zinc	780	46	17	None
Nitrocellulose	3.2	No ESV	--	None
Nitroguanidine	0.089	No ESV	--	None
Dibenzofuran	0.013	No ESV	--	None

Table excludes nutrients.
COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
MDC = Maximum detected concentration.
mg/kg = Milligrams per kilogram.
PBT = Persistent, bioaccumulative, and toxic.
x = Multiplier.
-- = Not applicable, no ESV is available for comparison.

Table 7–18. Summary of Integrated COPECs for Sediment at the Drainage Ditches

COPEC	MDC (mg/kg)	ESV (mg/kg)	Ratio of MDC to ESV	Comments
Beryllium	0.89	No ESV	--	None
Mercury	0.37	0.18	2.06	Second highest ratio at about 2x, PBT compound
Nitroguanidine	1.2	No ESV	--	None
PETN	0.13	No ESV	--	None
Benzenemethanol	0.036	0.00104	34.6	Highest ratio at about 35x

Table excludes nutrients.
COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
MDC = Maximum detected concentration.
mg/kg = Milligrams per kilogram.
PBT = Persistent, bioaccumulative, and toxic.
PETN = Pentaerythritol tetranitrate.
x = Multiplier.
-- = Not applicable, no ESV is available for comparison.

Table 7–19. Summary of Integrated COPECs for Sediment at the DWA

COPEC	MDC (mg/kg)	ESV (mg/kg)	Ratio of MDC to ESV	Comments
Beryllium	0.86	No ESV	--	None
Mercury	2.9	0.18	16.1	Highest ratio at about 16x, PBT compound

Table excludes nutrients.
COPEC = Chemical of potential ecological concern.
DWA = Dry Well Area.
ESV = Ecological screening value.
MDC = Maximum detected concentration.
mg/kg = Milligrams per kilogram.
PBT = Persistent, bioaccumulative, and toxic.
x = Multiplier.
-- = Not applicable, no ESV is available for comparison.

Table 7–20. Summary of Integrated COPECs Based on MDCs for Surface Water at the Drainage Ditches

COPEC	MDC (mg/L)	ESV (mg/L)	Ratio of MDC to ESV	Comments
Mercury	0.002	0.0017	1.18	PBT compound

Table excludes nutrients.
COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
MDC = Maximum detected concentration.
mg/L = Milligram per liter.
PBT = Persistent, bioaccumulative, and toxic.

Table 7–21. Summary of Integrated COPECs Based on Average Concentrations for Surface Water at the Drainage Ditches

COPEC	Average Detected Concentration (mg/L)	ESV (mg/L)	Ratio of Average Detected Concentration to ESV	Comments
Mercury	0.000733	0.00091	0.81	PBT compound

Table excludes nutrients.
COPEC = Chemical of Potential Ecological Concern.
ESV = Ecological Screening Value.
mg/L = Milligram per liter.
PBT = Persistent, Bioaccumulative, and Toxic.

Table 7–22. Summary of Integrated COPECs Based on MDCs for Surface Water at the DWA

COPEC	MDC (mg/L)	ESV (mg/L)	Ratio of MDC to ESV	Comments
Mercury	0.0003	0.0017	0.18	PBT compound
Nitrocellulose	0.12	No ESV	--	None

Table excludes nutrients.
COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
MDC = Maximum detected concentration.
mg/L = Milligram per liter.
PBT = Persistent, bioaccumulative, and toxic.
-- = Not applicable, no ESV is available for comparison.

Table 7–23. Summary of Integrated COPECs Based on Average Concentrations for Surface Water at the DWA

COPEC	Average Detected Concentration* (mg/L)	ESV (mg/L)	Ratio of Average Detected Concentration to ESV	Comments
Mercury	0.0003	0.00091	0.33	PBT compound
Nitrocellulose	0.12	No ESV	--	None

Table excludes nutrients.
*Note: As only one water sample was collected from the Dry Well Area, the MDC was used as the average concentration.
COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
MDC = Maximum detected concentration.
mg/L = Milligram per liter.
PBT = Persistent, bioaccumulative, and toxic.
-- = Not applicable, no ESV is available for comparison.

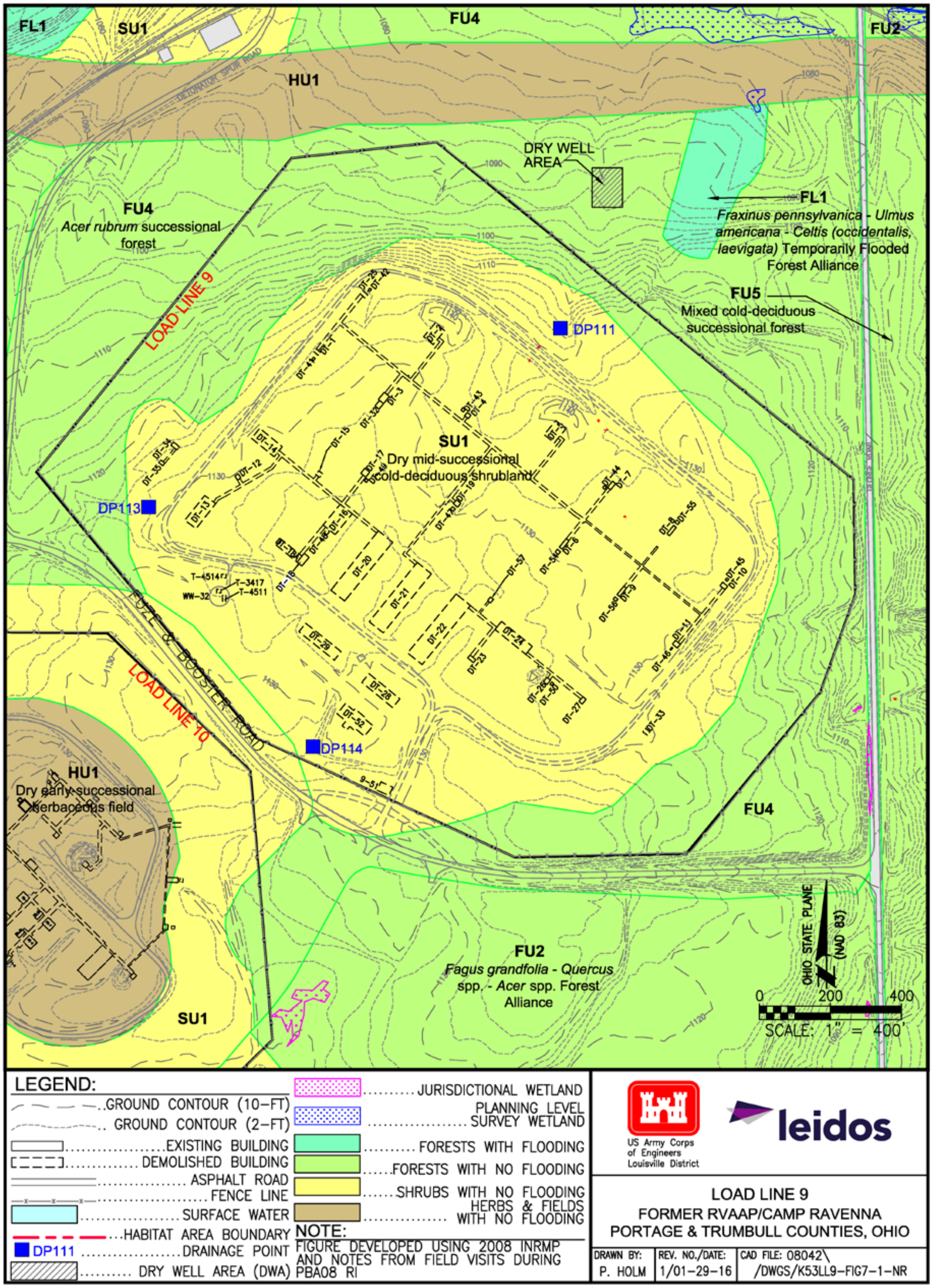


Figure 7-1. Natural Resources Inside the Habitat Area at Load Line 9

8.0 REMEDIAL INVESTIGATION CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

The RI Report for Load Line 9 presents a detailed analysis of historical and newly acquired environmental data. The following sections summarize the major findings of the nature and extent of contamination, modeling of contaminant fate and transport, HHRA, and ERA. A CSM incorporating all available information is also presented to integrate results of prior investigations and the PBA08 RI. The CSM denotes, based on available data, where source areas occur, the mechanisms for contaminant migration from source areas to receptor media (e.g., surface water and groundwater), exit pathways from the AOC, and whether COCs occur that may require further evaluation in an FS. This section presents the need for any further characterization of the media evaluated under the RI phase of work and whether to proceed to the FS phase of the CERCLA RI/FS process.

8.2 SUMMARY OF DATA USED IN THE REMEDIAL INVESTIGATION

Quality-assured sample data from the 2002 lead azide screening, 2003 Phase I RI, and 2010 and 2011 PBA08 RIs were used to evaluate nature and extent of contamination at Load Line 9. These investigations used discrete sampling methods.

All available sample data collected at the locations were evaluated to determine suitability for use in various key RI data screens and evaluations (i.e., nature and extent, fate and transport, risk assessment). Evaluation of data suitability for use in the PBA08 RI involved two primary considerations: (1) whether the data represented current AOC conditions, and (2) sample collection methods (e.g., discrete vs. ISM).

Samples from the 2002 lead azide screening and 2003 Phase I RI were evaluated to determine if conditions had changed substantively between earlier characterization efforts and the 2010 PBA08 RI. In October 2002, thermal decontamination and 5x certification of all buildings at Load Line 9 were initiated to burn structures in-place to remove potentially explosive residue from building material in order to achieve a 5X status. From May 2006 to July 2007, floor slabs, foundations, and footers of 22 buildings were removed to a minimum of 4 ft bgs. Phase I RI samples from soil borings LL9sb-048 through LL9sb-053 were collected under buildings that were subsequently demolished and were potentially affected by these demolition activities. These samples were omitted from the SRC screen; however, they were retained for purposes of nature and extent and contaminant migration evaluation.

Data collected in 2010 and 2011 as part of the PBA08 RI focused on delineating the extent of contaminants identified in surface soil (0–1 ft bgs), subsurface soil (1-13 ft bgs), sediment, and surface water. The PBA08 RI sampled locations with the greatest likelihood of contamination (e.g., adjacent to production buildings or within sediment accumulation areas, such as ditches) and analyzed for chemicals identified in historical investigations.

8.3 SUMMARY OF NATURE AND EXTENT

Nature and extent of contamination in surface soil (0-1 ft bgs), subsurface soil (greater than 1 ft bgs), sediment, and surface water was evaluated in the RI. Data from the 2002 lead azide screening, 2003 Phase I RI, and 2010 and 2011 PBA08 RIs provided effective characterization of the nature and extent of the contamination at the AOC. To support the evaluation of nature and extent of contamination, SRC concentrations were compared to SLs corresponding to the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 0.1 or TR of 1E-06, as presented in the FWCUG Report (USACE 2010a). It can be concluded that the vertical and horizontal extent of contamination is defined, and no further sampling is needed to evaluate Load Line 9.

Sites where explosives were identified as potential contaminants from previous use were thoroughly evaluated, including around former process buildings and across each EU. The maximum concentrations for explosives and propellants were all below their respective SLs and were not considered COPCs. Results from the March 2002 sample screening indicate that there is no detectable safety concern related to azide contamination at Load Line 9. The March 2002 screening results also indicated that there is minimal contamination of secondary explosives at Load Line 9. No explosives were detected above reporting limits in any of the surface soil, sediment, or surface water samples.

The soil around the elevated water tank was evaluated by soil samples collected at LL9sb-024 and LL9sb-025. The concentrations for lead in surface and subsurface soil at these locations were below the residential RSL of 400 mg/kg, with a maximum concentration of 320 mg/kg at LL9ss-024 in surface soil (0-1 ft bgs).

As identified in the Phase I RI Report, concentrations of contaminants are generally low, with a notable exception being a localized spot at LL9ss–011 in surface soil (0-1 ft bgs). Mercury was detected above the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1 with an MDC of 882 mg/kg observed at sample location LL9ss-011 adjacent a former detonator destroying house (DT-34). Additional samples analyzed for mercury in April 2011 helped delineate the lateral extent of mercury contamination at this location. In addition, lead had a concentration of 1,330 mg/kg at this location, exceeding the residential RSL of 400 mg/kg and industrial RSL of 800 mg/kg.

Soil borings LL9ss-096 and LL9ss-097 had PAH concentrations greater than their respective Resident Receptor FWCUG at a TR of 1E-05, HQ of 1. Both soil borings were located near the former dining facility (DT-52) and former change house (DT-28) buildings. Although these buildings were not production buildings, they were most likely heated and had heavy vehicle traffic during operations. Subsurface samples were not collected at these locations; however, subsurface soil was characterized at the neighboring change house (DT-29) and did not contain PAH detections in deeper sample intervals (1-4 and 4-6 ft bgs). In addition, identified PAH contamination at the former RVAAP has been predominately in the surface soil (0-1 ft bgs).

Building DT-33 was the only building at Load Line 9 whose purpose was solvent storage. The samples associated with former Building DT-33 (LL9sb-055 and LL9sb-056) had no detectable concentrations of VOCs in the surface soil. In addition, there were no detected concentrations of PCBs in the soil samples collected across the site, and none of the detected chemical concentrations in sediment or surface water were above the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1.

8.4 SUMMARY OF CONTAMINANT FATE AND TRANSPORT

All SRCs identified in the surface soil, subsurface soil and sediment at Load line 9 were evaluated through the stepwise contaminant fate and transport evaluation. The evaluation included analyzing leaching and migration from soil and sediment to groundwater, and determining whether contaminations present in soil and sediment may potentially impact groundwater quality at the site.

Maximum concentrations of SRCs identified in surface and subsurface soil were evaluated using a series of generic screening steps to identify initial contaminant migration CMCOPCs. Initial CMCOPCs for soil were further evaluated using the SESOIL model to predict leaching concentrations and identify final CMCOPCs based on RVAAP facility-wide background concentrations and the lowest risk-based screening criteria among USEPA MCLs, USEPA tap water RSLs, or RVAAP groundwater FWCUGs for the Resident Receptor Adult. A sediment screening analysis was performed for sediment samples at the AOC. Chemical-specific DAFs were calculated using co-located surface water and sediment concentrations for identified sediment SRCs. These DAFs were used in the sediment screening analysis to identify the final CMCOPCs based on RVAAP facility-wide background concentrations and the lowest risk-based screening criteria. Final CMCOPCs were evaluated using the AT123D model to predict groundwater concentrations beneath source areas and at the nearest downgradient groundwater receptor to the AOC (e.g., stream).

The evaluation of modeling results with respect to current AOC groundwater data and model limitations identified the following CMCOPCs:

- Among the soil CMCOPCs, arsenic, cobalt, manganese, mercury, and naphthalene were predicted to exceed the screening criteria in groundwater beneath the source area and only naphthalene was predicted to be above its criteria at the downgradient receptor location.
- Among the sediment CMCOPCs, mercury, nitroguanidine, PETN, benzo(a)anthracene, benzo(b)fluoranthene, and naphthalene were predicted to exceed the screening criteria in groundwater beneath the source area; however, none of these CMCOPCs were predicted to be above criteria in the downgradient receptor location.

A qualitative assessment of the sample results and considerations of the limitations and assumptions of the models were performed to identify if any CMCOCs are present in soil and sediment at Load Line 9 that may impact the groundwater beneath the source or at the downstream receptor location. This qualitative assessment concluded that there were no CMCOCs present in soil and sediment that may impact the groundwater beneath the source or at the downstream receptor location. No further action is required of soil and sediment at Load Line 9 for the protection of groundwater.

8.5 SUMMARY AND CONCLUSIONS OF THE HUMAN HEALTH RISK ASSESSMENT

The HHRA identified COCs and conducted risk management analysis to determine if COCs pose unacceptable risk to the Resident Receptor. If there is no unacceptable risk to the Resident Receptor, it can be concluded that there is no unacceptable risk to the National Guard Trainee and Industrial Receptor. However, if unacceptable risk is identified for the Resident Receptor, the risk to the National Guard Trainee and Industrial Receptor is evaluated.

Media of concern at Load Line 9 are surface soil, subsurface soil, surface water, and sediment. Soil data associated with Load Line 9 were aggregated into surface and subsurface soil at the FPA, NPA, and DWA. Surface water and sediment were evaluated at the Drainage Ditches and the DWA.

No COCs were identified for any receptor at any EU in subsurface soil, sediment, or surface water. Additionally, there were no COCs identified for any receptor for surface soil in the DWA.

Lead, mercury, and four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] were identified as COCs to be carried forward for potential remediation. Lead and mercury are COCs to be carried forward for potential remediation at the NPA in the area of the former detonator destroying house (DT-34) for all three Land Uses. Elevated levels of lead and mercury may be present in this area as a result of lead azide and mercury fulminate used in detonators.

The PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were identified as COCs to be carried forward for potential remediation at the FPA in the area of the former change house (DT-28) for Unrestricted (Residential) Land Use. Additionally, benzo(a)pyrene was identified as a COC in this area to be carried forward for potential remediation for Industrial and Military Training Land Uses. PAHs are present at the NPA, but at much lower concentrations than the FPA. For example, the maximum concentration of benzo(a)pyrene in the NPA is 0.24 mg/kg, compared to the Residential (Adult and Child) FWCUG of 0.221 mg/kg. PAH concentrations at the NPA are similar to those reported for normal atmospheric deposition and do not warrant evaluation in an FS.

8.6 SUMMARY AND CONCLUSIONS OF THE ECOLOGICAL RISK ASSESSMENT

The ERA Level I presents important ecological resources on or near the AOC and evaluates the potential for current contamination to impact ecological resources. At Load Line 9, there are 18 integrated COPECs identified in deep surface soil at the FPA and 12 integrated COPECs in deep surface soil at the NPA. In addition, there are five integrated COPECs in sediment at the Drainage Ditches (beryllium, mercury, benzenemethanol, nitroguanidine, and PETN), two integrated COPECs in sediment at the DWA (beryllium and mercury), one integrated COPEC in surface water at the Drainage Ditches (mercury), and two integrated COPECs in surface water at the DWA (mercury and nitrocellulose). Ecological resources at Load Line 9 were compared to the list of important ecological places and resources. None of the 39 important places and resources were present, and there is nothing ecologically significant at Load Line 9. The ERA summarizes in detail the chemicals and resources to demonstrate that there is contamination at Load Line 9, but no important or significant ecological resources are present. Consequently, the Level I Scoping Level Risk Assessment concluded that no further action is necessary to be protective of ecological resources.

8.7 UPDATED CONCEPTUAL SITE MODEL

The CSM is updated in this section to incorporate results of the PBA08 RI. Elements of the CSM include:

- Primary and secondary contaminant sources and release mechanisms;
- Contaminant migration pathways and discharge or exit points;
- Potential receptors with unacceptable risk; and
- Data gaps and uncertainties.

The following sections describe each of the above elements of the CSM for Load Line 9, and the CSM is presented on Figure 8-1. In addition, figures contained in earlier sections of the report that illustrate AOC features, topography, groundwater and surface water flow directions, and nature and extent of SRCs are cited to assist in visualizing key summary points of the revised CSM.

8.7.1 Primary and Secondary Contaminant Sources and Release Mechanisms

No primary contaminant sources (e.g., operational facilities) were located at the AOC, with the exception of an elevated water tank in the western portion of the AOC. All operations ceased at Load Line 9 in 1945. All buildings were thermally decontaminated and demolished by 2003, and the footer and slab removal was conducted by 2007. Remnant contamination in soil and sediment within the AOC is considered a secondary source of contamination.

The occurrence and distribution of inorganic SRCs above background concentrations in surface soil is generally widespread, and notable spatial patterns are not evident for most SRCs. A notable exception is a localized spot at LL9ss–011 in surface soil (0-1 ft bgs). Mercury was detected above the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1 with an MDC of 882 mg/kg observed at sample location LL9ss-011 adjacent a former detonator destroying house (DT-34). Additional samples analyzed for mercury in April 2011 helped delineate the lateral extent of mercury contamination at this location. In addition, lead had a concentration of 1,330 mg/kg at this location, exceeding the residential RSL of 400 mg/kg and industrial RSL of 800 mg/kg.

The soil around the elevated water tank was evaluated by soil samples collected at LL9sb-024 and LL9sb-025. The concentrations for lead in surface and subsurface soil at these locations were below the residential RSL of 400 mg/kg, with a maximum concentration of 320 mg/kg at LL9ss-024 in surface soil (0-1 ft bgs).

Soil borings LL9ss-096 and LL9ss-097 had PAH concentrations greater than their respective Resident Receptor FWCUG at a TR of 1E-05, HQ of 1. Both soil borings were located near the former dining facility (DT-52) and former change house (DT-28) buildings. Although these buildings were not production buildings, they were most likely heated and had heavy vehicle traffic during operations.

Subsurface samples were not collected at these locations; however, subsurface soil was characterized at the neighboring change house (DT-29) and did not contain PAH detections in deeper sample intervals (1-4 and 4-6 ft bgs). In addition, identified PAH contamination at the former RVAAP has been predominately in the surface soil (0-1 ft bgs).

Sites where explosives were identified as potential contaminants from previous use were thoroughly evaluated, including around former process buildings and across each EU. The maximum concentrations for explosives and propellants were all below their respective SLs and were not considered COPCs. Results from the March 2002 sample screening indicate that there is no detectable safety concern related to azide contamination at Load Line 9. The March 2002 screening results also indicated that there is minimal contamination of secondary explosives at Load Line 9. No explosives were detected above reporting limits in any of the surface soil, sediment, or surface water samples.

Building DT-33 was the only building at Load Line 9 whose purpose was solvent storage. The samples associated with former Building DT-33 (LL9sb-055 and LL9sb-056) had no detectable concentrations of VOCs in the surface soil.

None of the detected chemical concentrations in sediment or surface water were above the Resident Receptor FWCUG at a TR of 1E-05, HQ of 1.

The primary mechanisms for release of contaminants from secondary sources at the AOC are:

- Erosion of soil matrices with sorbed contaminants and mobilization in overland surface water storm runoff during heavy rainfall conditions; and
- Contaminant leaching to groundwater.

8.7.2 Contaminant Migration Pathways and Exit Points

8.7.2.1 Surface Water Pathways

Surface water at Load Line 9 occurs intermittently as storm water runoff within natural and constructed drainage ditches or conveyances. Migration of contaminants from soil sources via surface water occurs primarily by: (1) movement of the particle-bound contaminants in surface water runoff; and (2) transport of dissolved constituents in surface water. In the case of particle-bound contaminant migration, contaminants will be mobilized during periods of high flow (e.g., rain events). Upon reaching portions of surface water conveyances where flow velocities decrease, they will settle out as sediment accumulation. Sediment-bound contaminants may become re-suspended and migrate during storm events or may partition to dissolved phase in surface water.

In the case of particle-bound contaminant migration, contaminants will be mobilized during periods of high flow (e.g., rain events). Upon reaching the lowest elevation of the AOC where temporary ponding of water may occur, the particulates will settle out as sediment accumulation. Re-suspension and migration of sediment-bound contaminants from the low points in the AOC would not occur.

Dissolved phase contaminant migration in surface water is relevant with respect to leaching processes to groundwater. Temporary ponding of surface water runoff in the lowest points of the AOC is likely during heavy rainfall events or periods of snowmelt; however, visual observations during various investigations have not indicated evidence of long-term standing water. Infiltration rates and evapotranspiration processes appear sufficiently high to prevent long-term water retention.

8.7.2.2 Groundwater Pathways

The estimated direction of groundwater flow at the AOC is radially northwest to northeast. This reflects the January 2010 facility-wide potentiometric data presented in the *Facility-Wide Groundwater Monitoring Program Report on the January 2010 Sampling Event* (EQM 2010). Water level elevations at the AOC range from 1110.36-1124.15 ft amsl, with the highest elevation at LL9mw-003. Potentiometric data indicate the groundwater table occurs within bedrock throughout the AOC. Groundwater discharge to surface water features (e.g., via base flow to streams or springs) does not occur within the AOC boundary. Rather, the closest potential groundwater discharge locations are an unnamed tributary to Sand Creek located approximately 1,000 ft northwest of the AOC boundary and unnamed tributary to the Mahoning River approximately 2,400 ft to the southeast.

The FWGWMP was initiated in 2005 and involves quarterly sampling of selected wells within the former RVAAP. Between 2009–2010, seven different sampling events under the FWGWMP collected groundwater data at Load Line 9.

Contaminant leaching pathways from soil to the water table are through poorly sorted interbedded silty sand to clayey silt with an overall hydraulic conductivity average of 3.99E-04 cm/s. Conservative transport modeling indicated five chemicals may leach from soil and migrate to the groundwater table at concentrations exceeding MCLs/RSLs beneath their respective sources (arsenic, cobalt, manganese, mercury, and naphthalene); however, only naphthalene is predicted to migrate laterally and reach the nearest surface water receptor (unnamed tributary to the Mahoning River at a distance of 2,500 ft) at a concentration exceeding MCL/RSLs. These chemicals were not detected in AOC groundwater samples collected from 2009-2010 that were downgradient of the sample locations with the maximum concentrations; therefore, this evaluation concludes that the model-predicted concentrations are conservative. A qualitative assessment of the sample results was performed and the limitations and assumptions of the models were considered to identify if any CMCOCs are present in soil at Load Line 9 that may potentially impact groundwater at Load Line 9. This qualitative assessment concluded that CMCOCs are not adversely impacting groundwater quality based on current data and are not predicted to have future impacts. No further action is required of soil to be protective of groundwater.

8.7.2.3 Sewer System

The sewers within the perimeter of Load Line 9 are being investigated and assessed as part of the Facility-wide Sewers AOC (RVAAP-67). Storm sewers are not present at Load Line 9. While cracks and joint separations within the sanitary sewer system have been observed due to the advanced age of the system, the pipes are generally intact, which limits vertical migration from sewer sediment to the exterior of the piping system.

The compiled data provided effective characterization of the nature and extent of the contamination at the Load Line 9 FA, and no further sampling was recommended. All SRCs found in the subsurface sewer media samples within the Load Line 9 FA and evaluated through the stepwise fate and transport screening evaluation were eliminated as posing future impacts to groundwater. The HHRA did not identify COCs at the Load Line 9 FA for the National Guard Trainee or Resident Receptor. Since the Load Line 9 FA has no sewer outfalls, no further action was recommended from an ecological perspective (USACE 2012a).

8.7.3 Potential Receptors

In February 2014, the Army and Ohio EPA amended the risk assessment process to address changes in the RVAAP restoration program. The Technical Memorandum identified three Categorical Land Uses and Representative Receptors to be considered during the RI phase of the CERCLA process. These three Land Uses and Representative Receptors are presented below.

1. Unrestricted (Residential) Land Use – Resident Receptor (Adult and Child) (formerly called Resident Farmer).
2. Military Training Land Use – National Guard Trainee.
3. Commercial/Industrial Land Use – Industrial Receptor (USEPA Composite Worker).

Unrestricted (Residential) Land Use is considered protective for all three Land Uses at Camp Ravenna. Therefore, if an AOC meets the requirements for Unrestricted (Residential) Land Use, then the AOC is also considered to have met the requirements of the other Land Uses (i.e., Commercial/Industrial and Military Training), and the other Land Uses do not require evaluation.

The HHRA identified lead, mercury, and four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] as COCs to be carried forward for potential remediation. Lead and mercury are COCs to be carried forward for potential remediation at the NPA at sample location LL9ss-011, which is in the area of the former detonator destroying house (DT-34) for all three Land Uses. The PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were identified as COCs to be carried forward for potential remediation at the FPA at sample locations LL9ss-096 and LL9ss-097, which are in the area of the former change house (DT-28), for Unrestricted (Residential) Land Use. Additionally, benzo(a)pyrene was identified as a COC in this area to be carried forward for potential remediation for Industrial and Military Training Land Uses.

Camp Ravenna has a diverse range of vegetation and habitat resources. Habitats present within the facility include large tracts of closed-canopy hardwood forest, scrub/shrub open areas, grasslands, wetlands, open-water ponds and lakes, and semi-improved administration areas. An abundance of wildlife is present on the facility: 35 species of land mammals, 214 species of birds, 41 species of fish, and 34 species of amphibians and reptiles have been identified. Ecological resources at Load

Line 9 were compared to the list of important ecological places and resources. None of the 39 important ecological places were present, and there is nothing ecologically significant at Load Line 9.

8.7.4 Uncertainties

Uncertainties are inherent in the CSM depending on the density and availability of data. The CSM for Load Line 9 is overall well defined using existing data, and major data gaps do not remain to be resolved. However, some uncertainties for the CSM for the Load Line 9 include the following:

- Surface water characterization on the AOC is subject to some uncertainty due to the intermittent occurrence of surface water originating within the AOC during precipitation events. Discharge of surface water from the AOC is generally via ditches at the AOC. There are no permanent surface water features existing at Load Line 9.
- Removing primary contaminant sources (e.g., buildings), grading, and continuing vegetation succession within those areas likely have resulted in a lower overall degree of soil erosion and contaminant migration from the former operations area.
- The lack of established RVAAP-specific background concentrations for identifying SRCs for PAHs is a source of uncertainty. Evaluating potential former RVAAP process-related sources and other common anthropogenic sources using available PAH environmental data minimizes the impact of this uncertainty on the conclusions of the RI.
- While this RI addresses soil, sediment, and surface water, additional ongoing investigations are being conducted for the Facility-wide Groundwater and Facility-wide Sewers AOCs.

8.8 RECOMMENDATION OF THE REMEDIAL INVESTIGATION

Based on the investigation results, Load Line 9 has been adequately characterized, and further investigation is not warranted at this AOC. The nature and extent of potentially impacted media has been sufficiently characterized; the fate and transport modeling did not identify soil CMCOCs impacting groundwater; and no ecological risk was identified. However, the HHRA identified lead, mercury, and four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] as COCs to be carried forward for potential remediation.

Lead and mercury are COCs to be carried forward for potential remediation at the NPA at sample location LL9ss-011, which is in the area of the former detonator destroying house (DT-34) for all three Land Uses. Elevated levels of lead and mercury may be present in this area as a result of lead azide and mercury fulminate used in detonators. The PAHs benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were identified as COCs to be carried forward for potential remediation at the FPA at sample locations LL9ss-096 and LL9ss-097, which are in the area of the former change house (DT-28), for Unrestricted (Residential) Land Use. Additionally, benzo(a)pyrene was identified as a COC in this area to be carried forward for potential remediation for Industrial and Military Training Land Uses. No COCs were identified for any media or receptors in the DWA. No COCs were identified in sediment or surface water.

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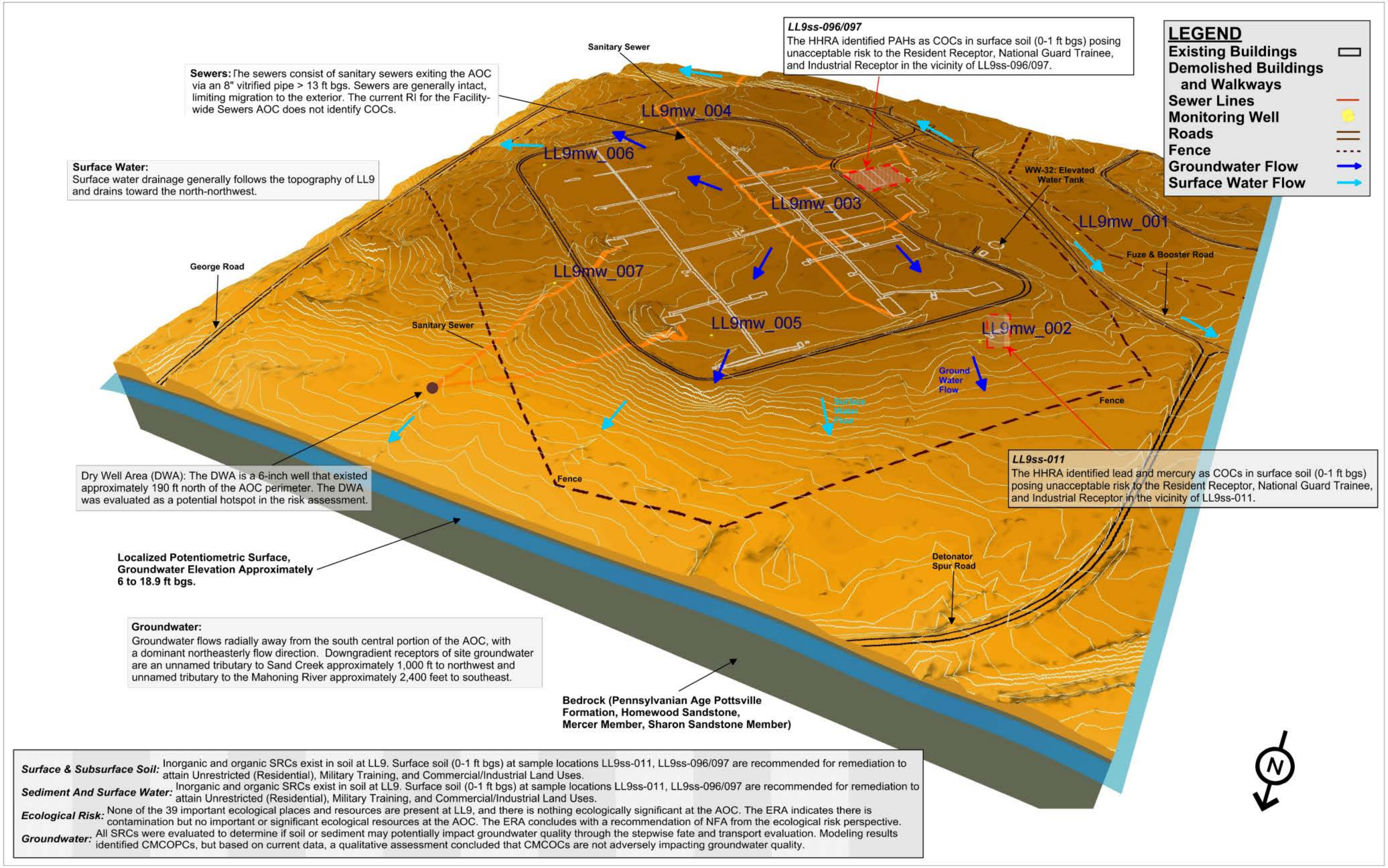

LL9ss-096/097
The HHRA identified PAHs as COCs in surface soil (0-1 ft bgs) posing unacceptable risk to the Resident Receptor, National Guard Trainee, and Industrial Receptor in the vicinity of LL9ss-096/097.

Sewers: The sewers consist of sanitary sewers exiting the AOC via an 8" vitrified pipe > 13 ft bgs. Sewers are generally intact, limiting migration to the exterior. The current RI for the Facility-wide Sewers AOC does not identify COCs.

Surface Water:
Surface water drainage generally follows the topography of LL9 and drains toward the north-northwest.

Dry Well Area (DWA): The DWA is a 6-inch well that existed approximately 190 ft north of the AOC perimeter. The DWA was evaluated as a potential hotspot in the risk assessment.

LL9ss-011
The HHRA identified lead and mercury as COCs in surface soil (0-1 ft bgs) posing unacceptable risk to the Resident Receptor, National Guard Trainee, and Industrial Receptor in the vicinity of LL9ss-011.

Localized Potentiometric Surface, Groundwater Elevation Approximately 6 to 18.9 ft bgs.

Groundwater:
Groundwater flows radially away from the south central portion of the AOC, with a dominant northeasterly flow direction. Downgradient receptors of site groundwater are an unnamed tributary to Sand Creek approximately 1,000 ft to northwest and unnamed tributary to the Mahoning River approximately 2,400 feet to southeast.

Bedrock (Pennsylvanian Age Pottsville Formation, Homewood Sandstone, Mercer Member, Sharon Sandstone Member)

Surface & Subsurface Soil: Inorganic and organic SRCs exist in soil at LL9. Surface soil (0-1 ft bgs) at sample locations LL9ss-011, LL9ss-096/097 are recommended for remediation to attain Unrestricted (Residential), Military Training, and Commercial/Industrial Land Uses.

Sediment And Surface Water: Inorganic and organic SRCs exist in soil at LL9. Surface soil (0-1 ft bgs) at sample locations LL9ss-011, LL9ss-096/097 are recommended for remediation to attain Unrestricted (Residential), Military Training, and Commercial/Industrial Land Uses.

Ecological Risk: None of the 39 important ecological places and resources are present at LL9, and there is nothing ecologically significant at the AOC. The ERA indicates there is contamination but no important or significant ecological resources at the AOC. The ERA concludes with a recommendation of NFA from the ecological risk perspective.

Groundwater: All SRCs were evaluated to determine if soil or sediment may potentially impact groundwater quality through the stepwise fate and transport evaluation. Modeling results identified CMCOPCs, but based on current data, a qualitative assessment concluded that CMCOCs are not adversely impacting groundwater quality.

Figure 8-1. Load Line 9 CSM

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9.0 REMEDIAL ACTION OBJECTIVES, CLEANUP GOALS, AND VOLUME CALCULATIONS

This section presents the RAOs, appropriate CUGs for remedial actions, and volume estimates of media requiring remediation to attain specific Land Use scenarios. The RAOs are in accordance with NCP and CERCLA RI/FS guidance, which specify receptors, exposure routes, and desired exposure levels. CUGs establish acceptable exposure levels to be protective of human health while considering potential Land Uses and provide the basis for screening, evaluating, and selecting a remedial alternative. This section also presents the estimated volume of soil exceeding the respective CUGs. The volume estimates present the estimated quantity and location of media requiring remediation to attain a specific Land Use scenario.

9.1 FUTURE USE

The future use and selection of the appropriate receptors are discussed in detail in Section 7.2.3. The potential future uses for the AOC are Military Training Land Use or Commercial/Industrial Land Use. The Representative Receptors corresponding to these potential future uses are the National Guard Trainee and Industrial Receptor.

Although residential use is not anticipated at the former RVAAP or at this AOC, Unrestricted (Residential) Land Use was evaluated. The Resident Receptor is the Representative Receptor for Unrestricted (Residential) Land Use. If a site is protective of the Resident Receptor, it is considered protective of all potential RVAAP receptors, as established in the Technical Memorandum (ARNG 2014).

9.2 REMEDIAL ACTION OBJECTIVE

The RI at Load Line 9 concluded that there is unacceptable risk in surface soil (0-1 ft bgs) for the Resident Receptor, National Guard Trainee, and Industrial Receptor. Consequently, remediation is required for each of the specified Land Uses [Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use]. The COCs and areas of contamination requiring remediation are basically the same for each Land Use scenario. Consequently, it is practical for the remediation to take measures to attain Unrestricted (Residential) Land Use. Accordingly, the RAO for Load Line 9 is as follows:

Prevent Resident Receptor exposure to surface soil (0-1 ft bgs) with 1) concentrations above lead and mercury CUGs at sample location LL9ss-011 and 2) concentrations above benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene CUGs at sample locations LL9ss-096 and LL9ss-097.

9.3 REMEDIAL ACTION CLEANUP GOALS

The HHRA identifies areas requiring remediation to meet the RAO. Figure 9-1 presents the estimated extent of contamination. The HHRA recommends CUGs for the COCs per receptor (i.e., Resident

Receptor, National Guard Trainee, and Industrial Receptor) to support the remedial alternative selection process. Table 9-1 presents the most stringent CUGs for each chemical to attain Unrestricted (Residential) Land Use.

9.4 APRIL 2011 DELINEATION SAMPLING OF MERCURY CONTAMINATION AT LL9SS-011

Location LL9ss-011 (0-1 ft bgs) was sampled in 2002 and laboratory analysis indicated the soil at that location had a mercury concentration of 882 mg/kg. In April 2011, additional sampling was performed to further delineate the mercury contamination around LL9ss-011. Five discrete surface soil samples (0-1 ft bgs) were collected and analyzed for mercury. Figure 9-1 presents the location of the samples. Table 9-2 presents the analytical results and a comparison against the CUG for mercury in soil (22.7 mg/kg).

Locations LL9ss-134 and LL9ss-135, which are to the immediate southeast of LL9ss-011, had mercury concentrations below the CUG for mercury in soil. The samples to the north and east (LL9ss-132 and LL9ss-133) exceeded the CUG for mercury in soil.

The elevated concentrations of lead are assumed to be co-located with the elevated concentrations of mercury. Therefore, the April 2011 sampling provided sufficient data to generate a volume estimate for this FS; however, additional sampling will be included as part of this remedy to further delineate the lead and mercury contamination prior to implementing the soil remedy.

Using the "Rule of 20," which provides an estimate of toxicity characteristic leaching procedure (TCLP) concentrations based on total concentrations, this FS assumes the area requiring remediation at location LL9ss-011 will require the soil to be disposed as hazardous waste. The TCLP regulatory limits for disposing mercury- and lead-contaminated soils as hazardous waste are 0.2 mg/L and 5 mg/L, respectively. The concentrations of lead and mercury in the removal area indicate the soil may exceed this regulatory limit and require disposal as hazardous waste. The remedy will include waste characterization sampling to verify this assumption; however, for purposes of this FS, it is assumed that if the soil at location LL9ss-011 is to be disposed, it will be disposed as hazardous waste.

9.5 VOLUME CALCULATIONS OF MEDIA REQUIRING REMEDIATION

To attain Unrestricted Land Use at Load Line 9, the HHRA identified locations LL9ss-096 and LL9ss-097 as one combined area requiring remediation for benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene in surface soil (0-1 ft bgs). For this location, the samples that strongly influenced the elevated PAH EPCs (LL9ss-096 and LL9ss-097) were collected from 0-1 ft bgs, as PAH contamination tends to reside in the shallow surface soil (0-1 ft bgs). Of the 15 subsurface soil samples (1-13 ft bgs) collected within the FPA, all had concentrations below the CUGs. Therefore, for the volume estimate to support the FS, the contamination is assumed to be from 0-1 ft bgs over an estimated surface area of 20,540 ft^2. Based on this assumption, approximately 761 yd^3 (in-situ) of PAH-contaminated soil will require remediation. Delineation sampling is included as part of remedy implementation to further refine lateral and horizontal extents of contamination.

For location LL9ss-011, lead and mercury were identified as a COCs for surface soil (0-1 ft bgs). For the volume estimate to support the FS, the contamination is assumed to be from 0-1 ft bgs over an estimated surface area of 430 ft^2. It is estimated that approximately 16 yd^3 (in-situ) of lead- and mercury-contaminated soil will require remediation. Delineation sampling is included as part of remedy implementation to further refine lateral and horizontal extents of contamination.

The areas and volumes are presented in Table 9-3 and on Figure 9-1.

Table 9–1. Cleanup Goals for Load Line 9

Location	Chemical of Concern	Concentration (mg/kg)	Cleanup Goal (mg/kg)
LL9ss-011	Mercury	882	22.7
	Lead	1,330	400
LL9ss-096	Benz(a)anthracene	17	2.21
	Benzo(a)pyrene	15	0.221
	Benzo(b)fluoranthene	20	2.21
	Dibenz(a,h)anthracene	2.2	0.221
LL9ss-097	Benz(a)anthracene	1	2.21
	Benzo(a)pyrene	1.7	0.221
	Benzo(b)fluoranthene	2.4	2.21
	Dibenz(a,h)anthracene	0.36	0.221

The Resident Receptor facility-wide cleanup goals at hazard index=1, target risk=10^{-5} are used to attain Unrestricted (Residential) Land Use.

mg/kg = Milligrams per kilogram.

Table 9-2. Delineation Sampling Results of Mercury Contamination at Location LL9ss-011

Surface Soil (0-1 ft bgs) Sample Location	Sample	Date Sampled	Mercury Concentration (mg/kg)	Above Cleanup Goal of 22.7 mg/kg?
LL9ss-131	LL9ss-131-5865-SO	04/26/11	65	Yes
LL9ss-132	LL9ss-132-5866-SO	04/26/11	280	Yes
LL9ss-133	LL9ss-133-5867-SO	04/26/11	520	Yes
LL9ss-134	LL9ss-134-5868-SO	04/26/11	5.2	No
LL9ss-134	LL9ss-134-6247-FD[a]	04/26/11	5.9	No
LL9ss-135	LL9ss-135-5869-SO	04/26/11	11.9	No

[a] Sample LL9ss-134-6247-FD is a field duplicate of sample LL9ss-134-5868-SO, collected for quality assurance/quality control.

bgs = Below ground surface.

ft = Feet.

mg/kg = Milligrams per kilogram.

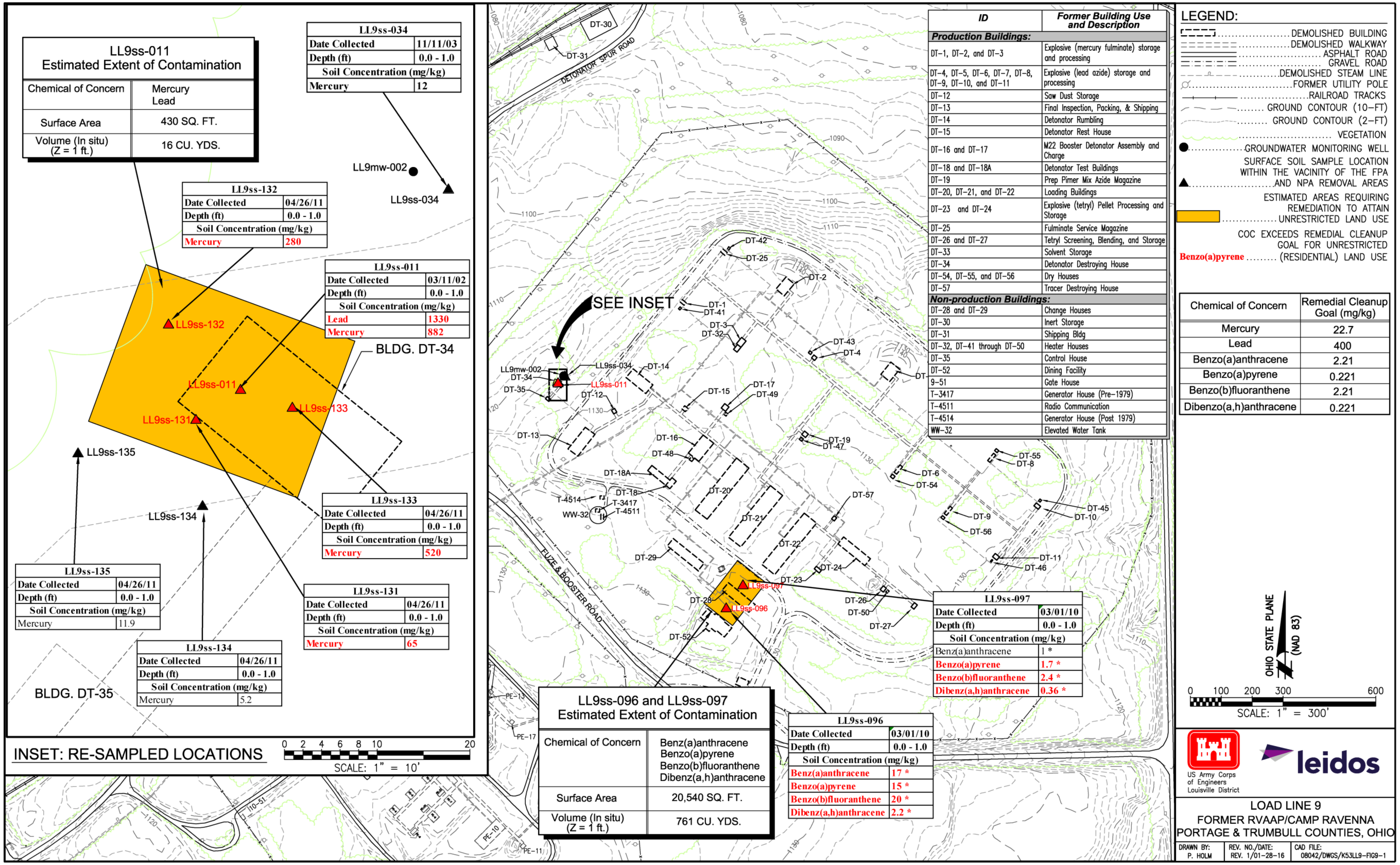
Table 9–3. Estimated Volume Requiring Remediation

ISM Sample Locations	Media	Treatment Interval (ft bgs)	Surface Area (ft^2)	In-situ		In-situ with Constructability[1]		Ex-situ[a,b]	
				Volume (ft^3)	**Volume (yd^3)**	**Volume (ft^3)**	**Volume (yd^3)**	**Volume (ft^3)**	**Volume (yd^3)**
LL9ss-011	Surface Soil	0-1	430	430	16	538	20	645	24
LL9ss-096 and LL9ss-097	Surface Soil	0-1	20,540	20,540	761	25,675	951	30,810	1,141
Totals			20,970	20,970	777	26,213	971	31,455	1,165

[a] Constructability factor accounts for over excavation, sloping of sidewalls, and addresses limitations of removal equipment. The in-situ volume is increased by 25% for a constructability factor.

[b] Includes 20% swell factor.

bgs = Below ground surface.
ft = Feet.
ISM = Incremental sample methodology.
yd = Yard.



LL9ss-011 Estimated Extent of Contamination	
Chemical of Concern	Mercury Lead
Surface Area	430 SQ. FT.
Volume (In situ) (Z = 1 ft.)	16 CU. YDS.

LL9ss-034	
Date Collected	11/11/03
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	12

LL9ss-132	
Date Collected	04/26/11
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	280

LL9ss-011	
Date Collected	03/11/02
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Lead	1330
Mercury	882

LL9ss-133	
Date Collected	04/26/11
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	520

LL9ss-135	
Date Collected	04/26/11
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	11.9

LL9ss-131	
Date Collected	04/26/11
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	65

LL9ss-134	
Date Collected	04/26/11
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Mercury	5.2

ID	Former Building Use and Description
Production Buildings:	
DT–1, DT–2, and DT–3	Explosive (mercury fulminate) storage and processing
DT–4, DT–5, DT–6, DT–7, DT–8, DT–9, DT–10, and DT–11	Explosive (lead azide) storage and processing
DT–12	Saw Dust Storage
DT–13	Final Inspection, Packing, & Shipping
DT–14	Detonator Rumbling
DT–15	Detonator Rest House
DT–16 and DT–17	M22 Booster Detonator Assembly and Charge
DT–18 and DT–18A	Detonator Test Buildings
DT–19	Prep Pimer Mix Azide Magazine
DT–20, DT–21, and DT–22	Loading Buildings
DT–23 and DT–24	Explosive (tetryl) Pellet Processing and Storage
DT–25	Fulminate Service Magazine
DT–26 and DT–27	Tetryl Screening, Blending, and Storage
DT–33	Solvent Storage
DT–34	Detonator Destroying House
DT–54, DT–55, and DT–56	Dry Houses
DT–57	Tracer Destroying House
Non-production Buildings:	
DT–28 and DT–29	Change Houses
DT–30	Inert Storage
DT–31	Shipping Bldg
DT–32, DT–41 through DT–50	Heater Houses
DT–35	Control House
DT–52	Dining Facility
9–51	Gate House
T–3417	Generator House (Pre–1979)
T–4511	Radio Communication
T–4514	Generator House (Post 1979)
WW–32	Elevated Water Tank

LEGEND:

- ▭ .... DEMOLISHED BUILDING
- .... DEMOLISHED WALKWAY
- .... ASPHALT ROAD
- .... GRAVEL ROAD
- .... DEMOLISHED STEAM LINE
- .... FORMER UTILITY POLE
- .... RAILROAD TRACKS
- .... GROUND CONTOUR (10–FT)
- .... GROUND CONTOUR (2–FT)
- .... VEGETATION
- ● .... GROUNDWATER MONITORING WELL
- ▲ .... SURFACE SOIL SAMPLE LOCATION WITHIN THE VACINITY OF THE FPA AND NPA REMOVAL AREAS
- 🟧 .... ESTIMATED AREAS REQUIRING REMEDIATION TO ATTAIN UNRESTRICTED LAND USE
- Benzo(a)pyrene .... COC EXCEEDS REMEDIAL CLEANUP GOAL FOR UNRESTRICTED (RESIDENTIAL) LAND USE

Chemical of Concern	Remedial Cleanup Goal (mg/kg)
Mercury	22.7
Lead	400
Benzo(a)anthracene	2.21
Benzo(a)pyrene	0.221
Benzo(b)fluoranthene	2.21
Dibenzo(a,h)anthracene	0.221

LL9ss-096 and LL9ss-097 Estimated Extent of Contamination	
Chemical of Concern	Benz(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenz(a,h)anthracene
Surface Area	20,540 SQ. FT.
Volume (In situ) (Z = 1 ft.)	761 CU. YDS.

LL9ss-097	
Date Collected	03/01/10
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Benz(a)anthracene	1 *
Benzo(a)pyrene	1.7 *
Benzo(b)fluoranthene	2.4 *
Dibenz(a,h)anthracene	0.36 *

LL9ss-096	
Date Collected	03/01/10
Depth (ft)	0.0 - 1.0
Soil Concentration (mg/kg)	
Benz(a)anthracene	17 *
Benzo(a)pyrene	15 *
Benzo(b)fluoranthene	20 *
Dibenz(a,h)anthracene	2.2 *

LOAD LINE 9
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	REV. 1/01–28–16	08042/DWGS/K53LL9–FIG9–1

Figure 9-1. Estimated Extent of Soil Requiring Remediation

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10.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

10.1 INTRODUCTION

CERCLA Section 121 specifies that remedial actions must comply with requirements or standards under federal or more stringent state environmental laws that are "applicable or relevant and appropriate to the hazardous substances or particular circumstances at the AOC." Inherent in the interpretation of ARARs is the assumption that protection of human health and the environment is ensured. This section summarizes potential federal and state chemical-, location-, and action-specific ARARs for potential remedial actions at the AOC.

ARARs include those federal and state regulations that are designed to protect the environment. Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (40 CFR 300.5). USEPA has stated in the NCP that applicable requirements are those requirements that would apply if the response action were not taken under CERCLA.

Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site" (40 CFR 300.5).

In the absence of federal- or state-promulgated regulations, there are many criteria, advisories, guidance values, and proposed standards that are not legally binding, but may serve as useful guidance for setting protective cleanup levels. These are not potential ARARs, but are to-be-considered guidance [40 CFR 300.400(g)(13)].

CERCLA remedial response actions at an AOC must comply only with the substantive requirements of a regulation [CERCLA Section 121(e)]. Substantive requirements are those that pertain directly to the actions or conditions at an AOC, while administrative requirements facilitate their implementation. USEPA recognizes that certain administrative requirements (e.g., consultation with state agencies, reporting) are accomplished through state involvement and public participation. These administrative requirements should also be observed if they are useful in determining cleanup standards at the AOC (55 CFR 8757).

Although remedial actions for AOCs at National Priorities List sites must comply only with the substantive requirements of federal or state environmental regulations, the Ohio Revised Code does not provide a similar permit waiver for actions conducted under the Ohio EPA Remedial Response Program Policy. Ohio EPA's Division of Environmental Response and Revitalization (DERR) Policy

DERR-00-RR-034 states “it has been DERR’s policy to require responsible parties to acquire and comply with all necessary permits, including the substantive and administrative requirements.” However, a DFFO was entered into on June 10, 2004 that provided certain exemptions from the Ohio Administrative Code (OAC) administrative requirements and required groundwater monitoring and remediation at RVAAP to be performed under the CERCLA process. The DFFO includes provisions for compliance that may result in the potential negation of all provided exemptions within the DFFO in the event non-compliant activities are identified.

10.2 POTENTIAL ARARS

USEPA classifies ARARs as chemical-, action-, and location-specific to provide guidance for identifying and complying with ARARs (USEPA 1988).

- Chemical-specific ARARs are health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, allow numerical values to be established. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment (USEPA 1988).
- Action-specific ARARs are rules, such as performance-, design-, or other activity-based rules which place requirements or limitations on actions.
- Location-specific ARARs are rules that place restrictions on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations (USEPA 1988).

As explained in the following paragraph, rules from each of these categories are ARARs only to the extent that they relate to the degree of cleanup.

CERCLA Section 121 governs cleanup standards at CERCLA sites. ARARs originate in the subsection of CERCLA that specifies the degree of cleanup at each AOC: CERCLA Section 121(d). In Section 121(d)(2), CERCLA expressly directs that ARARs are to address specific contaminants of concern at each AOC, specifying the level of protection to be attained by any chemicals remaining at the AOC. CERCLA Section 121(d)(2) provides that, with respect to hazardous substances, pollutants, or contaminants remaining on site after completing a remedial action, an ARAR is:

> “Any standard, requirement, criteria, or limitation under any Federal environmental law … or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation.”

CERCLA Section 121(d)(2) further states that the remedial action must attain a level of control established in rules determined to be ARARs.

In some cases, most ARARs will be chemical-specific. Action- or location-specific requirements will be ARARs to the extent that they establish standards addressing contaminants of concern that will remain at the AOC. In addition, CERCLA Section 121(d)(1) directs that remedial actions taken to achieve a degree of cleanup that is protective of human health and the environment are to be relevant and appropriate under the circumstances presented by the release. Accordingly, any chemical-, action-, or location-specific requirements will be ARARs to the extent that they ensure the degree of cleanup will be protective of human health and the environment under the circumstances presented by the release. An evaluation of the regulatory requirements has shown there are no chemical-specific ARARs for the chemicals identified in various media at the AOC.

In summary, chemical-, action-, or location-specific requirements will be ARARs to the extent that they establish standards protective of human health and the environment for chemicals that will remain on site after the remedial action and ensure protection of site works and the environment during remedy implementation. Requirements identified as chemical-specific ARARs must ensure a degree of cleanup that is protective of human health and the environment under the circumstances presented by the release.

10.2.1 Potential Chemical-Specific ARARs

The environmental media evaluated in this FS is surface soil (0-1 ft bgs), because surface soil with concentrations of lead and mercury at sample location LL9ss-011 and benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene at sample locations LL9ss-096 and LL9ss-097 pose unacceptable risk to the Resident Receptor, National Guard Trainee, and Industrial Receptor. No COCs were identified in subsurface soil, sediment, or surface water for any of these receptors. A review of the regulations indicated there are no potential chemical-specific ARARs for any of the contemplated alternatives due to the media and COCs. No regulations were identified that included specific chemical concentrations or requirements that would be a potential ARAR to drive the remedial action process.

10.2.2 Potential Action-Specific ARARs

Potential excavation and disposal of contaminated environmental media at the AOC will trigger potential ARARs associated with land disturbance and emission controls. OAC 3745-15-07 requires that nuisance air pollution emissions be controlled. This includes controlling potential fugitive dust from soil handling excavation activities. In addition, any construction (e.g., soil disturbance activities that would encompass over 1 acre) would trigger the storm water requirements found at 40 CFR Part 450. These requirements mandate that erosion and sedimentation control measures be designed and implemented to control erosion and sediment runoff.

Because excavation would include generating and managing contaminated media, RCRA requirements would be considered potential ARARs for this activity. RCRA requirements mandate that a generator must determine whether a material is (or contains in the case of environmental media) a hazardous waste under OAC 3745-52-11. If a material is determined to be or contain a listed hazardous waste, or exhibits a hazardous waste characteristic, additional management requirements under RCRA must be followed as an ARAR under CERCLA.

These requirements include how hazardous waste is stored, treated, transported, and disposed. These RCRA requirements are generally not considered to be chemical-specific ARARs because they do not relate directly to the degree of cleanup, or to specific chemicals. In addition to the substantive requirements associated with managing and storing material that is also RCRA hazardous waste (or found to contain such waste), some RCRA requirements prescribe standards for disposing hazardous material. These include: (1) land disposal restrictions (LDRs) prohibiting disposal of specific chemicals until they are treated to a specified level, or by a specific treatment technology; and (2) minimum technical requirements (MTRs) for land disposal units.

USEPA cautions that LDRs should not be used to determine site-specific cleanup levels for soil (USEPA 2002). The purpose of LDRs is to require appropriate treatment of RCRA hazardous waste that is to be disposed to minimize short- and long-term threats to human health or the environment based upon available technology. Performing treatment to meet LDR standards is different from the CERCLA approach to remediation, which analyzes risk and then develops soil cleanup standards based on the risk present, and may result in soil cleanup levels that are different from those of a risk-based approach. Nevertheless, if RCRA hazardous waste is generated from the CERCLA action and is disposed on site, the material must meet the standards established in the LDRs.

In order for LDRs to be triggered as potential ARARs, RCRA hazardous waste must be present. This requires: (1) that soil contains contaminants derived from RCRA-listed waste or exhibits a characteristic of RCRA hazardous waste, and (2) that soil is managed in a way that “generates” hazardous waste. Several methods of soil management that do not “generate” hazardous waste, and so do not trigger LDRs, are available for use. These methods include the AOC approach, using a staging pile, using a storage or treatment corrective action management unit (CAMU), or using a temporary unit.

If soil is managed in a manner that generates hazardous waste, such as removing it to an aboveground container and then redepositing it within the land unit for disposal, then LDRs become potential ARARs. LDRs are applied to the waste when it is removed from the unit under an AOC approach or when the soil is excavated and lifted out of the unit. Potential LDR ARARs in Ohio are variances from treatment standards in OAC Section 3745-700-44, LDR standards for contaminated debris in OAC Section 3745-47, Universal Treatment Standards (UTS) in OAC Section 3745-270-48, and Alternative Standards for Contaminated Soil in OAC Section 3745-270-49.

Ohio has adopted the alternative soil treatment standards promulgated by USEPA in its Phase IV LDR rule, in effect since August 1998. The rule provides that if RCRA hazardous waste is present, the material must meet one of two sets of LDRs before being disposed in a land unit: (1) the UTS; or (2) the contaminated soil (technology-based treatment) standards promulgated in Phase IV of the LDRs, whichever is greater. Or, if a generator so chooses, they may use the generic treatment standards in OAC Section 3745-270-40 which apply to all hazardous waste. Only the alternative soil treatment standards are explained in this document.

Under the alternative soil treatment standards, all soil subject to treatment must be treated as follows:

1. For non-metals, treatment must achieve 90% reduction in total constituent concentration (primary constituent for which the waste is characteristically hazardous as well as for any organic or inorganic underlying hazardous constituent), subject to item three below.
2. For the inorganic chemicals carbon disulfide, cyclohexanone, and methanol, treatment must achieve 90% reduction in constituent concentrations, as measured in leachate from the treated media (tested according to the TCLP), or 90% reduction in total constituent concentrations (when a inorganic chemical removal treatment technology is used), subject to item three below.
3. When treating any constituent subject to a 90% reduction standard would result in a concentration less than 10 times the UTS for that constituent, treatment to achieve constituent concentrations less than 10 times the UTS is not required. This is commonly referred to as "90% capped by 10xUTS."
4. USEPA and Ohio EPA have established a site-specific variance from the soil treatment standards that can be used when treating concentrations of hazardous constituents higher than those specified in the soil treatment standards and minimizes short- and long-term threats to human health and the environment. In this way, on a case-by-case basis, risk-based LDR treatment standards approved through a variance process could supersede soil treatment standards. Any variance granted cannot rely on capping, containment, or other physical or institutional controls.

If CAMUs are used as disposal units at the AOC, the design and treatment standards established in OAC Section 3745-57-72 will be potentially relevant and appropriate to the response action. Only CAMU-eligible waste can be disposed in a CAMU. CAMU-eligible waste includes hazardous and non-hazardous wastes that are managed for implementing cleanup, depending on the Ohio EPA Director's approval or prohibition of specific waste or waste streams. Using a CAMU for disposal does not trigger LDRs or MTRs as long as the standards specified in the rule are observed. The Director will incorporate design and treatment standards into a permit or order. Design standards include a composite liner and a leachate collection system designed and constructed to maintain less than 30 cm of leachate over the liner. A composite liner entails a system consisting of two components which each have detailed specifications and installation requirements. The Director may approve alternate requirements if he can make the findings adhere to the requirements specified in the rule. Treatment standards are similar to LDR standards for contaminated soil, although alternative and adjusted standards may be approved or required by the Director as long as the adjusted standard is protective of human health and the environment.

If soil is found to be contaminated but not a RCRA hazardous waste, management and disposal of this material would be subject to the requirements associated with managing and disposing solid waste within the state of Ohio. The requirements found in OAC Section 3745-27-05 would be potential ARARs for disposing non-hazardous contaminated soil generated during excavation and subsequent disposal at an off-site location.

A permit-by-rule (PBR) is a specific permit exemption in the OAC that applies to certain types of low-emitting air pollution sources. Soil vapor emissions from a thermal treatment system would require exemption under OAC 3745-31-03 (PBR). The PBR contains qualifying criteria, emission limitations, conditions for operation, and requirements for record keeping and reporting which must be followed. Potential action-specific ARARs are listed in Table 10-1.

10.2.3 Potential Location-Specific ARARs

Location requirements include, but are not limited to, those established for potential remedial activities conducted within wetlands, within a floodplain area, or with respect to federal- or state-listed species. Generally, for wetlands and floodplains, alternatives are required to be developed to conduct remedial activities within the sensitive area; if that is not feasible, adverse effects from any actions taken within the sensitive area must be mitigated to the extent possible. These requirements do not relate to specific chemicals, nor do they change the degree of cleanup in the sense of protecting human health or the environment from the effects of harmful substances. Rather, their purpose is to protect sensitive areas to the extent possible. Under CERCLA Section 121(d), relevance and appropriateness are related to the circumstances presented by the release of hazardous substances, with the goal of attaining a degree of cleanup and controlling further releases to ensure protection of human health and the environment. Within the area to be remediated, no sensitive resources (e.g., wetlands) or endangered species (including habitat) have been identified. As such, the requirements associated with such areas or species have not been identified as potential ARARs for the AOC and no location-specific ARARs have been identified for this action.

Although no location-specific standards have been identified as ARARs, any action taken by the federal government must be conducted in accordance with requirements established under the National Environmental Policy Act, Endangered Species Act, National Historic Preservation Act, Native American Graves Protection and Repatriation Act, state burial laws, and federal and state wetlands and floodplains construction and placement of materials considerations, even though these laws and rules do not establish standards, requirements, limitations, or criteria relating to the degree of cleanup for chemicals remaining on site at the close of the response actions.

Table 10–1. Potential Action-Specific ARARs

Media and Citation	Description of Requirement	Potential ARAR Status	Standard
Prohibition of air pollution nuisances (e.g., fugitive dust) OAC Section 3745-15-07	These rules prohibit releasing nuisance air pollution that endangers health, safety, or welfare of the public or cause personal injury or property damage.	Applies to any activity that could result in the release of a nuisance air pollutant. This would include dust from excavation or soil management processes.	Any person undertaking an activity is prohibited from emitting nuisance air pollution.
Storm water requirements at construction sites 40 CFR Part 450	These rules require that storm water controls be employed at construction sites that exceed 1 acre.	Applies to any construction activity that exceeds 1 acre.	Persons undertaking construction activities (including grubbing and land clearing) at an AOC where the construction footprint is over 1 acre must design and implement erosion and runoff controls.
Generation of contaminated soil or debris OAC Section 3745-52-11	These rules require that a generator determine whether a material generated is a hazardous waste.	Applies to any material that is or contains a solid waste. Must be characterized to determine whether the material is or contains a hazardous waste.	Any person that generates a waste as defined must use prescribed methods to determine if waste is considered characteristically hazardous using the prescribed methods.
Management of contaminated soil or debris that is or contains a hazardous waste OAC Sections 3745-52-30 through 3745-52-34	These rules require that hazardous waste be properly packaged, labeled, marked, and accumulated on site pending on- or off-site disposal.	Applies to any hazardous waste, or media containing a hazardous waste that is generated from on-site activities.	All hazardous waste must be accumulated in a compliant manner that includes proper marking, labeling, and packaging in accordance with the specified regulations. This includes inspecting containers or container areas where hazardous waste is accumulated on site.
Acquisition and use of manifests for hazardous waste shipments to off-site treatment, storage or disposal facilities OAC Sections 3745-52-20 through - 3745-52-23	These rules require that a Uniform Hazardous Waste Manifest be used for any off-site shipment of hazardous waste.	Applies to any shipment of hazardous waste to an off-site facility for treatment, storage, or disposal.	Requires a generator who transports or offers to transport hazardous waste for off-site treatment, storage, or disposal to prepare a uniform hazardous waste manifest.

Table 10-1. Potential Action-Specific ARARs (continued)

Media and Citation	Description of Requirement	Potential ARAR Status	Standard
Soil contaminated with RCRA hazardous waste OAC Section 3745-400-49 OAC Section 3745-400-48 UTS	These rules prohibit land disposal of RCRA hazardous waste subject to them, unless the waste is treated to meet certain standards that are protective of human health and the environment. Standards for treating hazardous waste-contaminated soil prior to disposal are set forth in the two cited rules. Using the greater of either technology-based standards or UTS is prescribed.	LDRs apply only to RCRA hazardous waste. This rule is considered for ARAR status only upon generating a RCRA hazardous waste. If any soil is determined to be RCRA hazardous waste, and if it will be disposed of on site, this rule is potentially applicable to disposal of the soil.	All soil subject to treatment must be treated as follows: 1) For non-metals, treatment must achieve 90% reduction in total constituent concentration (primary constituent for which the waste is characteristically hazardous as well as for any organic or inorganic UHC), subject to item 3 below. 2) For the inorganic chemicals carbon disulfide, cyclohexanone, and methanol, treatment must achieve 90% reduction in constituent concentrations as measured in leachate from the treated media (tested according to the TCLP) or 90% reduction in total constituent concentrations (when a inorganic chemical removal treatment technology is used), subject to item 3 below. 3) When treating any constituent subject to achieve a 90% reduction standard would result in a concentration less than 10 times the UTS for that constituent, treatment to achieve constituent concentrations less than 10 times the UTS is not required. This is commonly referred to as “90% capped by 10xUTS.”

Table 10-1. Potential Action-Specific ARARs (continued)

Media and Citation	Description of Requirement	Potential ARAR Status	Standard
Soil/debris contaminated with RCRA hazardous waste – variance OAC Section 3745-400-44	The Ohio EPA Director will recognize a variance approved by the USEPA from the alternative treatment standards for hazardous contaminated soil or for hazardous debris.	Potentially applicable to RCRA hazardous soil or debris that is generated and placed back into a unit and that will be disposed of on site.	A site-specific variance from the soil treatment standards that can be used when treatment to concentrations of hazardous constituents higher than those specified in the soil treatment standards and minimizes short- and long-term threats to human health and the environment. In this way, on a case-by-case basis, risk-based LDR treatment standards approved through a variance process could supersede the soil treatment standards.
Soil/debris that is contaminated but not a hazardous waste for disposal. OAC Section 3745-27-05	Establishes standard for disposing solid waste within the state of Ohio.	Potentially applicable to contaminated soil disposed offsite under state solid waste disposal requirements.	Establishes allowable methods of solid waste disposal and prohibits management by open burning or dumping.
Permits-to-install, exemptions and permits-by-rule OAC Section 3745-31-03	A permit-by-rule (PBR) is a specific permit provision in the OAC that applies to certain types of low-emitting air pollution sources.	Potentially applicable if a thermal treatment system is selected for remedy.	Requires a generator to obtain a PBR exemption for low emitting air pollution sources prior to operating a thermal treatment system.

AOC = Area of concern.
ARAR = Applicable and Relevant or Appropriate Requirements.
CFR = Code of Federal Regulations.
LDR = Land Disposal Restrictions.
OAC = Ohio Administrative Code.
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RCRA = Resource Conservation and Recovery Act.
TCLP = Toxicity characteristic leaching procedure.
UHC = Underlying Hazardous Constituent.
USEPA = U.S. Environmental Protection Agency.
UTS = Universal Treatment Standard.

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11.0 TECHNOLOGY TYPES AND PROCESS OPTIONS

This section identifies and describes GRAs which may be implemented to achieve CUGs. In addition, this section summarizes the remedial technologies and process options available to remediate COCs in soil as identified in Section 9.0 of this report.

The procedure for identifying and screening potential remedial technologies followed the method established in the USEPA guidance document, *Guidance for Conducting Remedial Investigation/Feasibility Studies Under CERCLA* (USEPA 1988). This guidance document provides the framework for identifying and screening all available remedial technologies with the most appropriate technologies available based on the COCs and AOC characteristics (e.g., soil type).

11.1 GENERAL RESPONSE ACTION

GRAs are actions which may be implemented to satisfy RAOs. The actions may be individual or a combination of responses. Surface soil in the vicinity of LL9ss-011 with lead and mercury contamination above CUGs requires remediating a small volume of contaminated soil (estimated ex-situ volume of 24 yd^3); therefore, the presumptive remedy for this small quantity of contaminated soil is excavation and off-site disposal. No additional GRAs were considered for treating soil at this location.

The following GRAs are applicable and are defined in greater detail for the PAHs in the surface soil (0-1 ft bgs) at locations LL9ss-096 and LL9ss-097:

- No action,
- Institutional controls,
- Containment,
- Removal, and
- Treatment.

11.1.1 No Action

No action is required for evaluation under the NCP and is the baseline to which other remedial alternatives are compared. No action may be an appropriate alternative if no unacceptable risk is present at the AOC. This GRA provides a baseline against which to compare other more proactive alternatives. No action is taken at the AOC to reduce risk to human health or the environment. Any existing actions, such as restrictions or monitoring, are discontinued.

11.1.2 Institutional Controls

Institutional controls include engineering measures (i.e., fencing and warning signs) and non-engineering measures, such as administrative or legal controls, and are used to prevent or limit exposure to hazardous substances. Institutional controls do not reduce contaminant mobility, volume, or toxicity.

If institutional controls are selected as a component of a remedial alternative, the effectiveness of the remedy must undergo five-year reviews. The primary goal of the five-year reviews is to evaluate the implementation and performance of the remedy to determine if the remedy is or will be protective of human health and the environment. The five-year reviews are discontinued when the remedy achieves CUGs for Unrestricted (Residential) Land Use.

11.1.3 Containment

Containment technologies are often used to prevent, or significantly reduce, the migration of contaminants in soil or sediment. In general, containment is performed when extensive subsurface contamination at a site precludes excavation and removal of wastes because of potential hazards, technical impracticality, and/or unrealistic cost.

The main advantage of containment methods is that they can prevent further migration of contaminant plumes by minimizing infiltration and leaching. Containment requires periodic inspections for leaks and ponding of liquids and periodic sampling to confirm integrity of the containment system.

Common types of containment technologies include capping (e.g., a clay cap, a multi-layered cap that includes clay and synthetic liners, or an asphalt or concrete cap) and soil covers.

11.1.4 Removal

Removing contaminated media from the AOC reduces or eliminates the potential for long-term human and environmental exposure to chemicals exceeding concentrations determined to be protective for a given Land Use. Removing soil may be combined with pre-treatment prior to off-site disposal, or soil may be shipped without pre-treatment.

Disposal and handling, after removal, involve the final and permanent placement of waste material in a manner protective of human health and the environment. The impacted media is disposed on site in an engineered facility or offsite in a permitted or licensed facility such as a regulated landfill. Similarly, concentrated waste resulting from treatment processes is disposed on site in a permanent disposal cell or offsite in an approved disposal facility.

Transportation is accomplished utilizing various methods, including truck, railcar, and/or barge.

11.1.5 Treatment

Treatment is conducted either in- or ex-situ to reduce contaminant concentrations to acceptable levels. Common types of treatment include biological, chemical, physical, and thermal. Biological treatment involves using microbes to degrade contaminants. Chemical treatment processes add chemicals to react with contaminants to reduce their toxicity or mobility. Physical processes involve either physically binding the contaminants to reduce mobility or the potential for exposure (e.g., encapsulation) or extracting the contaminant(s) from a medium to reduce volumes. Thermal treatment, such as incineration, uses high temperatures to volatilize, decompose, or melt contaminants. For soil treated by ex-situ methods, the treatment may allow soil to be placed back into the excavation, or soil may be treated to reduce the chemical concentration or stabilize the soil prior to off-site disposal.

11.2 INITIAL SCREENING OF TREATMENT TECHNOLOGIES

Table 11-1 summarizes the remedial technologies and process options available for treating PAH COCs in surface soil at LL9ss-096 and LL9ss-097. The initial screening focuses on technology types capable of remediating the PAH COCs and evaluates the implementability of the technology. If treatment technologies are evaluated and retained as potentially viable treatment options for the AOC, the retained technology will undergo a more detailed evaluation described in Section 11.3.

11.3 DETAILED SCREENING OF TECHNOLOGIES

The remedial action technologies retained from the initial screening process are evaluated against criteria of effectiveness, implementability, and cost (three of the NCP balancing criteria). The rationale for either retaining or eliminating treatment options for the AOC is presented and summarized in Table 11-2. The remedial options retained from the detailed screening process used to develop the remedial alternatives are presented in Section 12.0.

11.3.1 Effectiveness

The effectiveness criterion assesses the ability of a remedial technology to protect human health and the environment by reducing the toxicity, mobility, or volume of contaminants. Each technology is evaluated for its ability to achieve RAOs, potential impacts to human health and the environment during construction and implementation, and overall reliability of the technology.

11.3.2 Implementability

Each process option/technology is evaluated for implementability in terms of technical feasibility, administrative feasibility, and availability of the necessary material, equipment, and work force. The assessment considers each technology’s short- and long-term implementability. Short-term implementability considers constructability of the remedial technology, near-term reliability, ability to obtain necessary approvals with other agencies, and likelihood of obtaining a favorable community response. Long-term implementability evaluates the ease of undertaking additional remedial actions (if necessary), monitoring the effectiveness of the remedy, and operation and maintenance (O&M).

11.3.3 Cost

The cost criterion evaluates each remedial process in terms of relative capital and O&M costs. Costs for each technology are rated qualitatively, on the basis of engineering judgment, in terms of cost effectiveness. Therefore, a low cost remedial technology is rated as highly cost effective, while a costly technology is evaluated as being of low cost effectiveness.

Table 11–1. Initial Screening of Technologies

General Response Actions	Technology Type	Process Options	Description	Screening Results
No Action	None	None	No action is taken at AOC. Current LUCs, access restrictions, and monitoring programs will be discontinued. No remedial technologies are implemented to reduce hazards to potential human or ecological receptors.	Retained. Required under NCP to be carried through CERCLA analysis.
Institutional Controls	Access Restrictions	LUCs with CERCLA Five-Year Reviews	Implement LUCs at the AOC to restrict access and Land Use. LUCs will be administered and enforced as part of the Property Management Plan and reviewed in CERCLA five-year reviews. Five-year reviews include reviewing sampling and monitoring plans and results of monitoring activities, conducting interviews and inspections, and reviewing AOC status.	Not retained. LUCs would not provide adequate protection for expected future user, as chemicals are on site at concentrations that prevent Military Training or Commercial/Industrial Land Use.
		Fencing	Place fencing around areas of contamination (at a minimum) to restrict access and exposure to contamination left in place.	Not retained. Fencing will inhibit active use of the site for Military Training or Commercial/Industrial Land Use.
Containment	Capping	Native Soil/Sediment	Uses native soil or sediment to cover contamination and reduce migration by wind and water erosion.	Not retained. Using a cap, liner, or asphalt/concrete in areas with contamination will inhibit active use of the site for Military Training or Commercial/Industrial Land Use.
		Clay	Clay layers are used to cover contamination and eliminate prevent exposure. Installing clay cap will limit water infiltration. Susceptible to weathering effects (e.g., cracking).	
		Synthetic Liner	A synthetic liner is used to cover contamination and prevent exposure. Synthetic material is used to limit water infiltration, which is not as susceptible to cracking as clay.	
		Multi-layered	Multiple layers of different soil types are used to limit water infiltration, which is not as susceptible to cracking as clay.	
		Asphalt/Concrete	Asphalt or concrete layers are used to cover contamination and prevent exposure. Additionally, this technology limits water infiltration; however it is susceptible to cracking if not properly maintained.	
Removal	Bulk Removal	Excavation and Off-site Disposal	Contaminated material is removed and transported to permitted off-site treatment and disposal facilities.	Retained.

Table 11-1. Initial Screening of Technologies (continued)

General Response Actions	Technology Type	Process Options	Description	Screening Results
Treatment	In-situ Biological Treatment	Bioventing	Oxygen is delivered to contaminated unsaturated soil by forced air movement (either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation.	Not retained. Although the technology successfully remediates organic chemicals, the presence of saturated soil and shallow groundwater impacts performance. In addition, the soil at the site has lower permeability than needed for this treatment.
		Enhanced Bioremediation	Adding oxygen and nutrients aids indigenous or inoculated micro-organisms (e.g., fungi, bacteria, and other microbes) in degrading (metabolizing) organic contaminants found in soil and/or groundwater, converting them to innocuous end products.	Retained.
		Phytoremediation	Using plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment.	Retained.
	In-situ Physical/Chemical Treatment	Chemical Oxidation	Oxidation chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide.	Not retained. The technology is not very effective for high molecular weight PAHs in soil.
		Electrokinetic Separation	Removing inorganic chemicals and organic contaminants from low permeability soil, mud, sludge, and marine dredging. Electrokinetic remediation uses electrochemical and electrokinetic processes to desorb and then remove inorganic chemicals and polar organic chemicals.	Not retained. The targeted contaminants for electrokinetics are heavy metals and polar organics. Technology is not effective for non-polar organics (e.g., PAHs).
		Soil Flushing	Water, or water containing an additive to enhance contaminant solubility, is applied to soil or injected into groundwater to raise the water table into the contaminated soil zone. Contaminants are leached into the groundwater, which is then extracted and treated.	Not retained. The soil permeability at the site is not conducive for effective soil flushing contaminant removal.

Table 11-1. Initial Screening of Technologies (continued)

General Response Actions	Technology Type	Process Options	Description	Screening Results
		Soil Vapor Extraction	Vacuum is applied through extraction wells to create a pressure/concentration gradient that induces gas-phase volatiles to be removed from soil through extraction wells. This technology is also known as in-situ soil venting, in-situ volatilization, enhanced volatilization, or soil vacuum extraction.	Not retained. Technology focuses on remediating media contaminated with VOCs and some fuels. Not applicable for contaminants with low volatilization (e.g., PAHs).
		Solidification/Stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).	Not retained. This technology has limited effectiveness for PAHs.
	In-situ Thermal Treatment	Thermal Treatment	Steam/hot air injection or electrical resistance/electromagnetic/fiber optic/radio frequency heating is used to increase the volatilization rate of semi-volatiles and facilitate extraction.	Not retained. Soil borings indicated debris exists within remediation areas. Debris or other large objects buried in the media can cause operating difficulties. Additionally, high moisture content has a reduced permeability to air, hindering the operation.
	Ex-situ Biological Treatment	Biopiles	Excavated soil is mixed with soil amendments and placed in aboveground enclosures. It is an aerated static pile composting process in which compost is formed into piles and aerated with blowers or vacuum pumps.	Retained.
		Landfarming	Contaminated soil, sediment, or sludge is excavated, applied into lined beds, and periodically turned over or tilled to aerate the waste.	Not retained. Technology focuses on remediating media contaminated with volatile petroleum hydrocarbons. Not applicable for PAHs, as volatility is limited. Also, there is a chance of contaminant movement to previously non-contaminated areas of the site.

Table 11-1. Initial Screening of Technologies (continued)

General Response Actions	Technology Type	Process Options	Description	Screening Results
		Slurry Phase Biological Treatment	Aqueous slurry is created by combining soil, sediment, or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completing the process, the slurry is dewatered, and the treated soil is disposed.	Not retained. Due to the estimated quantities of soil requiring remediation, development, and the need for construction of a treatment area to dewater the slurry, this is not a practical technology.
	Ex-situ Physical/Chemical Treatment	Chemical Extraction	Waste-contaminated soil and extractant are mixed in an extractor, thereby dissolving the contaminants. The extracted solution is then placed in a separator, where the contaminants and extractant are separated for treatment and further use.	Not retained. Technology focuses on remediating media contaminated with PCBs, VOCs, halogenated solvents, and petroleum waste. Although the technology is considered suitable for PAHs, clay content (similar to site soil) reduces treatment efficiency.
		Chemical Reduction/Oxidation	Reduction/oxidation chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert.	Not retained. The target contaminant group for this technology is inorganics. It has low effectiveness for high molecular weight PAHs.
		Soil Washing	Contaminants sorbed onto fine soil particles are separated from bulk soil in an aqueous-based system on the basis of particle size. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organic chemicals and heavy metals.	Retained.

Table 11-1. Initial Screening of Technologies (continued)

General Response Actions	Technology Type	Process Options	Description	Screening Results
		Solidification/Stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).	Not retained. This technology has limited effectiveness for PAHs.
	Ex-situ Thermal Treatment	Hot Gas Decontamination	The process involves raising the temperature of the contaminated equipment or material for a specified period of time. The gas effluent from the material is treated in an afterburner system to destroy all volatilized contaminants.	Not retained. The technology is specific to addressing contaminated equipment or material, as opposed to contaminated soil.
		Incineration	High temperatures, 870-1,200°C (1,600-2,200°F), are used to combust (in the presence of oxygen) organic constituents in hazardous waste.	Retained.
		Pyrolysis	Chemical decomposition is induced in organic material by heat in the absence of oxygen. Organic material is transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash.	Retained.
		Thermal Treatment	Waste is heated in a mobile thermal treatment system to volatilize organic contaminants. The vapor emissions are treated using air filters, and the treated vapor is reused as an energy source for the operation of the thermal treatment system.	Retained.

AOC = Area of Concern.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
LUC = Land use control.
NCP = National Contingency Plan.
PAH = Polycyclic aromatic hydrocarbon.
PCB = Polychlorinated biphenyl.
VOC = Volatile organic compound.

Table 11–2. Detailed Screening of Technologies

General Response Actions	Technology Type	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	None	Not effective. Exposure to contaminants left in place goes unsupervised and uncontrolled.	Easy to implement. No activities are implemented.	No cost. No activities driving cost.	Retained. Required by CERCLA.
Removal	Bulk Removal	Excavation and Off-site Disposal	Effective. Once the contaminated soil is removed to achieve goals of a specific receptor, contaminant exposure to human health and the environment are eliminated for that receptor.	Moderately easy to implement. Technology has been implemented at the former RVAAP in the past. Equipment for implementation is readily available and disposal facilities are available within a reasonable distance.	Moderate cost.	Retained.
Treatment	In-situ Biological Treatment	Enhanced Bioremediation	Moderate effectiveness. Requires applying and mixing amendments in-situ for treatment.	Requires moderate effort for implementation. Long treatment times are required for reducing the high molecular weight PAH concentrations to below CUGs. These treatment times may extend beyond desirable schedule for the Army to start using the site.	Moderate cost.	Not retained. The time required for enhanced bioremediation to reduce PAH concentrations in soil to below CUGs is not practical given the desired Army schedule to begin using the site.
		Phytoremediation	Moderate to low effectiveness. Phytoremediation can be designed to address PAH constituents; however, effectiveness is limited.	Not easy to implement. The time required for phytoremediation to reduce PAH concentrations in the soil may extend beyond desirable schedule for the Army to start using the site. Phytoremediation usually takes more than one growing season. This technology is currently at the demonstration stage and not widely recognized by regulators. Additionally, concentrations can be hazardous to plants and may be mobilized into groundwater or bioaccumulated in animals.	Moderate cost. The cost effectiveness increases as the remedial footprint increases. The area requiring remediation is small; therefore, there is not optimal cost effectiveness.	Not retained. The time required for phytoremediation to reduce PAH concentrations in soil to below CUGs is not practical given the desired Army schedule to begin using the site.
	Ex-situ Biological Treatment	Biopiles	Moderate to low effectiveness. Biopiles are generally applied to VOCs and fuel hydrocarbons. The effectiveness of this technology decreases when applied to PAHs.	Moderate to low implementability. The time required for implementing biopiles (including a treatability study) may extend beyond desirable schedule for the Army to start using the site.	Moderate cost relative to anticipated soil quantity.	Not retained. Technology is not very effective for PAHs. Additionally, the time required for biopile treatment (including a treatability study) may extend beyond desirable schedule for the Army to start using the site.
	Ex-situ Physical/ Chemical Treatment	Soil Washing	Moderate effectiveness. Soil washing is more effective at reducing soil with high concentrations of contaminants (e.g., hazardous waste levels). Only a moderate reduction in concentration is required to achieve CUGs.	Not easy to implement. Treatability study may be required to demonstrate effectiveness. Implementing a treatability study is not practical given time constraints to transfer the AOC to NGB. An additional treatment step of washing the solvent (potentially a hazardous waste) will be required.	High cost. Soil washing is cost effective with high soil volumes. However, a relatively low volume of soil at Load Line 9 requires remediation.	Not retained. The volume of soil requiring remediation does not result in cost efficiency for this technology.

Table 11-2. Detailed Screening of Technologies (continued)

General Response Actions	Technology Type	Process Options	Effectiveness	Implementability	Cost	Screening Comments
	Ex-situ Thermal Treatment	Incineration	Effective. PAHs are a main contaminant group for incineration.	Not easy to implement. Incineration uses combustors, fluidized beds, or kilns to combust the chemicals in soil. These are not readily available, nor would obtaining and installing the equipment be appropriate for a small removal quantity.	High cost. Incineration uses combustors, fluidized beds, or kilns to remediate the chemicals in soil. These are generally put in place for remediating large soil volumes and are not cost effective for the smaller volumes of soil requiring remediation at Load Line 9.	Not retained. The technology is not easy to implement, as combustors, fluidized beds, or kilns are not readily available. There would be high cost relative to implementing incineration for the relatively small removal volume.
		Pyrolysis	Effective. PAHs are a main contaminant group for pyrolysis.	Not easy to implement. Pyrolysis uses kilns or furnaces to serve as a heating chamber for the contaminated soil. These are not readily available, nor would obtaining and installing a kiln or furnace be appropriate for a small removal quantity.	High cost. Pyrolysis includes a rotary kiln or fluidized bed furnace. These are generally put in place for remediating large soil volumes and are not cost effective for the smaller volumes of soil requiring remediation at FPA.	Not retained. The technology is not easy to implement, as kilns or furnaces are not readily available. There would be high cost relative to implementing pyrolysis for the relatively small removal volume.
		Thermal Treatment	Effective. PAH concentrations can be reduced to low levels meeting unrestricted use criteria. It is a green and sustainable technology that minimizes secondary waste generation and reduces carbon footprint.	Not easy to implement. However, the mobile treatment system is not as complex as the incineration or pyrolysis technology and can be easily mobilized onsite.	High cost if mobilization is required for such a small quantity. Thermal treatment is cost effective with high soil volumes; however, a relatively low volume of soil at Load Line 9 requires remediation. Cost can be considered low if on-site treatment system is readily available at the former RVAAP.	Retained. The volume of soil requiring remediation does not result in cost efficiency for this technology if mobilization of the thermal treatment system is required. However, if a treatment system is readily available at the former RVAAP, this alternative can be feasible.

AOC = Area of concern.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
CUG = Cleanup goal.
FPA = Former production area.
NGB = National Guard Bureau.
PAH = Polycyclic aromatic hydrocarbon.
RVAAP = Ravenna Army Ammunition Plant.
VOC = Volatile organic compound.

12.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

This section describes the remedial alternatives developed and retained from the initial and detailed technology screening process. The retained remedial alternatives are composed of implementable and cost-effective technology types and process options that address COCs in soil at Load Line 9.

The retained remedial alternatives are:

- Alternative 1: No Action.
- Alternative 2: Excavation and Off-site Disposal – Attain Unrestricted (Residential) Land Use.
- Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097 – Attain Unrestricted (Residential) Land Use.

A detailed description of each remedial alternative is provided in the following sections.

12.1 ALTERNATIVE 1: NO ACTION

The no action alternative is required for evaluation under the NCP. This alternative is the baseline to which other remedial alternatives are compared. This alternative assumes all current actions (e.g., access restrictions and environmental monitoring) will be discontinued and no future actions will take place to protect human receptors or the environment. Removal or treatment of COCs at the AOC will not be implemented.

12.2 ALTERNATIVE 2: EXCAVATION AND OFF-SITE DISPOSAL – ATTAIN UNRESTRICTED (RESIDENTIAL) LAND USE

Implementing surface soil removal (0-1 ft bgs) at sample locations LL9ss-011 and LL9ss-096/097 will attain Unrestricted (Residential) Land Use. This remedial alternative requires coordinating remediation activities with Ohio EPA, OHARNG, and the Army. Coordinating with stakeholders during implementation of the excavation minimizes health and safety risks to on-site personnel and potential disruptions of RVAAP/Camp Ravenna activities. The time period to complete this remedial action is relatively short and will not include an O&M period to assess impacts from soil, as an Unrestricted (Residential) Land Use scenario will be achieved. Components of this remedial alternative include:

- Delineation/pre-excavation confirmation sampling,
- Waste characterization sampling,
- Remedial design (RD),
- Soil excavation and off-site disposal, and
- Restoration.

12.2.1 Delineation/Pre-Excavation Confirmation Sampling

To coincide with and support development of the RD, delineation/pre-excavation confirmation sampling will be conducted to confirm the limits of soil excavation. The delineation/pre-excavation sampling plan will be implemented with the intent of: (1) adequately defining the extent of soil requiring removal to support the direct loading of soil to trucks for off-site disposal, and (2) minimizing the time required to implement the remedial action by eliminating the need for post-excavation confirmation sampling.

A delineation/pre-excavation confirmation sampling plan will be presented to the Army and Ohio EPA for approval. This plan will present a scheme of discrete sample locations around LL9ss-011 to be analyzed for lead and mercury in soil. This plan will also present discrete sample locations around LL9ss-096 and LL9ss-097 to be analyzed for benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene in soil.

A grid of delineation/pre-excavation confirmation samples will be proposed, including an estimated 8 borings at each location. Soil samples from 0-1, 1-2, 2-3, and 3-4 ft bgs will be analyzed for COCs until the lateral and horizontal extents of contamination are established by soil samples with concentrations below the respective CUGs. When the delineation sampling is complete, the vertical and horizontal extents of soil removal will be defined, and post-excavation confirmation sampling will not be required.

12.2.2 Waste Characterization Sampling

Waste characterization samples will be collected from the area requiring removal. The waste characterization samples will be collected as ISM samples from the area(s) undergoing this remedy to provide data to properly profile the waste and determine if it is characteristically non-hazardous or hazardous. Each ISM sample analysis can include (but is not limited to) TCLP metals, TCLP SVOCs, TCLP pesticides, TCLP herbicides, reactive cyanide, reactive sulfide, and PCBs. As noted previously, for purposes of this FS, the contaminated soil at LL9ss-011 may be considered characteristically hazardous. The waste characterization sampling results will confirm or refute that assumption.

12.2.3 Remedial Design

An RD will be developed prior to initiating remedial actions. This RD will outline construction permitting requirements; site preparation activities (e.g., staging and equipment storage areas, truck routes, storm water controls); the extent of the excavation; sequence and description of excavation and site restoration activities; decontamination; and segregation, transportation, and disposal of various waste streams. Erosion and health and safety controls will be developed during the active construction period to ensure remediation workers and the environment are protected.

12.2.4 Soil Excavation and Off-site Disposal

Prior to any ground disturbance, erosion control material such as silt fences and straw bales will be installed to minimize sediment runoff. Dust generation will be minimized during excavation activities by keeping equipment movement areas and excavation areas misted with water. The health and safety of remediation workers, on-site RVAAP/Camp Ravenna employees, and the general public will be covered in a site-specific health and safety plan.

To achieve a scenario in which the AOC is protective for Unrestricted (Residential) Land Use, soil will be removed from (1) the vicinity of LL9ss-011 which exceeded the CUG for lead and mercury and (2) the vicinity of LL9ss-096 and LL9ss-097 which exceeded the CUGs for benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene. The limits of the excavation will be defined by delineation/pre-excavation confirmation sampling conducted prior to soil removal. Soil removal will be accomplished using conventional construction equipment such as backhoes, bulldozers, front-end loaders, and scrapers. Oversize debris will be crushed or otherwise processed to meet disposal facility requirements.

Excavated soil will be segregated if certain areas have different soil characteristics (e.g., characteristically hazardous soil at LL9ss-011). Soil will be hauled by truck to a licensed and permitted disposal facility. All trucks will be inspected prior to exiting the AOC. Appropriate waste manifests will accompany each waste shipment. If the soil at LL9ss-011 is confirmed to be characteristically hazardous waste based on the waste characterization sampling, trucks will be placarded accordingly, and the waste will be transported under a hazardous waste manifest. Only regulated and licensed transporters and vehicles will be used. All trucks will travel pre-designated routes within RVAAP.

Excavated soil will be disposed at an existing off-site facility licensed and permitted to accept the characterized waste stream. The selection of an appropriate facility will consider the type of waste, location, transportation options, and cost. Waste streams with different constituents and/or characteristics may be generated. Disposal cost savings will be made possible by utilizing specific disposal facilities for different waste streams.

At the end of soil excavation, confirmatory samples will not be needed, as the previously conducted delineation/pre-excavation confirmation sampling will provide the vertical and lateral boundary of the areas requiring excavation.

12.2.5 Restoration

Upon completing soil excavation, all disturbed and excavated areas will be backfilled with clean soil and graded to meet neighboring contours. The backfill soil will come from a clean source that was previously sampled and approved for use by Ohio EPA. After the area is backfilled and graded, workers will apply a seed mixture (as approved by OHARNG) and mulch. Restored areas will be inspected and monitored as required in the storm water best management practices established in the RD.

12.3 ALTERNATIVE 3: EXCAVATION AND OFF-SITE DISPOSAL AT LL9SS-011 AND EX-SITU THERMAL TREATMENT AT LL9SS-096/097– ATTAIN UNRESTRICTED (RESIDENTIAL) LAND USE

This alternative involves two remedial technologies: Excavation and off-site disposal for the soil at LL9ss-011 and ex-situ thermal treatment, such as the Vapor Energy Generation (VEG©) treatment, for soil at sample locations LL9ss-096 and LL9ss-097. Implementing these remedial technologies will attain Unrestricted (Residential) Land Use. The evaluation of this alternative assumes that a mobile thermal treatment system is already on site and readily available for use. An alternative to mobilize a treatment system on site solely for treating the soil volume specified in this FS may not be feasible.

This remedial alternative requires coordinating remediation activities with Ohio EPA, OHARNG, and the Army. Coordinating with stakeholders during implementation of the excavation will minimize health and safety risks to on-site personnel and potential disruptions of Camp Ravenna activities. The time period to complete this remedial action is relatively short and will not include an O&M period to assess impacts from soil, as an Unrestricted (Residential) Land Use scenario will be achieved. Components of this remedial alternative include:

- Delineation/pre-excavation confirmation sampling,
- Waste characterization sampling,
- RD,
- Soil excavation and off-site disposal (LL9ss-011 soil),
- Soil treatment (LL9ss-096 and LL9ss-097 soil), and
- Restoration.

12.3.1 Delineation/Pre-Excavation Confirmation Sampling

To coincide with and support development of the RD, delineation/pre-excavation confirmation sampling will be conducted to confirm the limits of soil excavation. The delineation/pre-excavation sampling plan will be implemented with the intent of: (1) adequately defining the extent of soil requiring removal to support the direct loading of soil on to trucks for off-site disposal, and (2) minimizing the time required to implement the remedial action by eliminating the need for post-excavation confirmation sampling.

A delineation/pre-excavation confirmation sampling plan will be presented to the Army and Ohio EPA for approval. This plan will present a scheme of discrete sample locations around LL9ss-011 to be analyzed for lead and mercury in soil. This plan will also present discrete sample locations around LL9ss-096 and LL9ss-097 to be analyzed for benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene in soil.

A grid of delineation/pre-excavation confirmation samples will be proposed, including an estimated 12 borings at each location. Soil samples from 0-1, 1-2, 2-3, and 3-4 ft bgs will be analyzed until the lateral and horizontal extents of contamination are established by soil samples with concentrations below the respective CUGs. When the delineation sampling is complete, the vertical and horizontal extents of soil removal will be defined, and post-excavation confirmation sampling will not be required.

12.3.2 Waste Characterization Sampling

Waste characterization samples will be collected from the area requiring removal and off-site disposal (LL9ss-011). The waste characterization samples will be collected as ISM samples from the area(s) undergoing this remedy to provide data to properly profile the waste and determine if it is characteristically non-hazardous or hazardous. Each ISM sample analysis can include (but is not limited to) TCLP metals, TCLP SVOCs, TCLP pesticides, TCLP herbicides, reactive cyanide, reactive sulfide, and PCBs. As noted previously, for purposes of this FS, the contaminated soil at LL9ss-011 may be considered characteristically hazardous. The waste characterization sampling results will confirm or refute that assumption.

12.3.3 Remedial Design

An RD will be developed prior to initiating remedial actions. This RD will outline construction permitting requirements; site preparation activities (e.g., staging and equipment storage areas, truck routes, storm water controls); the extent of the excavation; sequence and description of excavation and site restoration activities; decontamination; and segregation, transportation, and disposal of various waste streams. Erosion and health and safety controls will be developed during the active construction period to ensure remediation workers and the environment are protected. In addition to these planning activities, the estimated CO_2 emissions will be calculated, and a PBR will be acquired prior to full-scale implementation.

12.3.4 Soil Excavation and Off-site Disposal (LL9ss-011 Soil)

Prior to any ground disturbance, erosion control material such as silt fences and straw bales will be installed to minimize sediment runoff. Dust generation will be minimized during excavation activities by keeping equipment movement areas and excavation areas misted with water. The health and safety of remediation workers, on-site RVAAP/Camp Ravenna employees, and the general public will be covered in a site-specific health and safety plan.

To achieve a scenario in which the AOC is protective for Unrestricted (Residential) Land Use, soil will be removed from the vicinity of LL9ss-011, which exceeded the CUG for lead and mercury. The limits of the excavation will be defined by delineation/pre-excavation confirmation sampling conducted prior to soil removal. Soil removal is accomplished using conventional construction equipment such as backhoes, bulldozers, front-end loaders, and scrapers. Oversize debris will be crushed or otherwise processed to meet disposal facility requirements.

Soil will be hauled by truck to a licensed and permitted disposal facility. All trucks will be inspected prior to exiting the AOC. Appropriate waste manifests will accompany each waste shipment. If the soil at LL9ss-011 is confirmed to be characteristically hazardous waste based on the waste characterization sampling, trucks will be placarded accordingly, and the waste will be transported under a hazardous waste manifest. Only regulated and licensed transporters and vehicles will be used. All trucks will travel pre-designated routes within RVAAP.

Excavated soil will be disposed at an existing off-site facility licensed and permitted to accept the characterized waste stream. The selection of an appropriate facility considers the type of waste, location, transportation options, and cost. Waste streams with different constituents and/or characteristics may be generated. Disposal cost savings will be made possible by utilizing specific disposal facilities for different waste streams.

At the end of the soil excavation, confirmatory samples will not be needed, as the previously conducted delineation/pre-excavation confirmation sampling will provide the vertical and lateral boundary of the areas requiring excavation.

12.3.5 Soil Treatment (LL9ss-096 and LL9ss-097 Soil)

Prior to any ground disturbance, the excavation area will be surveyed and demarcated by stakes. Erosion control material such as silt fences and straw bales will be installed to minimize sediment runoff. Dust generation will be minimized during excavation activities by keeping equipment movement areas and excavation areas misted with water. The health and safety of remediation workers, on-site Camp Ravenna employees, and the general public will be covered in a site-specific health and safety plan.

To achieve Unrestricted (Residential) Land Use at LL9ss-096 and LL9ss-097, the contaminated soil, delineated by the delineation/pre-excavation confirmation sampling, will undergo ex-situ thermal treatment. The treatment system, such as the VEG© treatment system, will be pre-heated to the optimal treatment temperature based on results of past bench- and pilot-scale tests previously conducted using the VEG Technology at the former RVAAP. While the system is being heated, soil will be excavated using conventional construction equipment such as backhoes, bulldozers, front-end loaders, and scrapers and will be stockpiled immediately adjacent to the treatment system into approximately 50 yd^3 piles.

Once the treatment system is at the optimal treatment temperature, contaminated soil will be fed directly into the fully enclosed, preheated chamber by being placed onto a conveyor. Steam at a temperature of 1300°F will be fed into the renewal/treatment chamber, where it serves as the heat source for thermally treating soils. As the soil moves through the system via a rotational auger, the soil contaminants will be desorbed at specified temperatures and residence times and passed as vapors into the box head space within the enclosed chamber.

The PAH vapors will then be subject to a patented filter/scrubber system to remove the acidic gases [i.e., nitrous oxides, sulfur oxides, and hydrogen chloride] and CO_2 components, using an engineered mixture of sodium hydroxide, lime, zero valent iron, steam, and water within a slender packed column. Induced vapors from the contaminated soils will be routed through this filtration system, allowing for full treatment of acidic gases, SVOC vapors, and conversion of any remaining vapors into a synthetic gas. This synthetic gas will be used as a renewable source of fuel to replace the propane used initially to generate steam and to continue operating the VEG treatment system.

Relying on this fully-enclosed looping system, there will be no emissions to the atmosphere, and the limited CO_2 generated through the process may be further reduced (by some 90% to levels below background) using the water-lime component of the patented filtration process. After treatment, the soil will be stockpiled into approximately 50 yd^3 stockpiles on tarp and covered with plastic sheeting.

Soil samples will be collected from the individual stockpiles, and soil will be analyzed for COCs using USEPA Method 8270. The laboratory results will be compared to CUGs. Once the laboratory analysis determines COCs are below CUGs, the treated soil will be used for backfill and site restoration. Should confirmation samples indicate that any contaminants are not sufficiently treated, then those soils will be rerun through the VEG system, likely at a higher temperature, until the target post-treatment levels are reached.

12.3.6 Restoration

Upon removing the contaminated soil at LL9ss-011, all disturbed and excavated areas will be backfilled with clean soil and graded to meet neighboring contours. The backfill soil will come from a clean source that was previously sampled and approved for use by Ohio EPA.

After confirming that the treated soil at LL9ss-096 and LL9ss-097 is below CUGs, all treated soil will be placed back into the excavated area and graded to meet neighboring contours. To ensure adequate vegetation is established within the excavated area, a layer of topsoil from a clean source that was previously sampled and approved for use by Ohio EPA will be placed on the treated soil.

After the areas are backfilled and graded, workers will apply a seed mixture (as approved by the OHARNG) and mulch. Restored areas will be inspected and monitored as required in the storm water best management practices established in the RD.

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13.0 ANALYSIS OF REMEDIAL ALTERNATIVES

13.1 INTRODUCTION

This section presents a detailed analysis of the viable remedial alternatives retained and developed throughout the technology screening process. The purpose of this detailed analysis is to provide stakeholders ample information to identify and select an appropriate remedy and prepare the PP. Based on this detailed analysis of the retained alternatives, one or more is recommended for media requiring remediation at Load Line 9.

CERCLA guidance suggests the principle element of the selected remedy should reduce volume, toxicity, or mobility. If the selected remedy's principle element does not meet this criterion, an explanation as to why must be presented. In addition, the remedy must meet the following four statutory requirements:

- Be protective of human health and the environment,
- Comply with ARARs (or provide justification for a waiver),
- Be cost effective, and
- Use permanent solutions and treatment or recovery technologies to the maximum extent practicable.

There are nine established NCP evaluation criteria used to perform a detailed analysis of remedial alternatives to ensure the selected alternative meets the above CERCLA statutory requirements. The nine criteria are grouped into three categories: threshold, balancing, and modifying criteria.

13.1.1 Threshold Criteria

There are two evaluation criteria classified as threshold criteria. This criteria group relates directly to statutory findings. Threshold criteria must be met by the selected remedy. The evaluation criteria in this group are:

1. Overall protection of human health and the environment, and
2. Compliance with ARARs.

Each alternative must be evaluated to determine how it achieves and maintains protection of human health and the environment. An alternative is considered to be protective of human health and the environment if it complies with medium-specific CUGs. Similarly, each remedial alternative must be assessed to determine how it complies with ARARs or, if a waiver is required, an explanation of why a waiver is justified.

13.1.2 Balancing Criteria

There are five evaluation criteria classified as balancing criteria. This group represents the primary criteria upon which the detailed and comparative analysis of each remedial alternative are based. The evaluation criteria in this group are:

1. Long-term effectiveness and permanence;
2. Reduction of toxicity, mobility, or volume through treatment;
3. Short-term effectiveness;
4. Implementability; and
5. Cost.

Long-term effectiveness and permanence evaluates the magnitude of residual risk (risk remaining after implementing the alternative) and the adequacy and reliability of controls used to manage the remaining waste (untreated waste and treatment residuals) over the long term. Alternatives that provide the highest degree of long-term effectiveness and permanence leave little or no untreated waste at the AOC, make long-term maintenance and monitoring unnecessary, and minimize the need for LUCs.

Reduction of toxicity, mobility, or volume through treatment evaluates the ability of the alternative to reduce the toxicity, mobility, or volume of waste. The irreversibility of the treatment process and the type and quantity of residuals remaining after treatment are also assessed.

Short-term effectiveness addresses the protection of workers and the community during the remedial action, the environmental effects of implementing the action, and the time required to achieve media-specific preliminary CUGs.

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during implementation. Technical feasibility assesses the ability to construct and operate a technology, the reliability of the technology, the ease in undertaking additional remedial actions, and the ability to monitor the effectiveness of the alternative. Administrative feasibility is addressed in terms of the ability to obtain approval from federal, state, and local agencies.

Cost analyses estimate the dollar cost of each alternative. The cost estimates in this report are based on reference manuals, historical costs, vendor quotes, and engineering estimates. Costs are reported in base year 2015 dollars. The cost estimates are for guidance in project evaluation and implementation and are believed to be accurate within a range of -30% to +50%, in accordance with USEPA guidance (USEPA 1988). Actual costs could be higher than estimated due to unexpected conditions or potential delays. Details and assumptions used in developing cost estimates for each of the alternatives are provided in Appendix J.

13.1.3 Modifying Criteria

There are two evaluation criteria categorized as modifying criteria. Modifying criteria are formally evaluated as part of the ROD and after the public has had an opportunity to comment on the PP. This criteria group consists of:

1. State acceptance, and
2. Community acceptance.

State Acceptance considers comments received from agencies of the state of Ohio. Ohio EPA is the primary state agency supporting this investigation. Ohio EPA, as well as other state agencies, will provide comments on the FS and the preferred remedy presented in the PP. This criterion is addressed in the responsiveness summary of the ROD.

Community Acceptance considers comments made by the community, including stakeholders, on the alternatives being considered. Comments will be solicited and accepted from the community on the FS and the preferred remedy will be presented in the PP. This criterion is addressed in the responsiveness summary of the ROD.

Modifying criteria are future activities. These actions are the same for the retained alternatives. Therefore, the detailed analysis of the remedial alternatives does not include an evaluation of modifying criteria. The detailed analysis of the retained remedial alternatives for Load Line 9 is presented in the following sections. This analysis is based on seven evaluation criteria (two threshold and five balancing criteria).

13.2 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

A detailed analysis of each alternative against the seven NCP evaluation criteria is contained in the following sections. The detailed analysis further defines each alternative (if necessary), compares the alternatives against one another, and presents considerations common to the alternatives.

As presented in Section 12.0, the following remedial alternatives were retained for Load Line 9:

- Alternative 1: No Action.
- Alternative 2: Excavation and Off-site Disposal – Attain Unrestricted (Residential) Land Use.
- Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097– Attain Unrestricted (Residential) Land Use

13.2.1 Alternative 1: No Action

Under this alternative, no remedial actions will take place for any media to meet the RAO. The media posing unacceptable risk to the Resident Receptor will be left in place. Existing access restrictions (e.g., RVAAP perimeter fence) will not be continued. Environmental monitoring will not be performed, and no restrictions on Land Use will be implemented.

13.2.1.1 Overall Protection of Human Health and the Environment

Alternative 1 is not protective for the Resident Receptor, National Guard Trainee, or Industrial Receptor, as surface soil posing unacceptable risk at sample locations LL9ss-011, LL9ss-096, and LL9ss-097 will remain on site.

The ERA concluded there is chemical contamination and possible risk; however, there are no important or significant ecological resources at Load Line 9, and no further action is required for protection of ecological resources. Current and future Land Uses allow for sustainability of terrestrial habitat for ecological receptors.

13.2.1.2 Compliance with ARARs

Potential ARARs for remediating soil at Load Line 9 are presented in Section 10.0. Because no action would be taken to address the contamination, Alternative 1 would not meet any ARARs and is considered not compliant.

13.2.1.3 Long-Term Effectiveness and Permanence

Alternative 1 has no long-term management measures to prevent Resident Receptor, National Guard Trainee, or Industrial Receptor exposure to COCs. Existing security will be discontinued under this Alternative, and there will be no access controls or LUCs at Load Line 9.

13.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 will not reduce the toxicity, mobility, or volume of COCs. This alternative will not remove or treat soil with concentrations of COCs above CUGs.

13.2.1.5 Short-Term Effectiveness

Alternative 1 will have no additional short-term health risks to the community, remediation workers, or the environment. This remedial alternative will offer no short-term benefits or progress to achieve the RAO.

13.2.1.6 Implementability

Since it does not change the existing condition at Load Line 9, this alternative will not require any additional effort to implement.

13.2.1.7 Cost

The present value cost to complete Alternative 1 is $0. No capital and O&M costs are associated with this alternative.

13.2.2 Alternative 2: Excavation and Off-site Disposal – Attain Unrestricted (Residential) Land Use

Under this alternative, soil removal and off-site disposal will be implemented to remove contaminated surface soil at sample locations LL9ss-011, LL9ss-096, and LL9ss-097 that pose unacceptable risk to the Resident Receptor, National Guard Trainee, and Industrial Receptor. Upon removal of the contaminated soil, no additional controls will be required for any receptor.

13.2.2.1 Overall Protection of Human Health and the Environment

Under this alternative, surface soil (0-1 ft bgs) will be excavated and removed from the two distinct locations. Removing contaminated soil within these locations, as described in the remedial alternative, results in the AOC being protective of human health for Unrestricted (Residential) Land Use. In addition, removing contaminated soil to attain human health CUGs will also provide a secondary benefit of reducing any existing risk to ecological receptors. Soil removal to be protective of the Resident Receptor will also reduce ecological risk. Removing contaminated soil assists in keeping terrestrial habitat for ecological receptors sustainable. A large part of this advantage is due to the small area of the soil being removed relative to the large home range sizes of the wildlife. Excavating soil disrupts approximately 20,970 ft^2 (0.5 acres) of the forest and shrubland area. The small cleared area should recover from excavation activities in 1-5 years.

13.2.2.2 Compliance with ARARs

There are no identified chemical- or location-specific ARARs for Alternative 2. However, there are action-specific ARARs for this alternative. Those requirements identified as ARARs deal primarily with characterizing, managing, and disposing contaminated soil generated from excavation. Disturbing the soil will also trigger ARARs for controlling fugitive dust emissions and potentially may trigger ARARs for erosion-control measures. Action-specific ARARs only apply if the action is taken. Potential ARARs for excavating soil are presented in Section 10.0.

13.2.2.3 Long-Term Effectiveness and Permanence

Alternative 2 is effective in the long-term by reducing soil COC concentrations to below Resident Receptor CUGs, thus attaining Unrestricted (Residential) Land Use. Contaminated surface soil (LL9ss-011, LL9ss-096, and LL9ss-097) will be excavated and transported to an off-site disposal facility. This will result in Unrestricted (Residential) Land Use at Load Line 9, thereby mitigating risk to human health. Accordingly, LUCs will not be required when removal activities are complete. No CERCLA five-year reviews or O&M sampling will be required.

13.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 involves excavating contaminated soil for disposal in a permitted solid waste landfill. This alternative will reduce the mobility of COCs by placing the contaminated soil in an engineered, lined disposal cell at the landfill. This alternative will not reduce the toxicity or volume of the contaminated soil.

13.2.2.5 Short-Term Effectiveness

There will be potential short-term worker and community exposures associated with Alternative 2. Workers may be exposed during excavation activities. A health and safety plan that identifies appropriate personal protective equipment (PPE) for workers will minimize and/or eliminate exposures.

The community near the excavation area and along the route to the disposal facility may be exposed during removal and transportation activities. Mitigation measures during excavation, such as erosion and dust control, will minimize/eliminate potential short-term impacts. The community will be protected during soil transport by inspecting vehicles before and after use, decontaminating as needed, covering the transported waste, observing safety protocols, following pre-designated routes, and limiting the distance to the disposal facility. Transportation risk associated with material leaks increases with distance and volume of material. Transportation of soil to an off-site disposal facility will comply with all applicable state and federal regulations. Pre-designated travel routes will be established, and an emergency response program will be developed to facilitate any potential accident response.

Excavating the soil and restoring the AOC is estimated to be completed in approximately one month. Storm water controls will be monitored weekly for five weeks, or until the vegetation is 70% established. Upon completing the excavation and site restoration activities, Load Line 9 will be released for Unrestricted (Residential) Land Use.

13.2.2.6 Implementability

Alternative 2 will be easily implemented after the RD is developed and approved by stakeholders and all appropriate coordination with local, state, and federal agencies is completed. Excavating soil, constructing temporary roads, and conducting waste handling are conventional, straightforward construction techniques and methods. Multiple off-site disposal facilities will be available to accept generated waste. Resources (e.g., equipment, material, trained personnel) to implement this alternative will be readily available.

Excavation activities will be coordinated with Camp Ravenna and OHARNG to minimize alterations and/or impacts to OHARNG proceedings. The RD will identify access routes to the AOC for heavy equipment and provides steps to minimize potential hazards to on-site personnel. Developing the RD and coordinating with local, state, and federal agencies will increase the implementation difficulty of Alternative 2.

13.2.2.7 Cost

The present value cost to complete Alternative 2 is approximately $410,360 (in base year 2015 dollars). This alternative does not include an O&M period subsequent to the soil removal, as Unrestricted (Residential) Land Use is achieved. See Appendix J for a detailed description of Alternative 2 costs.

13.2.3 Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097– Attain Unrestricted (Residential) Land Use

Under this alternative, contaminated soil will undergo 1) excavation and off-site disposal at LL9ss-011 and 2) ex-situ thermal treatment at LL9ss-096/097 to address contaminated surface soil (0-1 ft bgs) that pose unacceptable risk to the Resident Receptor, National Guard Trainee, and Industrial Receptor. Upon removal and treatment of the contaminated soil, no additional controls will be required for any receptor.

13.2.3.1 Overall Protection of Human Health and the Environment

Under this alternative, surface soil (0-1 ft bgs) from LL9ss-011 will be removed for off-site disposal and surface soil (0-1 ft bgs) from LL9ss-096/097 will be thermally treated to concentrations that are protective for the Resident Receptor. These remedial activities will result in the AOC being protective of human health for Unrestricted (Residential) Land Use. In addition, removal and treatment of contaminated soil will provide a secondary benefit of reducing any existing risk to ecological receptors. A large part of this advantage is due to the small area of the soil being removed relative to the large home range sizes of the wildlife. Excavating soil will disrupt approximately 20,970 ft^2 (0.5 acres) of the forest and shrubland area. The small cleared area should recover from excavation activities in 1-5 years.

13.2.3.2 Compliance with ARARs

There are no identified chemical- or location-specific ARARs for Alternative 3. However, there are action-specific ARARs for this alternative. Those requirements identified as ARARs deal primarily with characterizing, managing, and treating contaminated soil generated from excavation, as well as obtaining a PBR exemption for low-emitting air pollution sources prior to operating the thermal treatment system. Disturbing the soil will also trigger ARARs for controlling fugitive dust emissions and potentially may trigger ARARs for erosion-control measures. Action-specific ARARs only apply if the action is taken. Potential ARARs for excavating soil are presented in Section 10.0.

13.2.3.3 Long-Term Effectiveness and Permanence

Alternative 3 will effectively reduce COC concentrations to below CUGs in soil and is protective over the long term. Surface soil at LL9ss-011 will be removed and disposed offsite, and surface soil at LL9ss-096/097 will be thermally treated to reduce COC concentrations that are protective of the Resident Receptor, thereby mitigating risk to human health. Accordingly, LUCs will not be required when removal activities are complete. No CERCLA five-year reviews or O&M sampling will be required.

In addition, the VEG technology thermal treatment is a green and highly sustainable alternative for on-site treatment and unrestricted reuse of soils. This technology converts contaminants into a renewable source of fuel to run treatment operations, and reduces or eliminates air emissions, including CO_2, which may normally result if vehicles are used to transport contaminated soil to a disposal facility.

13.2.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 3 will involve excavating contaminated soil for disposal in a permitted solid waste landfill. This alternative will reduce the mobility of COCs by placing the mercury and lead contaminated soil in an engineered, lined disposal cell at the landfill. Additionally, Alternative 3 will involve treating PAH contamination in surface soil. This alternative will reduce the toxicity, mobility, and volume of COCs through treatment.

13.2.3.5 Short-Term Effectiveness

Workers may be exposed during excavation activities, stockpiling soil, and loading soil into the treatment system with Alternative 3. A health and safety plan that identifies appropriate PPE for workers will minimize and/or eliminate exposures.

Mitigation measures during excavation, such as erosion and dust control, will minimize/eliminate potential short-term impacts. The treatment of the soil will occur in a fully enclosed chamber, thus minimizing worker exposure to heat from the treatment process or resulting vapors. The soil treatment and restoration of the AOC is estimated to be completed in approximately one month. Storm water controls will be monitored weekly for five weeks, or until the vegetation is 70% established. Upon completing the excavation and site restoration activities, Load Line 9 will be released for Unrestricted (Residential) Land Use.

13.2.3.6 Implementability

The implementability of Alternative 3 is predicated on having an existing on-site thermal treatment system performing remediation at other sites on the installation. The treatment system can efficiently mobilize from within the former RVAAP; however, this alternative may not be practical if a treatment system needs to mobilize solely for this remediation.
Alternative 3 will be implementable after using historic bench-scale tests to establish optimal treatment temperature and residence times, developing an RD that is approved by stakeholders, and completing all appropriate coordination with local, state, and federal agencies. Excavating soil, constructing temporary roads, and waste handling are conventional, straightforward construction techniques and methods. Implementing this alternative is predicated on the availability of an on-site thermal treatment system, thus resulting in readily available equipment and minimal mobilization.

Soil treatment activities will be coordinated with Camp Ravenna and OHARNG to minimize alterations and/or impacts to OHARNG proceedings. The RD will identify access routes to the AOC for heavy equipment and steps to minimize potential hazards to on-site personnel. Developing the RD and coordinating with local, state, and federal agencies will increase the implementation difficulty of Alternative 3.

13.2.3.7 Cost

The present value cost to complete Alternative 3 is approximately $296,732 (in base year 2015 dollars). This alternative does not include an O&M period subsequent to the soil treatment, as Unrestricted (Residential) Land Use is achieved. See Appendix J for a detailed description of Alternative 3 costs.

This cost assumes an existing thermal treatment system is on site and ready for mobilization. The mobilization cost in that scenario is an estimated $1,000. If no treatment system is on site and readily available, the mobilization cost may increase to an estimated $25,000, increasing the estimated cost of Alternative 3 to $320,732 (in base year 2015 dollars).

13.3 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES USING NCP CRITERIA

The comparative analysis provides a means by which remedial alternatives can be directly compared to one another with respect to common criteria. Table 13-1 provides a comparative analysis of the alternatives conducted.

Overall protection and compliance with ARARs are threshold criteria that must be met by any alternative to be eligible for selection. If any alternative is considered “not protective” for overall protectiveness of human health and the environment or “not compliant” for compliance with ARARs, it is not eligible for selection as the recommended alternative.

Alternative 1 is not protective of human health and is not compliant with ARARs. In addition, Alternative 1 does not meet the RAO to prevent Resident Receptor exposure to surface soil (0-1 ft bgs) with 1) concentrations above lead and mercury CUGs at sample location LL9ss-011 and 2) concentrations above benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene CUGs at sample locations LL9ss-096 and LL9ss-097. Therefore, Alternative 1 is not eligible for selection.

For the remaining alternatives, the balancing criteria (short- and long-term effectiveness; reduction of contaminant toxicity, mobility, or volume through treatment; ease of implementation; and cost) are used to select a recommended alternative among the alternatives that satisfies the threshold criteria. The remaining alternatives are ranked amongst one another for each of the balancing criteria and a total score is generated.

Alternative 3 scores the highest and is the recommended alternative. Alternative 3 is effective in the long term and will attain Unrestricted (Residential) Land Use. In addition, Alternative 3 is a green and highly sustainable alternative for on-site treatment and unrestricted reuse of soil and implements a treatment alternative to reduce the toxicity, mobility, and volume of contamination.

The implementability of Alternative 3 is predicated on the on-site availability of the thermal treatment system. In the event that a thermal treatment system is not available on site at the former RVAAP, Alternative 2 is readily available for implementation. Excavation and off-site disposal alternatives have been implemented multiple times during restoration efforts at the former RVAAP. As with Alternative 3, Alternative 2 is effective in the long term and attains Unrestricted (Residential) Land Use. Alternative 2 reduces the mobility of contaminants by placing contamination in an engineered landfill.

1

Table 13–1. Summary of Comparative Analysis of Remedial Alternatives

NCP Evaluation Criteria	**Alternative 1: No Action**	**Alternative 2: Excavation and Off-site Disposal - Attain Unrestricted (Residential) Land Use**	**Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097– Attain Unrestricted (Residential) Land Use**
Threshold Criteria	***Result***	***Result***	***Result***
1. Overall Protectiveness of Human Health and the Environment	Not protective	Protective	Protective
2. Compliance with ARARs	Not compliant	Compliant	Compliant
Balancing Criteria	***Ranking***	***Ranking***	***Ranking***
3. Long-term Effectiveness and Permanence	Not applicable	1	2
4. Reduction of Toxicity, Mobility, or Volume through Treatment	Not applicable	1	2
5. Short-term Effectiveness	Not applicable	1	2
6. Implementability	Not applicable	2	1
7. Cost	Not applicable ($0)	1 ($410,360)	2 ($296,732)
Balancing Criteria Score	*Not applicable*	*6*	*9*

Any alternative considered “not protective” for overall protectiveness of human health and the environment or “not compliant” for compliance with ARARs is not eligible for selection as the recommended alternative. Therefore, that alternative is not ranked as part of the balancing criteria evaluation.

Scoring for the balancing criteria is as follows: Most favorable = 2, least favorable = 1. The alternative with the highest total balancing criteria score is considered the most feasible.

ARAR = Applicable and Relevant or Appropriate Requirement.

NCP = National Contingency Plan.

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14.0 CONCLUSIONS AND RECOMMENDED ALTERNATIVE

14.1 CONCLUSIONS

The primary purposes of this RI/FS Report are to review the history of Load Line 9, summarize RI activities, evaluate results of the RI, develop RAOs and remedial alternatives, and present a recommended alternative to address soil, sediment, and surface water at the AOC.

An assessment of data collected at this AOC concluded remediation was not necessary for subsurface soil, sediment, or surface water for any receptor. Conclusions of the ERA indicate remedial actions are not needed to protect ecological receptors. Anticipated remedial activities to protect the human receptor will benefit ecological resources and reduce the potential for contaminant migration to groundwater. Fate and transport modeling indicates soil remediation to protect groundwater is not warranted. Remedial actions specific to groundwater media at Load Line 9 will be evaluated in a separate report.

The HHRA identified COCs in surface soil (0-1 ft bgs) at sample locations LL9ss-011, LL9ss-096, and LL9ss-097 that posed unacceptable risk for all future receptors (Resident Receptor, National Guard Trainee, and Industrial Receptor. This risk prevents achieving Unrestricted (Residential) Land Use and planned future use (Military Training and Commercial/Industrial Land Use) without appropriate remedial actions. Consequently, alternatives were developed and evaluated to determine the most feasible remedial alternative at Load Line 9.

After COCs were identified and CUGs were established, remedial technologies were screened and the following viable remedial alternatives developed:

- Alternative 1: No Action.
- Alternative 2: Excavation and Off-site Disposal - Attain Unrestricted (Residential) Land Use.
- Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097– Attain Unrestricted (Residential) Land Use.

These alternatives are applicable and are compared against one another to provide information of sufficient quality and quantity to justify the selection of a remedy. The following section provides the recommended alternative for Load Line 9 soil.

14.2 RECOMMENDED ALTERNATIVE

The recommended alternative for Load Line 9 is Alternative 3: Excavation and Off-site Disposal at LL9ss-011 and Ex-situ Thermal Treatment at LL9ss-096/097– Attain Unrestricted (Residential) Land Use. Alternative 3 meets the threshold and primary balancing criteria and is protective of the Resident Receptor by thermally treating PAH-contaminated soil and disposing the mercury and lead contaminated soil offsite at an engineered landfill. The cost of Alternative 3 is $296,732 and has no O&M costs, as implementing the alternative results in attaining Unrestricted (Residential) Land Use. In addition, Alternative 3 is a green and highly sustainable alternative for on-site treatment and unrestricted reuse of soil and implements a treatment alternative to reduce the toxicity, mobility, and volume of contamination.

Alternative 1: No Action was also evaluated. However, since the threshold criterion of overall protectiveness of human health is not met, this alternative was eliminated from consideration. In the event that a thermal treatment system is not on site at the former RVAAP, Alternative 2: Excavation and Off-site Disposal – Attain Unrestricted (Residential) Land Use is readily available and may be implemented. Excavation and off-site disposal alternatives have been implemented multiple times during restoration efforts at the former RVAAP. As with Alternative 3, Alternative 2 is effective in the long term and attains Unrestricted (Residential) Land Use.

The next step in the CERCLA process is to prepare a PP to solicit public input on the remedial alternatives. The PP will present these alternatives with the preferred remedial alternative for Load Line 9. Comments on the PP provided by state and federal agencies and the public will be presented in the Responsive Summary section of the Load Line 9 ROD. The ROD will provide a brief summary of the history, characteristics, and risks of the AOC and will document the selected remedy.

15.0 AGENCY COORDINATION AND PUBLIC INVOLVEMENT

The Army is the lead agency responsible for executing the CERCLA process and ultimately completing an approved ROD for soil, sediment, and surface water at Load Line 9. This section reviews actions that have been conducted and presents activities that are planned to ensure the regulatory agencies and members of the public have been provided with appropriate opportunities to stay informed of the progress of the Load Line 9 environmental investigation, restoration efforts, and final selection of a remedy.

As described in Section 13.0, two of the nine NCP evaluation criteria are known as “modifying criteria” – state acceptance and community acceptance. These criteria provide a framework for obtaining the necessary agency coordination and public involvement in the remedy selection process.

15.1 STATE ACCEPTANCE

State acceptance considers comments received from agencies of the state of Ohio on the proposed remedial alternatives. Ohio EPA is the lead regulatory agency for supporting the remedy for soil, sediment, and surface water at Load Line 9. This RI/FS Report has been prepared in consultation with Ohio EPA.

Ohio EPA has provided input during the ongoing investigation and report development to ensure the remedy ultimately selected for Load Line 9 is protective of human health and the environment and fulfills the requirements of the DFFO (Ohio EPA 2004). Ohio EPA will provide comments on this RI/FS Report and the subsequent PP and ROD. The Army will obtain Ohio EPA concurrence prior to the final selection of the remedy for soil, sediment, and surface water at the AOC.

15.2 COMMUNITY ACCEPTANCE

Community acceptance considers comments provided by community members for each proposed remedial alternative. CERCLA 42 U.S.C. 9617(a) emphasizes early, constant, and responsive community relations. The Army has prepared a *Community Relations Plan for the Ravenna Army Ammunition Plant Restoration Program* (Vista 2015) to facilitate communication between the former RVAAP and the community surrounding Ravenna, Ohio, during environmental investigations and potential remedial action. The plan was developed to ensure the public has convenient access to information regarding project progress. The community relations program interacts with the public through news releases, public meetings, public workshops, and Restoration Advisory Board meetings with local officials, interest groups, and the general public.

CERCLA 42 U.S.C. 9617(a) requires an Administrative Record to be established “at or near the facility at issue.” Relevant documents regarding the former RVAAP have been made available to the public for review and comment.

The Administrative Record for this project is available at the following location:

Camp Ravenna
Environmental Office
1438 State Route 534 SW
Newton Falls, OH 44444

Access to Camp Ravenna is restricted but can be obtained by contacting the environmental office at (614) 336-6136. In addition, an Information Repository of current information and final documents is available to any interested reader at the following libraries:

Reed Memorial Library
167 East Main Street
Ravenna, Ohio 44266

Newton Falls Public Library
204 South Canal Street
Newton Falls, Ohio 44444-1694

Additionally, there is an online resource for restoration news and information. This website is available at: www.rvaap.org.

Comments will be received from the community upon issuing the RI/FS Report and PP. As required by the CERCLA regulatory process and the Community Relations Plan (Vista 2015), the Army will hold a public meeting and request public comments on the PP for Load Line 9. These comments will be considered prior to the final selection of a remedy. Responses to these comments will be addressed in the responsiveness summary of the ROD.

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