Revised Draft

Remedial Investigation Report for Soil, Sediment, and Surface Water at RVAAP-46 Buildings F-15 and F-16

Former Ravenna Army Ammunition Plant
Portage and Trumbull Counties, Ohio

Contract No. W912QR-15-C-0046

Prepared for:

US Army Corps of Engineers®

U.S. Army Corps of Engineers
Louisville District

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December 23, 2016

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)* 23-12-2016	**2. REPORT TYPE** Technical	**3. DATES COVERED** *(From - To)* 1941 to 2016

4. TITLE AND SUBTITLE Final Remedial Investigation Report for Soil, Sediment, and Surface Water at RVAAP-46 Buildings F-15 and F-16 Former Ravenna Army Ammunition Plant Portage and Trumbull Counties, Ohio	**5a. CONTRACT NUMBER** W912QR-15-C-0046
	5b. GRANT NUMBER NA
	5c. PROGRAM ELEMENT NUMBER NA
6. AUTHOR(S) Sprinzl, Richard, E. Adams, Heather, R. Khan, Alauddin, PhD Barta, Michael, L. Robers, Sharon, K.	**5d. PROJECT NUMBER** NA
	5e. TASK NUMBER NA
	5f. WORK UNIT NUMBER NA
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Leidos 8866 Commons Boulevard Suite 201 Twinsburg, Ohio 44087	**8. PERFORMING ORGANIZATION REPORT NUMBER** 16-062(E)/121616
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) USACE - Louisville District U.S. Army Corps of Engineers 600 Martin Luther King Jr., Place PO Box 59 Louisville, Kentucky 40202-0059	**10. SPONSOR/MONITOR'S ACRONYM(S)** USACE
	11. SPONSOR/MONITOR'S REPORT NUMBER(S) NA

12. DISTRIBUTION/AVAILABILITY STATEMENT

Reference distribution page.

13. SUPPLEMENTARY NOTES

None.

14. ABSTRACT

This Remedial Investigation Report for the Buildings F-15 and F-16 presents physical characteristics, geology, and hydrogeology of the AOC; compiles historical and newly acquired environmental data; summarizes nature and extent of contamination in soil, sediment, and surface water; evaluates contaminant fate and transport; and provides human health and ecological risk assessments. These evaluations indicate there are no chemicals of concern (COCs) that pose unacceptable risk; and, therefore this report recommends No Further Action with respect to soil, sediment, and surface water at the Buildings F-15 and F-16 AOC to attain Unrestricted (Residential) Land Use.

15. SUBJECT TERMS

Risk assessment, weight of evidence, nature and extent, fate and transport, no further action

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Nathaniel Peters, II
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DISCLAIMER STATEMENT

CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Leidos has completed the Remedial Investigation Report for Soil, Sediment, and Surface Water at RVAAP-46 Buildings F-15 and F-16 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 U.S. Army Corps of Engineers (USACE) policy. In addition, an independent verification was performed to ensure all applicable changes were made per regulatory and Army comments.

12/23/16

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12/23/16

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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.

12/23/16

Lisa Jones-Bateman
Senior Program Manager

Date

PLACEHOLDER FOR:

Documentation of Ohio EPA Approval of Final Document

(Documentation to be provided once approval is issued.)

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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 = U.S. Army Corps of Engineers.

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ACRONYMS AND ABBREVIATIONS

ACM	Asbestos-containing Material
amsl	Above Mean Sea Level
AOC	Area of Concern
Army	U.S. Department of the Army
AST	Aboveground Storage Tank
AT123D	Analytical Transient 1-, 2-, 3-Dimensional
bgs	Below Ground Surface
Camp Ravenna	Camp Ravenna Joint Military Training Center
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
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
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DERR	Division of Environmental Response and Revitalization
DFFO	Director’s Final Findings and Orders
DNT	Dinitrotoluene
DQO	Data Quality Objective
EcoSSL	Ecological Soil Screening Level
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERS	Ecological Risk Screening
ESV	Ecological Screening Value
EU	Exposure Unit
f_{oc}	Mass Fraction of the Organic Carbon Soil
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 Assessors Manual
FWSAP	Facility-wide Sampling and Analysis Plan
gpm	Gallons Per Minute
GSSL	Generic Soil Screening Level
HELP	Hydrologic Evaluation of Landfill Performance
HHRA	Human Health Risk Assessment
HHRS	Human Health Risk Screening
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
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
MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
MDL	Maximum Detection Limit
MI	Multi-Increment
MRS	Munitions Response Site
NCP	National Contingency Plan
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
ORAM	Ohio Rapid Assessment Method
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
PBT	Persistent, Bioaccumulative, and Toxic
PCB	Polychlorinated Biphenyl
PP	Proposed Plan
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QC	Quality Control
R	Retardation Factor
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
SAIC	Science Applications International Corporation
SESOIL	Seasonal Soil Compartment Model
SL	Screening Level
SOR	Sum-of-Ratios

SRC	Site-related Contaminant
SSL	Soil Screening Level
SSSL	Site-Specific Soil Screening Level
SVOC	Semi-Volatile Organic Compound
TAL	Target Analyte List
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
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USP&FO	U.S. Property and Fiscal Officer
UST	Underground Storage Tank
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 U.S. Army Corps of Engineers (USACE) Louisville District Contract Number W912QR-15-C-0046. This Remedial Investigation (RI) Report addresses soil, sediment, and surface water at the Buildings F-15 and F-16 area of concern (AOC) 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 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 a Feasibility Study (FS) (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

Buildings F-15 and F-16 were used for surveillance testing on explosives and propellants and testing disassembly processes during World War II, the Korean War, and the Vietnam War (between 1941 and 1974). The number of tests conducted on miscellaneous explosives and propellants, the quantities of material tested, and the exact dates of testing are unknown. No additional information exists to indicate the AOC was used for any other processes.

The AOC is located west of Block D and east of Slagle Road in the west-central portion of RVAAP. Historical facilities at the AOC included five process and support buildings. All buildings and structures at the AOC have been demolished, except for one former coal-powered boiler house (Building U-17). During a visual survey conducted by the Army National Guard in April 2016, ceramic insulators and metal debris were observed south of the old abandoned Building U-17 in a fenced area that is mostly likely the location of former electrical equipment (ARNG 2016). An old metal platform (in place) and wooden debris are located north of former Building F-15. Several debris piles, including corrugated metal, concrete, brick, asphalt, and wood were seen throughout the AOC.

The northernmost former Building F-15 was separated from former Building F-16 by approximately 1,000 ft. No fences exist around the perimeter boundary of the AOC operational areas. The AOC, which is the combined operational areas for both Buildings F-15 and F-16, is approximately 12.3 acres (6.6 and 5.7 acres, respectively).

ES.1.2 Scope

The scope of this RI Report is to perform a CERCLA evaluation of soil, sediment, and surface water at the Buildings F-15 and F-16 AOC using available RI data to evaluate the nature and extent of contamination; fate and transport of contaminants in the environment; and risk assessments for surface and subsurface soil, sediment, and surface water. This report includes sample results and information from the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 Incremental Sampling Methodology (ISM) Surface Soil Sampling, and also provides a summary of the Performance-based Acquisition 2008 Remedial Investigation (PBA08 RI) at the AOC that was performed to supplement data from previous sampling events.

The media of concern are surface soil [0–1 ft below ground surface (bgs)] and subsurface soil (1–13 ft bgs). Perennial surface water and corresponding sediment are not present at the AOC. However, off-AOC samples in an unnamed tributary to Sand Creek and an intermittent pond south of Building F-16 are included in the nature and extent of contamination evaluation.

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 Report to determine whether additional 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/Commercial Use 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 a summary of data used in this 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 2004 Characterization of 14 AOCs (MKM 2007), 2009 Under Slab Sampling (USACE 2010c), 2009 USACE ISM Surface Soil Sampling (Prudent 2011), and 2010 PBA08 RIs were used to evaluate nature and extent of contamination at the AOC. These investigations used ISM 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, and risk assessment). Evaluation of the data’s suitability for use in the PBA08 RI involved two primary considerations: whether the data represented current AOC conditions and sample collection methods (e.g., discrete vs. ISM).

Samples from the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, and 2009 USACE ISM Surface Soil Sampling data sets were evaluated to determine if conditions had changed substantively between earlier characterization efforts and the 2010 PBA08 RI, as building demolition activities occurred in 2007–2009 after the 2004 Characterization of 14 AOCs sampling. The samples collected in 2004 were collected within ditch lines adjacent to former buildings and in areas encompassing, but also extending substantially beyond the footprint of the former buildings. Therefore, all data sets were considered representative of current conditions within and surrounding the footprints of the former buildings and removal areas.

Data collected in 2010 as part of the PBA08 RI focused on delineating the extent of contaminants identified in surface soil (0–1 ft bgs) and subsurface soil (1–13 ft bgs). 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. Perennial surface water and corresponding sediment are not present at the Buildings F-15 and F-16 AOC. However, off-AOC samples in an unnamed tributary to Sand Creek and an intermittent pond south of Building F-16 are included in the nature and extent of contamination evaluation.

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 were evaluated in this RI. Data from the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and 2010 PBA08 RIs effectively characterized 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, site-related contaminant (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 the Buildings F-15 and F-16 AOC.

ES.2.2.1 <u>Soil</u>

Building F-15 Aggregate

No explosives were detected at Building F-15 in surface or subsurface soil samples. One propellant (nitrocellulose) was detected in one ISM surface soil sample (F15ss-006M) at a concentration below the SL. No propellants were detected in subsurface soil samples at Building F-15. Arsenic and cobalt were the only two inorganic chemicals to exceed their background concentrations and FWCUGs of HQ of 0.1 or TR of 1E-06 in surface soil. No propellants were detected in subsurface soil samples at Building F-15. Arsenic exceeded the background concentration of 15.4 mg/kg in two of the 2004 Characterization of 14 AOCs ISM surface samples collected to evaluate the ditch to the southwest (F15ss-005M) and former buildings T-3002 and T-3003 (F15ss-011M) and was not detected above background in subsurface soil samples.

One location (F15ss-036M at 0.48 mg/kg) slightly exceeded the benzo(a)pyrene Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1 (0.221 mg/kg). Sample location F15ss-036M was collected as an ISM surface soil sample during the PBA08 RI from a ditch along Slagle Road northwest of Building F-15. Polycyclic aromatic hydrocarbons (PAHs) were not detected in any subsurface soil samples at Building F-15. PAH concentrations detected across the entire AOC were generally higher in samples taken from low-lying areas and ditches bordering Slagle Road and parking areas. PAHs were identified as potential contaminants from previous site use at Buildings U-17 that were formerly used as a coal-powered boiler house; however, concentrations in surface soil at this former building location were less than SLs.

Historical records indicated three transformers serviced all buildings at the AOC. Polychlorinated biphenyls (PCBs) were not detected in surface or subsurface soil at Building F-15. Furthermore, volatile organic compounds (VOCs) and pesticides were not detected in surface or subsurface soil at Building F-15, which is consistent with the historical record that shows they were not previously used at the AOC.

Building F-16 Aggregate

No explosives were detected at Building F-16 in ISM surface or discrete subsurface soil samples. One explosive, 2,6-dinitrotoluene, was detected below its SL in the discrete surface soil sample taken at F16sb-021. Two propellants (nitrocellulose and nitroglycerin) were detected in two ISM surface soil samples (F16ss-026M and F16ss-005M) collected from ditches located at the northern end of Building F-16 at concentrations below their respective SLs; therefore, nitrocellulose and nitroglycerin were not considered chemicals of potential concern (COPCs). No propellants were detected in subsurface soil samples at Building F-16.

Arsenic, cobalt, manganese, and thallium were the only four inorganic chemicals to exceed their background concentration and FWCUGs of HQ of 0.1 or TR of 1E-06 in surface soil. Cobalt and thallium did not exceed the FWCUGs of HQ of 1 or TR of 1E-05 and were not detected in subsurface soil samples. Arsenic exceeded the background concentration of 15.4 mg/kg in the 2004 Characterization of 14 AOCs ISM surface sample F16ss-004M (18 mg/kg) collected to evaluate the ditch located to the north of former Building F-15 and in PBA08 RI sample location F16sb-021 (31.3 mg/kg) collected from a discrete boring installed in the ditch to the west of former Building F-16. Arsenic exceeded the background concentration of 19.8 mg/kg in subsurface soil at F16sb-021 (24.3J mg/kg from 4–7 ft bgs). Evaluation of the vertical extent at F16sb-021 indicated a potential decreasing concentration profile of 24.3J mg/kg from 4–7 ft bgs and 11.3J mg/kg from 7–13 ft bgs. Manganese was detected above the background concentration (1,450 mg/kg) and FWCUG at a TR of 1E-05, HQ of 1 (2,927 mg/kg) in only one of the two discrete surface soil samples with a concentration of 2,140 mg/kg at PBA08 RI location F16sb-022. All subsurface samples collected at these locations had concentrations of manganese below the SL.

Benzo(a)pyrene and benzo(b)fluoranthene, the only PAHs detected above the SLs were detected below the FWCUG at a TR of 1E-05, HQ of 1 in all surface soil samples at Building F-16. PAHs were not detected in subsurface soil samples. PAHs were identified as potential contaminants from previous site use at Building U-18 which was formerly used as a coal-powered boiler house; however, concentrations in surface soil at this former building location were less than SLs.

Although no previous use of VOCs or pesticides were documented at Building F-16, chloroform was detected at PBA08 RI surface sample location F16ss-026M at a concentration of 0.00068J mg/kg. Pesticides [4,4’-dichlorodiphenyldichloroethylene (DDE) and 4,4’-dichlorodiphenyltrichloroethane (DDT)] were also detected in one of two surface samples in the RI data set at 2004 Characterization of 14 AOCs ISM sample F16ss-005M at a concentration of 0.012J and 0.019J mg/kg, respectively. Historical records indicated three transformers serviced all buildings at the AOC. PCB-1260 was detected in surface soil at F16ss-005M at a concentration of 0.12 mg/kg. No VOCs, PCBs, or pesticides were detected in subsurface soil samples collected at Building F-16. Also, the detected VOC, pesticide, and PCB concentrations in surface soil were all below the FWCUGs at a TR of 1E-05, HQ of 1.

ES.2.2.2 Sediment and Surface Water

Sediment and surface water are not considered media of concern at the Buildings F-15 and F-16 AOC, as surface water is only intermittent at the AOC. However, during the 2004 Characterization of 14 AOCs, two ISM sediment samples (F16sd-001M-SD and F16sd-002M-SD) and two surface water samples (F16sw-001 and F16sw-002) were collected.

Sediment sample F16sd-001M-SD was collected from the former coal storage area immediately south of former Building F-16. Sample FWCss-008-0001-SO was collected by USACE in 2009 in that same area. The more recent sample (FWCss-008-0001-SO) is used in the risk assessment.

The results from the 2004 sample F16sd-001M-SD are summarized below.

- Only explosives and metals analyses were performed.
- No explosives were detected.
- No metal concentrations exceeded the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 1 or TR of 1E-05.

Sediment sample F16sd-002M-SD was collected downstream of the Building F-16 aggregate in the unnamed tributary to Sand Creek. The results of this sample are summarized below.

- Only explosives and metals analyses were performed.
- No explosives were detected.
- Cobalt at a concentration of 11 mg/kg was the only metal that exceeded the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 0.1 (2.3 mg/kg) but not at HQ of 1 (23 mg/kg).

Surface water sample F16sw-002 was collected downstream of the Building F-16 aggregate in the unnamed tributary to Sand Creek. All the concentrations from this sample were below their background concentration or the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 1 or TR of 1E-05.

Surface water sample F16sw-001 was collected from the former coal storage area immediately south of former Building F-16. Effectively, this was a sample from accumulated, ponded water. The metal, semi-volatile organic compound, VOC, PCB, and pesticide concentrations were either non-detectable or had a concentration below the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 1 or TR of 1E-05. Nitroglycerin at 0.0021 mg/L exceeded the tap water regional screening level of 0.0002 mg/L at HQ of 0.1 and 0.002 mg/kg at HQ of 1.

ES.2.3 Summary of Contaminant Fate and Transport

All SRCs identified in the surface and subsurface soil at the AOC were evaluated through the stepwise contaminant fate and transport evaluation. The evaluation included analyzing leaching and migration from soil to groundwater and determining whether contamination present in soil 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 (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 regional screening levels, or RVAAP groundwater FWCUGs for the Resident Receptor Adult.

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

- Naphthalene at the Building F-15 aggregate, and nitroglycerin and selenium at the Building F-16 aggregate were predicted to exceed the screening criteria in groundwater beneath the source area; however, only naphthalene was predicted to be above its groundwater screening criteria at the downgradient receptor location (i.e., unnamed tributary to Sand Creek).

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 at the AOC 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 that may impact the groundwater beneath the source or at the downstream receptor location. No further action is required of soil at Buildings F-15 and F-16 AOC for the protection of groundwater.

ES.2.4 Summary of the 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 (Adult and Child). Since the risk management analysis determined there were no unacceptable risks to the Resident Receptor (Adult and Child), it can be concluded that there is no unacceptable risk to the National Guard Trainee and Industrial Receptor.

Media of concern at the Buildings F-15 and F-16 AOC are surface and subsurface soil. Perennial surface water and corresponding sediment are not present at the AOC. However, off-AOC samples in an unnamed tributary to Sand Creek and an intermittent pond south of Building F-16 are included in the nature and extent of contamination evaluation. Soil data associated with the AOC were aggregated into surface and subsurface soil. In addition, soil data were aggregated into two exposure units (EUs) (Buildings F-15 EU and Building F-16 EU).

No COCs were identified for the Resident Receptor (Adult and Child) in subsurface soil at the Building F-15 EU and surface soil at Building F-16 EU. PAHs in surface soil at the Building F-15 EU and arsenic in the subsurface soil at the Building F-16 EU were identified as COCs for the Resident Receptor (Adult and Child).

Four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] were identified as surface soil COCs for the Resident Receptor (Adult and Child). Benzo(a)pyrene (0.48 mg/kg) is present in one sample (F15ss-036M) above the FWCUG (0.221 mg/kg) and benz(a)anthracene, benzo(b)fluoranthene, and dibenz(a,h)anthracene contribute to an sum-of-ratios greater than one in the same sample. The F15ss-036M ISM area is approximately 0.012 acres and was located within a ditch northwest of the former Building F-15 and immediately adjacent to Slagle Road and an unnamed access road. The ditch where F15ss-036M was collected would have received runoff from the adjacent roads, as well as the asphalt parking lots surrounding the former Building F-15. No PAHs were detected at the PBA08 RI ISM sample F15ss-038M collected in the footprint of former Building F-15 after slab removal was conducted. Due to the low concentrations of PAHs reported in F15ss-036M collected from an area with no identified source of PAHs other than roads and traffic, PAHs were not identified as COCs for potential remediation at the Building F-15 EU.

The arsenic exposure point concentration (23.1 mg/kg) exceeded the FWCUG (4.25 mg/kg) and subsurface background criteria of 19.8 mg/kg in subsurface soil at the Building F-16 EU. Only the maximum detected concentration (MDC) in subsurface soil (24.3 mg/kg in the 4–7 ft bgs interval of soil boring F16sb-021) exceeded the background criteria. Reported concentrations in F16sb-021 above (1–4 ft bgs) and below (7–13 ft bgs) the MDC did not exceed the subsurface background criteria (13.7 and 11.3 mg/kg, respectively). Regional studies indicate arsenic may be naturally occurring in Ohio soils at greater than 20 mg/kg. Arsenic appears to be present at the Building F-16 EU at naturally occurring concentrations and there is no known operational source of arsenic at the Buildings F-15 and F-16 AOC. Based on this evaluation, arsenic was not identified as a COC for potential remediation in subsurface soil.

Based on the risk management analysis, no COCs were identified to be carried forth in an FS for the Resident Receptor (Adult and Child) in any of the media of concern at either the Building F-15 EU or the Building F-16 EU; therefore, no other receptors were evaluated and no further action is recommended from a human health risk perspective.

ES.2.5 Summary of the Ecological Risk Assessment

The Buildings F-15 and F-16 AOC is approximately 5.3 acres and is vegetated with dry, early-successional, herbaceous field; dry, late-successional, cold-deciduous shrubland; Red Maple (*Acer rubrum*) successional forest; mixed, cold-deciduous, successional forest; and a wetland. The Level I ERA presents important ecological resources on or near the AOC and evaluates the potential for current contamination to impact ecological resources. There are 18 integrated soil chemicals of potential ecological concern (COPECs) at the Buildings F-15 and F-16 AOC based on the soil data collected for the historical ERA and for the PBA08 RI. These COPECs consist of inorganic chemicals, explosives, PCBs, pesticides, and semi-volatile organic compounds. Thus, there is contamination present at the AOC.

Ecological resources at the Buildings F-15 and F-16 AOC were compared to the list of important ecological places and resources. Only 1 of the 39 important places (wetlands) was present. Although the wetland is an important resource, this wetland is not a significant resource, as soil sampling results in and around the wetland do not indicate chemicals are present at concentrations of concern for ecological receptors.

The ERA summarizes the chemicals and resources in detail to demonstrate that there is contamination at the Buildings F-15 and F-16 AOC, but no significant ecological resources are present. Consequently, the ERA for the Buildings F-15 and F-16 AOC concludes with a Level I Scoping Level Risk Assessment and a recommendation that no further action is required to be protective of ecological resources.

ES.2.6 Conclusions of the Remedial Investigation

Based on the investigation results, the Buildings F-15 and F-16 AOC has been adequately characterized and the recommended path forward is no further action for soil, sediment, and surface water to attain Unrestricted (Residential) Land Use. Further investigation is not warranted at this AOC for the following reasons: (1) the current nature and extent of impacted media has been sufficiently characterized; (2) the fate and transport modeling did not identify soil CMCOCs requiring further evaluation or remediation to protect groundwater; (3) there are no CERCLA release-related human health COCs identified in soil, sediment, or surface water requiring further evaluation in an FS or additional remediation; and (4) remedial actions to protect ecological resources are not warranted.

The next step in the CERCLA process is to prepare a PP to solicit public input with respect to no further action for soil, sediment, and surface water. The PP will briefly summarize the history, characteristics, risks, and the basis for no further action. Comments on the PP received from state and federal agencies and 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.

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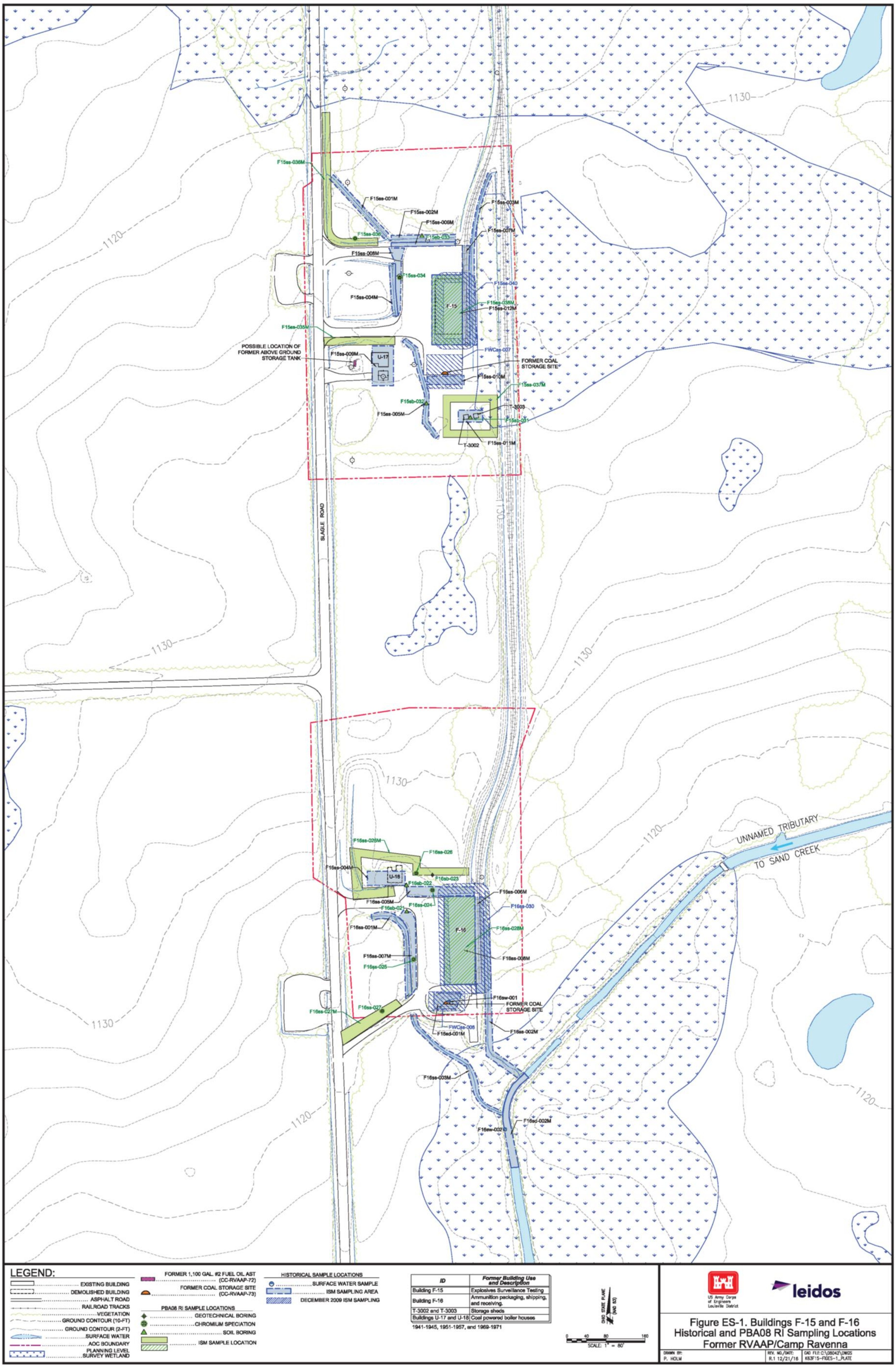

ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

Figure ES–1. Buildings F-15 and F-16 Map Showing Historical and PBA08 RI Sampling Locations - Former RVAAP/Camp Ravenna

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1.0 INTRODUCTION

This document has been revised by Leidos under U.S. Army Corps of Engineers (USACE) Louisville District Contract Number W912QR-15-C-0046. This Remedial Investigation (RI) Report addresses soil, sediment, and surface water at the Buildings F-15 and F-16 area of concern (AOC) 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). The Buildings F-15 and F-16 AOC is designated as RVAAP-46.

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 the National Contingency Plan (NCP) to implement an RI to characterize the AOC, develop a Feasibility Study (FS) (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).

This RI Report includes the following components:

- A description of the operational history and environmental setting for the AOC.
- A summary of all historical assessments and investigations at the Buildings F-15 and F-16 AOC.
- A description of the nature and extent of contamination, including the identification of site-related contaminants (SRCs) by screening applicable data against background concentrations, 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.

1.1 PURPOSE

The purpose of this RI Report is to use RI data to evaluate the nature and extent of contamination, fate and transport of contaminants in the environment, and risk assessments for soil, sediment, and surface water at the Buildings F-15 and F-16 AOC. This report includes sample results and information from the 2004 Characterization of 14 AOCs (MKM 2007), 2009 Under Slab Sampling (USACE 2010c), 2009 USACE ISM Surface Soil Sampling (Prudent 2011), and also summarizes the Performance-based Acquisition 2008 Remedial Investigation (PBA08 RI) performed at the Buildings F-15 and F-16 AOC to supplement data from previous sampling events. Depending on the results of the evaluations contained in this report, 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.

1.2 SCOPE

The scope of this RI Report is to present: (1) the nature and extent of contamination, fate and transport of contaminants in the environment, and risk assessments for surface and subsurface soil at the AOC; (2) the results of the evaluation of remedial alternatives for meeting remedial action objectives for any CERCLA-related COCs identified in these media at the AOC; and (3) a conclusion of no further action or a preferred alternative to present to the public in a PP. Perennial surface water and corresponding sediment are not present at the Buildings F-15 and F-16 AOC. However, off-AOC samples in an unnamed tributary to Sand Creek and an intermittent pond south of Building F-16 are included in the nature and extent of contamination evaluation.

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 are inundated for extended periods. These definitions and terminology usage are 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. 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.

Except for the former coal-powered boiler house (Building U-17) and a small metal platform north of former Building F-15 (ARNG 2016), all buildings and structures at the Buildings F-15 and F-16 AOC have been demolished. Building U-17 is an old abandoned building in disrepair and has had asbestos-containing material (ACM), piping, and equipment removed. Therefore, this building is not considered a continuing source of contamination in this report. No sanitary or storm water sewer system exists within the AOC boundary.

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 Buildings F-15 and F-16 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 the AOC, including the geology, hydrogeology, climate, and population.
- Section 4.0 summarizes previous assessments and investigations at AOC, 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 this RI.
- Section 9.0 summarizes the framework for conducting the necessary agency and public involvement activities.
- Section 10.0 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, and
  Appendix I: PBA08 RI Summary.

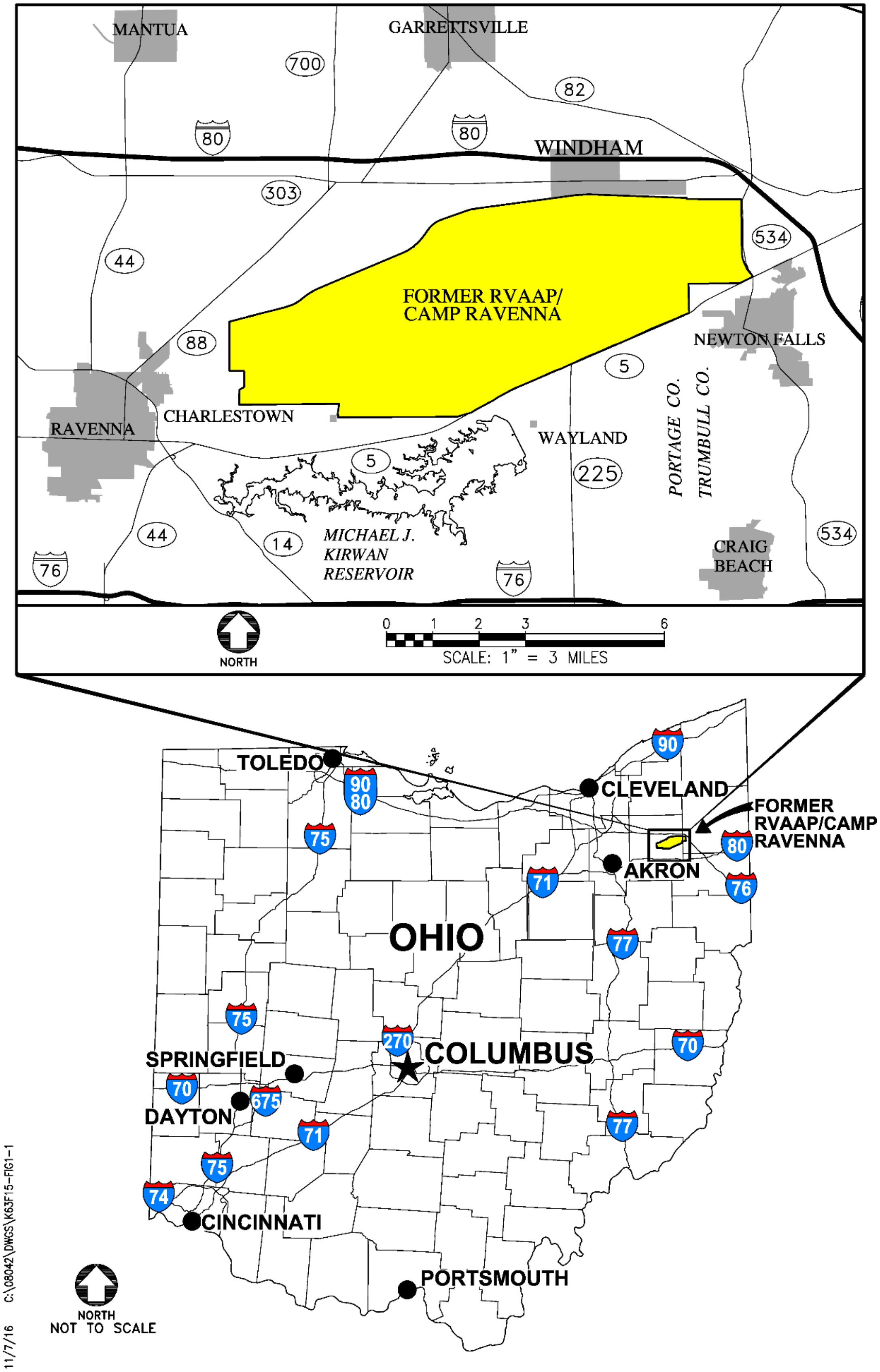
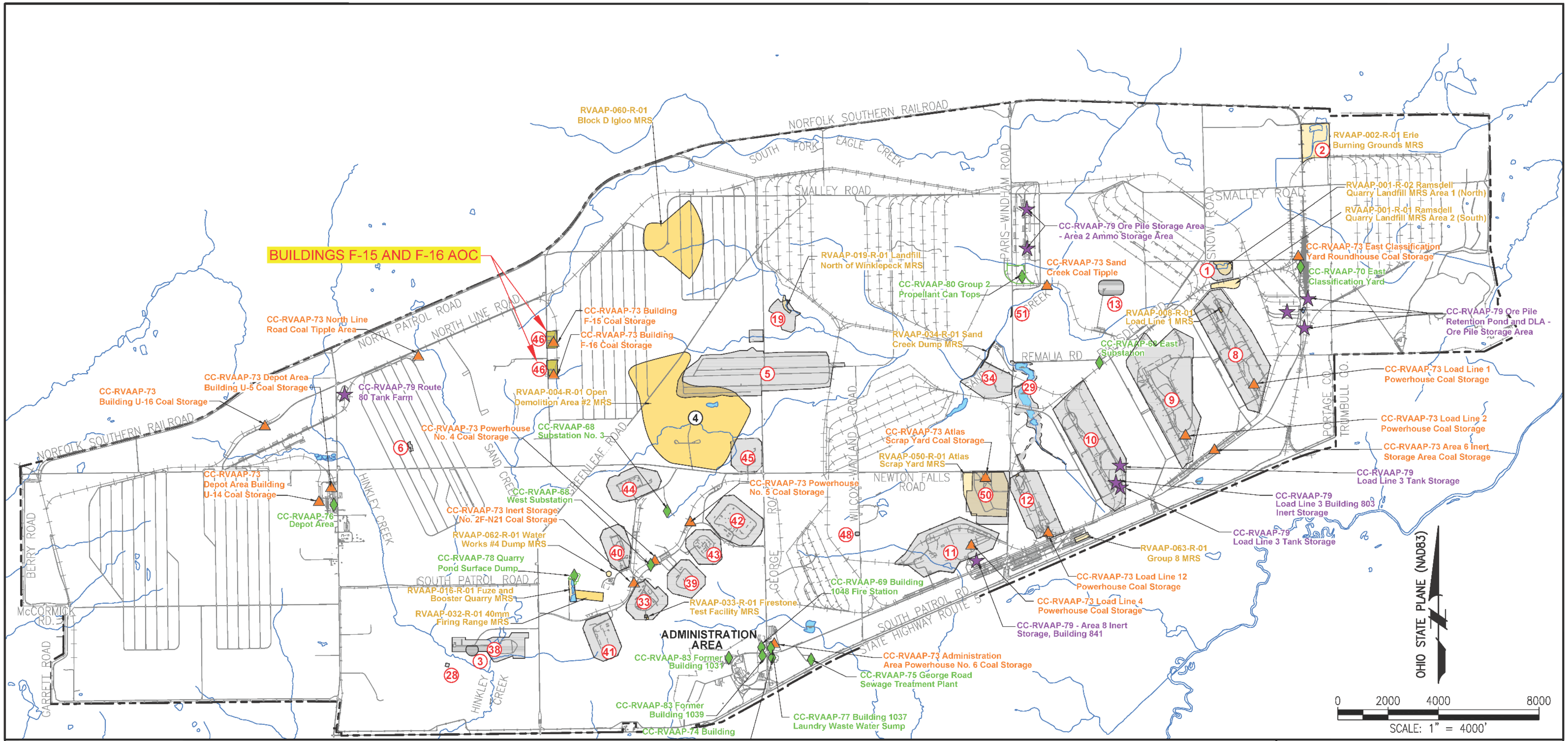


Figure 1–1. General Location and Orientation of Camp Ravenna



IRP SITES - CERCLA

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

COMPLIANCE RESTORATION SITES (13 SITES)

RVAAP-68	ELECTRIC SUBSTATIONS (E,W,NO.3)
RVAAP-69	BUILDING 1048 – FIRE STATION
RVAAP-70	EAST CLASSIFICATION YARD
RVAAP-72	FACILITY–WIDE USTs
RVAAP-73	FACILITY–WIDE COAL STORAGE
RVAAP-74	BUILDING 1034 MOTOR POOL HYDRAULIC LIFT
RVAAP-75	GEORGE ROAD SEWAGE TREATMENT PLANT
RVAAP-76	DEPOT AREA
RVAAP-77	BUILDING 1037 LAUNDRY WASTE WATER SUMP
RVAAP-78	QUARRY POND SURFACE DUMP
RVAAP-79	DLA ORE STORAGE SITES
RVAAP-80	GROUP 2 PROPELLANT CAN TOPS
RVAAP-83	FORMER BUILDINGS 1031 AND 1039

MMRP SITES (14 SITES)

RVAAP-001-R-02	RAMSDELL QUARRY LANDFILL AREA 1 (NORTH)
RVAAP-001-R-01	RAMSDELL QUARRY LANDFILL AREA 2 (SOUTH)
RVAAP-002-R-01	ERIE BURNING GROUNDS MRS
RVAAP-004-R-01	OPEN DEMOLITION AREA #2 MRS
RVAAP-008-R-01	LOAD LINE 1 MRS
RVAAP-016-R-01	FUZE AND BOOSTER QUARRY MRS
RVAAP-019-R-01	LANDFILL NORTH OF WINKLEPECK MRS
RVAAP-032-R-01	40MM FIRING RANGE MRS
RVAAP-033-R-01	FIRESTONE TEST FACILITY MRS
RVAAP-034-R-01	SAND CREEK DUMP MRS
RVAAP-050-R-01	ATLAS SCRAP YARD MRS
RVAAP-060-R-01	BLOCK D IGLOO MRS
RVAAP-061-R-01	BLOCK D IGLOO – TD MRS
RVAAP-062-R-01	WATER WORKS #4 DUMP MRS
RVAAP-063-R-01	GROUP 8 MRS

OTHER REGULATORY - RCRA

④RVAAP–04	OPEN DEMOLITION AREA #2

LEGEND:

◆	COMPLIANCE RESTORATION SITES – APPROVED
★	DLA ORE STORAGE AREAS (7 SITES)
▲	COAL STORAGE AREAS (17 SITES)
▭	AOC SITES
🟨	MMRP SITES
┼┼┼┼┼┼┼┼	RAILROAD TRACKS
—·—·—	FENCELINE
～	STREAM OR CREEK

US Army Corps of Engineers Louisville District

leidos

FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE: C:\08042\DWGS
P. HOLM	REV.2/ 11/7/16	K63F15–FIG1–2

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

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2.0 BACKGROUND

This section provides a description of the facility. In addition, it provides a summary of the Buildings F-15 and F-16 AOC 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 conducted an Installation Assessment of RVAAP to review the potential for contaminant release at multiple former operations areas, as documented in Installation Assessment of Ravenna Army Ammunition Plant (USATHAMA 1978). The Installation Assessment indicated explosives and propellants were identified as the potential contaminants from proof and surveillance testing at the Buildings F-15 and F-16 AOC.

The former RVAAP received bulk 2,4,6-trinitrotoluene (TNT) product during operational activities but 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 U.S. Department of the Army's (Army) 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 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 BUILDINGS F-15 AND F-16 AOC BACKGROUND INFORMATION

2.2.1 Operational History

The Buildings F-15 and F-16 AOC is located west of Block D and east of Slagle Road in the northwest part of RVAAP (Figure 1-2 and Figure 2-1). Buildings F-15 and F-16 were used for surveillance testing on explosives and propellants and testing disassembly processes during World War II, the Korean War, and the Vietnam War (between 1941 and 1974). The number of tests conducted on miscellaneous explosives and propellants, the quantities of material tested, and the exact dates of testing are unknown. No additional information exists to indicate the AOC was used for any other processes.

The northernmost Building F-15 was separated from Building F-16 by approximately 1,000 ft. The AOC, which is the combined operational areas for both Buildings F-15 and F-16, is approximately 12.3 acres (6.6 and 5.7 acres, respectively). The defined AOC area does not include the forested area between the two buildings

The AOC is relatively flat with drainage ditches beside access roads and at the western boundary of the AOC along Slagle Road. The Building F-15 area is currently a gravel- and grass-covered clearing with dense vegetation growing on the edges of the site (ARNG 2016). Gravel-lined roads lead to the site off of Slagle Road. Building F-16 is densely vegetated with trees and grass, with a gravel- and grass-covered clearing located in the southeastern portion of the site. Gravel roads lead to the clearing off of Slagle Road. Railroad tracks oriented in a north-south direction are located in the eastern portion of the AOC. No fences exist around the perimeter boundary of the AOC operational areas.

Two former coal piles were located south of Buildings F-15 and F-16, respectively. These former coal piles are addressed as a separate AOC (designated as CC-RVAAP-73); however, they are further discussed in Section 2.4.4.2.

As discussed in Section 2.2.3, all buildings and structures at the Buildings F-15 and F-16 AOC have been demolished, except for one former coal-powered boiler house (Building U-17). During a visual survey conducted by the Army National Guard in April 2016, ceramic insulators and metal debris were observed south of the old abandoned Building U-17 in a fenced area that is mostly likely the location of former electrical equipment (ARNG 2016). An old metal platform (in place) and wooden debris are located north of former Building F-15. Several debris piles, including corrugated metal, concrete, brick, asphalt, and wood were seen throughout the AOC (Section 2.2.3).

2.2.2 Potential Sources

Historical facilities at the Buildings F-15 and F-16 AOC included two operational buildings (Buildings F-15 and F-16) and four support buildings ranging in size from 316–11,843 ft^2. Support buildings included two coal-powered boiler houses (Building U-17 and former Building U-18) and two storage sheds (former Buildings T-3002 and T-3003). The locations of these buildings are shown on Figure 2-1 and in the aerial photograph shown in Figure 2-2.

Table 2-1 summarizes potential sources of contamination at the Buildings F-15 and F-16 AOC. This table 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 products 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 site-specific contaminants include mercury fulminate; tetryl; octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX); nitroglycerine; nitrocellulose; nitroguanidine; and heavy metals (lead, chromium, mercury, and arsenic) from testing munitions. Site-specific contaminants also include polycyclic aromatic hydrocarbons (PAHs) from coal storage and their use in the two boiler houses (Buildings U-17 and U-18) and polychlorinated biphenyls (PCBs) from the on-site transformers at Building F-15. The evaluation of historical chemical contamination is not limited to these chemicals; rather, this evaluation is expanded to include all eligible chemical data that is available.

In summary, the following chemicals were targeted to investigate these potential SRCs:

- Inorganic chemicals – arsenic, chromium, lead, and mercury.
- Explosives and propellants – lead azide, mercury fulminate, tetryl, TNT, RDX, HMX, nitroglycerine, nitrocellulose, and nitroguanidine.
- Other – PAHs and PCBs.

Many other chemicals were analyzed in the site investigations and are discussed in this report.

2.2.3 Building Decontamination and Demolition

Limited documentation exists regarding the demolition of Buildings F-16, U-18, T-3002, and T-3003. Building F-15 was demolished in 2005, as documented in the *Thermal Decomposition and Demolition of Load Line 11 and Buildings F15, 1200, S-4605 and T-4602* (MKM 2005). The following summarizes the demolition activities at Building F-15.

- A building hazard analysis and engineering survey was performed.
- Paint was sampled for PCB concentrations, which were determined to be less than 50 parts per million.
- The building was swept and loose paint chips or other potentially contaminated debris were containerized and removed.
- Building F-15 was assessed and it was determined that no transite roofing material was present.
- Unexploded ordnance (UXO) personnel visually inspected the building and determined no bulk or visible explosives accumulated in the building; therefore, building decontamination prior to demolition was not required.
- Walls, structural steel, and building material were demolished. All painted brick and structural steel was loaded for off-site disposal as PCB Bulk Product Waste to an approved facility. Due to the presence of transite ceiling tiles, remaining building materials were disposed offsite as ACM. Building F-15 was deemed structurally unsound by the structural engineer during the hazard analysis building inspection. Consequently, the transite material was not possible to remove prior to building demolition. Building materials were adequately wetted throughout demolition operations to ensure potential dust emissions were controlled.
- Floor slab and footer removal were not included in the scope for Building F-15.
- One concrete sump (no lead or asbestos liner present) was present at Building F-15; however, removal was not included in the scope of work.
- Upon completing the demolition activities, all areas were re-graded to ensure positive drainage and seeded and mulched.

After Buildings F-15, F-16, U-18, T-3002, and T-3003 were demolished, USACE completed the *Sampling and Analysis of Soils Below Floor Slabs at RVAAP-08 Load Line 1 and Other Building Locations* (URS 2010) in November 2009 (Section 4.2.2). Remnant infrastructure within the Buildings F-15 and F-16 AOC consists of the old abandoned Building U-17 (boiler house), which is in disrepair.

In addition, historical documentation indicates that ACM removal from Building U-17 was completed in February 1998. Historical documentation also indicates that there was an ACM survey performed at T-3002 and T-3003 in August 1991; no suspect ACM was observed.

2.2.4 AOC Boundary

The Buildings F-15 and F-16 AOC is approximately 12.3 acres (6.6 and 5.7 acres, respectively), as presented in Figure 2-1. The AOC is comprised of the two separate locations of the former Buildings F-15 and F-16 areas and not the forested land between them. The northernmost former Building F-15 was approximately 1,000 ft north of Building F-16. Railroad tracks oriented in a north-south direction are located in the eastern portion of the AOC. No fences exist around the perimeter boundary of the AOC operational areas.

Two former coal piles were located south of Buildings F-15 and F-16. These former coal piles are addressed as a separate AOC (designated as CC-RVAAP-73) (Section 2.4.4.2).

2.3 POTENTIAL RECEPTORS AT BUILDINGS F-15 AND F-16

The following sections discuss potential human and ecological receptors at the Buildings F-15 and F-16 AOC.

2.3.1 Human Receptors

Camp Ravenna is a controlled-access facility. The Buildings F-15 and F-16 AOC is in the northwestern part 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 the following 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.

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.

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.

With the exception of the access roads and parking area, the AOC is vegetated with grasses in the central portion and mature forest around the perimeter. An unnamed tributary to Sand Creek is located outside (southeast) of the former Building F-16 operational area. A small portion (0.06 acres) of a wetland (0.69 acre in total size) is within the AOC, along the eastern edge of the former Building F-15 operational area. There are other wetlands near the AOC, including a small wetland (0.5 acres) located south of former Building F-15, a larger wetland (7.6+ acres) located east of former Building F-15, and a wetland (over 9.5 acres) located south of former Building F-16.

Additional information specific to ecological resources at Buildings F-15 and F-16 AOC 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 the Buildings F-15 and F-16 AOC but are addressed separately.

2.4.1 Facility-wide Sewers

There are no sanitary or storm water sewers within the perimeter of the Buildings F-15 and F-16 AOC.

2.4.2 Facility-wide Groundwater

As part of the Installation Restoration Program, 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.

No monitoring wells are present at the AOC. The nearest downgradient facility-wide monitoring well is BKGmw-019, located approximately 2,500 ft to the south on Road 10-X-7 (Figure 3-4). Well gauging data collected at this well during the January 2010 facility-wide sampling event indicated a water level of 1,102.89 ft above mean sea level (amsl) (EQM 2010). In 2006–2007 and October 2009, groundwater samples from BKGmw-019 were collected under the FWGWMP. All chemical concentrations in groundwater were below the maximum contaminant level (MCL) or regional screening level (RSL) [target risk (TR) of 1E-05, hazard quotient (HQ) of 1].

The facility-wide groundwater AOC is currently at the RI phase of the CERCLA process. Any future decisions or actions respective to groundwater at the Buildings F-15 and F-16 AOC will be addressed as part of that AOC.

2.4.3 Munitions Response Sites

There was one historical munitions response site (MRS), RVAAP-046-R-01 Building #F-15 and F-16 MRS, documented within the AOC. This MRS attained site closeout in May 2005 as a result of a no further action recommendation made in a 2008 Site Inspection (SI) Report developed under the Military

Munitions Response Program (e2M 2008). The SI included a meandering path magnetometer survey that did not find any munitions or explosives of concern or munitions debris. Subsurface anomalies were recorded around the buildings and along the railroad tracks, but these anomalies were determined to be non-munitions related. These anomalies were attributed to demolition/underground utilities and remnants of the railroad tracks.

2.4.4 Compliance Restoration Sites

Two former coal storage locations were identified and assessed within the Buildings F-15 and F-16 AOC as part of the Facility-wide Coal Storage compliance restoration site. In addition, an interview triggered the assessment of a potential underground storage tank (UST) at the AOC. The following subsections summarize the applicable investigations.

2.4.4.1 Facility-wide USTs

Per the *Historical Records Review for the 2010 Phase I Remedial Investigation Services at Compliance Restoration Sites (9 Areas of Concern)* (SAIC 2011) under the Compliance Restoration Program, one interviewee noted the presence of one underground vault with a 3,000–5,000-gal diesel tank for a fire suppression system (including diesel-powered fire pump) near Building F-15 during a historical records review (SAIC 2011). The historical records review produced documentation of a 1,100-gal aboveground storage tank (AST) previously undocumented in the RVAAP tank inventory at Building U-17, the boiler house adjacent to the former Building F-15. The former AST contained #2 fuel oil.

No documentation or reference to the presence of a UST, its location, or its removal was located as part of this historical records review. The *Historical Records Review for the 2010 Phase I Remedial Investigation Services at Compliance Restoration Sites (9 Areas of Concern)* (SAIC 2011) concluded there was no UST located within the Buildings F-15 and F-16 AOC.

2.4.4.2 Facility-wide Coal Storage

The Facility-wide Coal Storage AOC (CC-RVAAP-73) consists of 17 former documented coal storage locations located throughout the former RVAAP (Figure 1-2). Historical facility operations included using coal to fuel power houses, boiler houses, and for heating other buildings at the former RVAAP. Point-of-use coal storage locations included covered bins and uncovered storage piles on the ground surface. The Building F-15 coal storage pile (approximately 0.11 acre) was located immediately south of Building F-15, and the Building F-16 coal storage pile (approximately 0.06 acre) was located immediately south of Building F-16. Primary use of coal was boiler supply/steam generation at Buildings U-17 and U-18 (SAIC 2011).

Surface soil incremental sampling methodology (ISM) samples (FWCss-007 and FWCss-008) were collected from these former coal storage areas during the 2009 USACE ISM Surface Soil Sampling (Section 4.2.3, Figure 4-3). This investigation was conducted as prescribed in a Technical Memorandum dated November 20, 2009.

Samples collected from the coal storage areas were analyzed for target analyte list (TAL) metals and semi-volatile organic compounds (SVOCs). The results of this surface soil ISM sampling were included in the land use control assessment to characterize soil adjacent to the former coal and ore storage areas, including at Buildings F-15 and F-16. No metals or SVOCs exceeded their respective cleanup goal (CUG) (Prudent 2011).

The coal storage areas at the Buildings F-15 and F-16 AOC were also evaluated in the *Historical Records Review for the 2010 Phase I Remedial Investigation Services at Compliance Restoration Sites (9 Areas of Concern)* (SAIC 2011); however, no visual evidence of coal storage was observed at Buildings F-15 and F-16. This is largely due to extensive previous demolition and restoration. Soil at the AOC is being addressed in this RI Report; consequently, no further action was recommended for these coal storage locations.

2.5 POTENTIAL SITE-RELATED RELEASES

Table 2-1 presents potential contaminants that may be present in the Buildings F-15 and F-16 AOC media from previous use of the site. As presented in Table 2-2, there have been no documented site-related releases at the Buildings F-15 and F-16 AOC.

1

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 F-15	1941–1945, 1951–1957, and 1969–1971: Former Building F-15 was used as the inspector's workshop where surveillance testing occurred.	None	Metals, Explosives
Building F-16	1941–1945, 1951–1957, and 1969–1971: Former Building F-16 was used for ammunition packaging, shipping, and receiving.	None	Metals, Explosives
Buildings T-3002 and T-3003	1941–1945, 1951–1957, and 1969-–1971: Former Buildings T-3002 and T-3003 were storage sheds located south of former Building F-15.	None	Metals, Explosives
Buildings U-17 and U-18	1941–1945, 1951–1957, and 1969–1971: Building U-17 and former Building U-18 were coal-powered boiler houses for former Buildings F-15 and F-16. Building U-17 is only remaining feature at the AOC. Each building had an associated coal storage pile which were evaluated under the Facility-wide Coal Storage AOC (CC-RVAAP-73) (see Section 2.4.4). A 1,100-gal #2 fuel oil AST was previously located near Building U-17 and evaluated under the Facility-wide USTs AOC (CC-RVAAP-72) (see Section 2.4.4).	None	Metals, PAHs
Coal Storage Piles	Building F-15 Coal Storage (approximately 0.11 acre) and Building F-16 Coal Storage (approximately 0.06 acre) are within the AOC footprint. The coal storage piles were used at the boiler houses (Buildings U-17 and U-18). No visual evidence of coal storage was observed at Buildings F-15 and F-16 during 2011 HRR (SAIC 2011) (See Section 2.4.4.2).	None	Metals, PAHs
Transformers	Historical PCB Disposition Records indicated three transformers located at the Buildings F-15 and F-16 AOC serviced Building F-15. The transformers were tested for PCBs; one had a PCB concentration of 38 ppm and two were non-detect for PCBs (<2ppm). The transformers were removed on June 15, 1993, and stored at Building 854 (RVAAP-27, PCB Storage) awaiting final disposition by the Defense Reutilization Material Office.	None	PCBs

1

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
	Two adjacent debris piles consisting of metal, brick, and concrete were observed near the Building F-16 Coal Storage area. The two debris piles are collectively approximately 12 ft wide, 24 ft long, and 2 ft high.		

Target metals = Lead, chromium, mercury, and arsenic.
Target explosives = Black powder; 2,4,6-trinitrotoluene; octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocane; and hexahydro-1,3,5-trinitro-1,3,5-triazine.
AOC = Area of concern.
AST = Aboveground storage tank.
gal = Gallon.
HRR = Historical records review.
PAH = Polycyclic aromatic hydrocarbon.
PCB = Polychlorinated biphenyl.
ppm = Parts per million.
UST = Underground storage tank.
< = Less than.

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. Northern long-eared bat, *Myotis septentrionalis* 7. Hobblebush, *Viburnum alnifolium* 8. Simple willow-herb, *Epilobium strictum* 9. Lurking leskea, *Plagiothecium latebricola* 10. 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. Pygmy shrew, *Sorex hovi* 7. Southern bog lemming, *Svnaptomys cooperi* 8. Star-nosed mole, *Condylura cristata* 9. Tri-colored bat, *Perimyotis subflavus* 10. Woodland jumping mouse, *Napaeozapus insignis* 11. Sharp-shinned hawk, *Accipiter striatus* 12. Marsh wren, *Cistothorus palustris* 13. Henslow's sparrow, *Ammodramus henslowii* 14. Cerulean warbler, *Dendroica cerulean* 15. Prothonotary warbler, *Protonotaria citrea* 16. Bobolink, *Dolichonyx oryzivorus*	17. Northern bobwhite, *Colinus virginianus* 18. Common moorhen, *Gallinula chloropus* 19. Great egret, *Ardea alba* (migrant) 20. Sora, *Porzana carolina* 21. Virginia Rail, *Rallus limicola* 22. Yellow-bellied Sapsucker, *Sphyrapicus varius* 23. Creek heelsplitter, *Lasmigona compressa* 24. Eastern box turtle, *Terrapene carolina* 25. Four-toed Salamander, *Hemidacrylium scutatum* 26. Eastern garter snake, *Thamnophis sirtalis* 27. Smooth green snake, *Opheodrys vernalis* 28. Eastern sand darter, *Ammocrypta pellucida* 29. Mayfly, *Stenonema ithica* 30. Moth, *Apamea mixta* 31. Moth, *Brachylomia algens* 32. Scurfy quaker, *Homorthodes furfurata* 33. Sedge wren, *Cistothorus platensis*

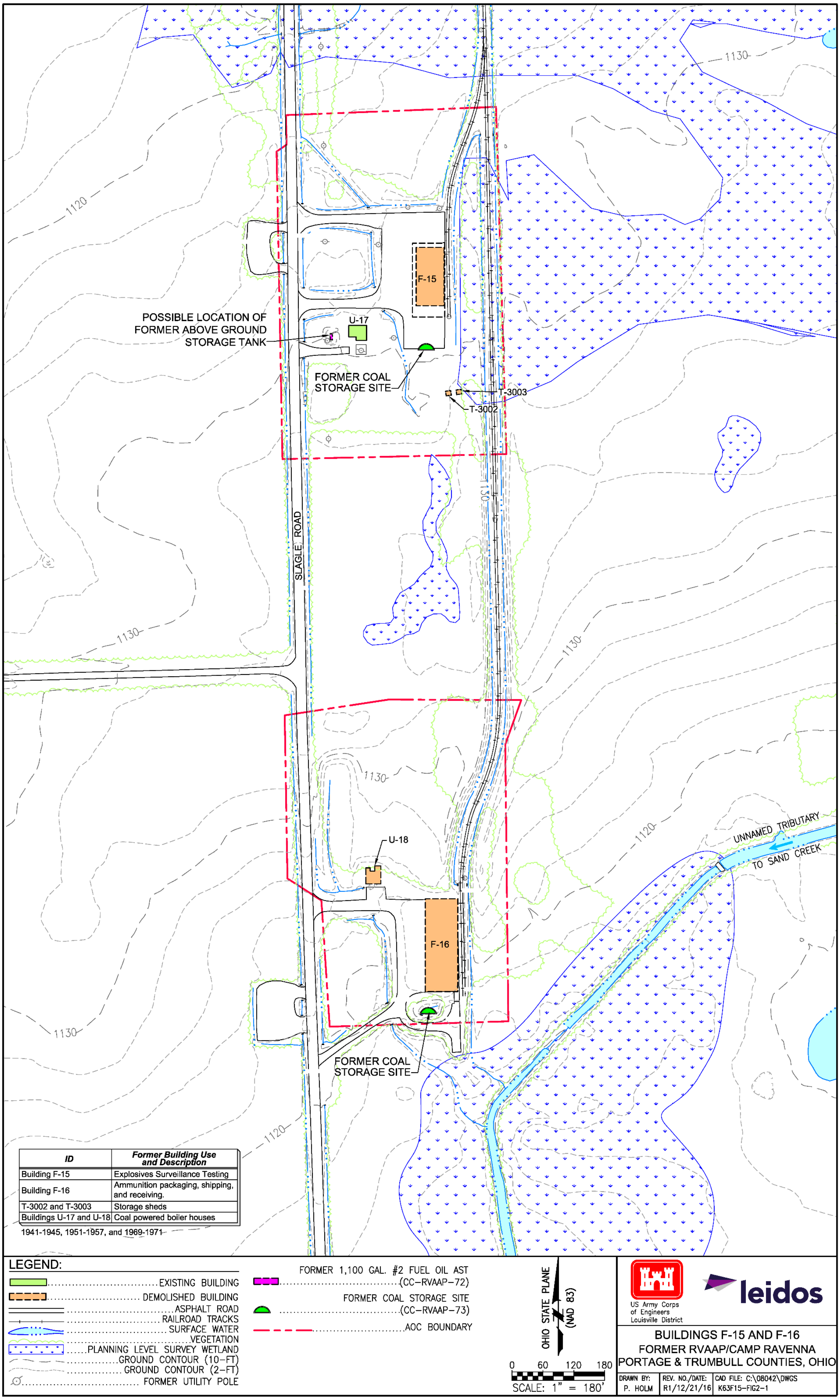
Table 2–2. Federal- and State-listed Species List (continued)

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*

Note: The Integrated Natural Resources Management Plan (OHARNG 2014) indicated that no federally listed species are known to reside at Camp Ravenna, and no critical habitat occurs. However, the northern long-eared bat exists at Camp Ravenna and was expected to be listed as an endangered species in mid-2015. Accordingly, this table indicates the northern long-eared bat is federally threatened (USFWS 2016) and state threatened (ODNR 2016).



ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

Figure 2–1. Buildings F-15 and F-16 AOC Site Features

ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

LEGEND:

AOC BOUNDARY

NOTE:

SOURCE OF AERIAL PHOTO: USGS
(1952-03-30 – 1952-04-27)

BUILDINGS F-15 AND F-16
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE: C:\08042\DWGS
P. HOLM	R1/12/19/16	K63F15–FIG2-2

Figure 2–2. Buildings F-15 and F-16 AOC Prior to Building Demolition (Aerial Photo dated 1952)

3.0 ENVIRONMENTAL SETTING

This section describes the physical features, topography, geology, hydrogeology, and environmental characteristics of Camp Ravenna and the Buildings F-15 and F-16 AOC that are factors in identifying the potential contaminant transport pathways, receptor populations, and exposure scenarios to evaluate human health and ecological risks.

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-age and Pennsylvanian-age bedrock units that are horizontal or gently dipping. The province is also 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 amsl) in the far western portion of the facility to low areas at approximately 930 ft amsl in the far eastern portion. USACE mapped the facility topography in February 1998 using a 2-ft (60.1-cm) contour interval with an accuracy of 0.02 ft (0.61 cm). 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.

The Buildings F-15 and F-16 AOC is located west of Block D and east of Slagle Rd in the northwest part of RVAAP (Figure 1-2). An unnamed tributary to Sand Creek is southeast of the AOC. The areas surrounding the AOC are lightly forested except for the clearing that defines the AOC operational area. No fences exist around the perimeter boundary of the AOC operational areas.

All buildings within the Buildings F-15 and F-16 AOC, except a former coal-powered boiler house (Building U-17) and a small metal platform north of former Building F-15, have been demolished. Building slabs and footers have been removed. The remaining surface features at the Buildings F-15 and F-16 AOC consist of the access roads within the AOC, several debris piles (Section 2.2.3), the abandoned Building U-17, and a fenced area south of Building U-17, which was most likely a former electrical equipment area (ARNG 2016) (Figures 2-1 and 3-1).

Soil near former production buildings was extensively disturbed during building demolition activities. The work areas were re-graded, cavities were filled with existing mound dirt as needed, and the area was vegetated following the building decontamination and demolition activities discussed in Section

2.2.3. Small drainage ditches border some portions of the access roads, and drainage conveyances are located throughout the AOC boundary.

Topographic relief at the AOC is low. A local topographic high is between former Buildings F-15 and F-16 and slopes downward to the northwest and southeast. The topography within the AOC ranges from approximately 1,120 ft amsl near the southern and northern boundaries of the AOC to 1,130 ft amsl in the center of the AOC (Figure 3-1). Surface water follows topographic relief and drains into ditches that exit the AOC. Surface runoff from the Building F-15 operational area flows overland to the northwest to a tributary to Eagle Creek. Surface runoff from the Building F-16 operational area flows overland to the southeast to a tributary to Sand Creek.

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 the Buildings F-15 and F-16 AOC are presented in the following subsections.

3.3.2 Soil and Glacial Deposits

Bedrock at Camp Ravenna is overlain by deposits of the Wisconsin-aged 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 Load Line 1 and the Erie Burning Grounds (USACE 2001a). Where this glacial material is still present, the distribution and character indicate their 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 also has 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 west portion of Camp Ravenna is between 5–11.5 ft per mile to the south.

3.3.3 Geologic Setting of the Buildings F-15 and F-16 AOC

Bedrock (shale) was encountered at the AOC from 30–37 ft bgs during groundwater well installation activities at Buildings U-17 and U-18 in the 1940s. Bedrock was not encountered during PBA08 RI activities where subsurface borings were drilled to a maximum depth of 13 ft bgs. The bedrock formation encountered during groundwater well installation at the AOC is the Pennsylvanian-age Pottsville Formation, Sharon Member Shale (Figure 3-3). The Sharon Shale Member is a gray to black sandy shale that contains thin coal, underclay, sandstone, and siderite zones. The Sharon Shale is generally fissile. Plant fragments are also frequently observed within the Sharon Shale Member (Winslow et al. 1966).

Two soil types are found at the AOC: Mahoning silt loams (0–2% and 2–6% slopes), which is present over 90% of the AOC, with the remaining 10% being the Trumbull silt loam (TrA). Mahoning silt loam is a gently sloping, poorly drained soil formed in silty clay loam or clay loam glacial till, generally where bedrock is greater than 6 ft bgs. The Mahoning silt loam has low permeability, with rapid runoff and seasonal wetness. The Mahoning silt loam (MgA) (0-2% slopes) is present at the former Building F-15 operational area to the northern boundary of the Building F-16 operational area, while the Mahoning silt loam (MgB) (2–6% slopes) is exclusively located at the F-16 operational area. Trumbull silt loam (0–2% slopes) is located on the eastern side of the Building F-15 operational area. Trumbull silt loam is gently sloping, very poorly drained soil formed in silty clay loam glacial till, generally where bedrock is greater than 6 ft bgs. Trumbull silt loam is generally found in topographic lows (USDA 2010).

As observed in PBA08 RI soil borings, the composition of unconsolidated deposits at the AOC generally consist of yellowish-brown and gray, medium dense, silty clay tills with trace gravel. Brown, medium dense, fine-grained sand was observed in some soil borings from 9–13 ft bgs. Groundwater was encountered from 4.8 ft bgs in soil borings placed in ditches to approximately 10.8 ft bgs in soil borings at the Building F-16 operational area. Groundwater was not encountered in any subsurface soil borings at the Building F-15 operational area. PBA08 RI boring logs, which contain geologic descriptions of unconsolidated deposits at the AOC, are presented in Appendix A.

Two undisturbed geotechnical samples were collected from the Building F-16 operational area during the PBA08 RI. No previous geotechnical samples have been collected at the AOC. Geotechnical results show a narrow range of variation in porosity, density, and moisture content. The geotechnical samples collected from 4–5 ft bgs and from 8–8.8 ft bgs were characterized as clayey silt with some sand with 5.3–6.4% gravel, 20.1–28.4% sand, 44.1–45.8% silt, and 21.2–28.9% clay. A summary of the PBA08 RI geotechnical analysis, including porosity and permeability, is presented in Section 5.4 and Table 5-2.

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 comes from surface water infiltrating 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 (46 m) 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 that hydraulic communication between the two aquifers is occurring.

3.4.2 Buildings F-15 and F-16 AOC Hydrologic/Hydrogeologic Setting

Groundwater at the former RVAAP is evaluated on a facility-wide basis, sampled under the FWGWMP, and will be evaluated through the CERCLA process in a separate report. Potential leaching of soil contaminants to groundwater is evaluated through fate and transport modeling.

No monitoring wells are present at the AOC. During the PBA08 RI, the nearest downgradient facility-wide monitoring well was BKGmw-019, located approximately 2,500 ft to the south on Road 10-X-7 (Figure 3-4). Well gauging data collected at this well during the January 2010 facility-wide sampling event indicated a water level of 1,102.89 ft amsl (EQM 2010). Monitoring well BKGmw-019 is completed in the unconsolidated zone to a depth of 33.18 ft bgs (1,075.06 ft amsl). The generalized regional groundwater flow direction near the AOC is towards the southeast, based upon the results of facility-wide groundwater monitoring.

Two 6-inch groundwater wells were installed in the 1940s at Buildings U-17 and U-18 (identified as RVAAP wells #84 and #83, respectively). These wells have been abandoned. The water level at well #84 at Building U-17 was recorded at 1,113.75 ft amsl (13.25 ft bgs).The water level at well #83 at Building U-18 was recorded at 1,110.57 ft amsl (12.7 ft bgs).

Potentiometric surface of the AOC 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). The general groundwater flow direction across most of the AOC is to the southeast based on the RVAAP facility-wide potentiometric surface map (EQM 2010). The hydraulic gradient from the facility-wide potentiometric surface is 0.00743 (Figure 3-1).

3.4.3 Surface Water

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

3.4.3.1 <u>Regional Surface Water</u>

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 Eagle Creek,
- Sand Creek, and
- Hinkley Creek.

These watercourses have many associated tributaries. Sand Creek, with a drainage area of 13.9 square miles, generally flows in a northeast direction to its confluence with South Fork Eagle Creek. In turn, South Fork Eagle Creek continues in a northerly direction for 2.7 miles to its confluence with Eagle Creek. The drainage area of South Fork 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 RVAAP 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 30 ponds are scattered throughout the facility. Many were constructed within natural drainageways 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 could 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 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 Buildings F-15 and F-16 AOC Surface Water

Surface water at the Buildings F-15 and F-16 AOC occurs intermittently as storm water runoff within constructed drainage ditches or conveyances throughout the AOC (Figure 3-1). Sediment within these drainage ditches is considered dry sediment and is addressed along with surface soil as potential secondary source of contaminants. Surface water flow is the primary migration pathway for contamination to leave the AOC, flowing through ditches or surface water drainage features that exit the AOC. Surface runoff from the Building F-15 operational area flows overland to the northwest to a tributary to Eagle Creek. Some of the surface drainage at the Building F-16 operational area flows southeast toward an unnamed tributary to Sand Creek. During the PBA08 RI, surface water was not observed at the AOC.

Significant aquatic and wetland resources exist on and near the AOC. A wetlands delineation conducted in 2006 identified four wetlands of varying sizes and quality (from Category 1 to Category 3) on or near the AOC (EnviroScience 2006). A small portion (0.06 acres) of a Category 1 wetland (0.69 acre in total size) is within the AOC, along the eastern edge of the Building F-15 operational area. The wetland is associated with two wet weather ditches in a low area between the old railroad beds for the Buildings F-15 and F-16 railroad spurs. There are other wetlands near the AOC, including a small wetland (0.5 acres) is located south of former Building F-15, a larger wetland (7.6+ acres) is located east of former Building F-15, and a wetland (9.5+ acres) located south of former Building F-16.

3.5 CLIMATE

The general climate of Camp Ravenna 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 Camp Ravenna 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 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 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.

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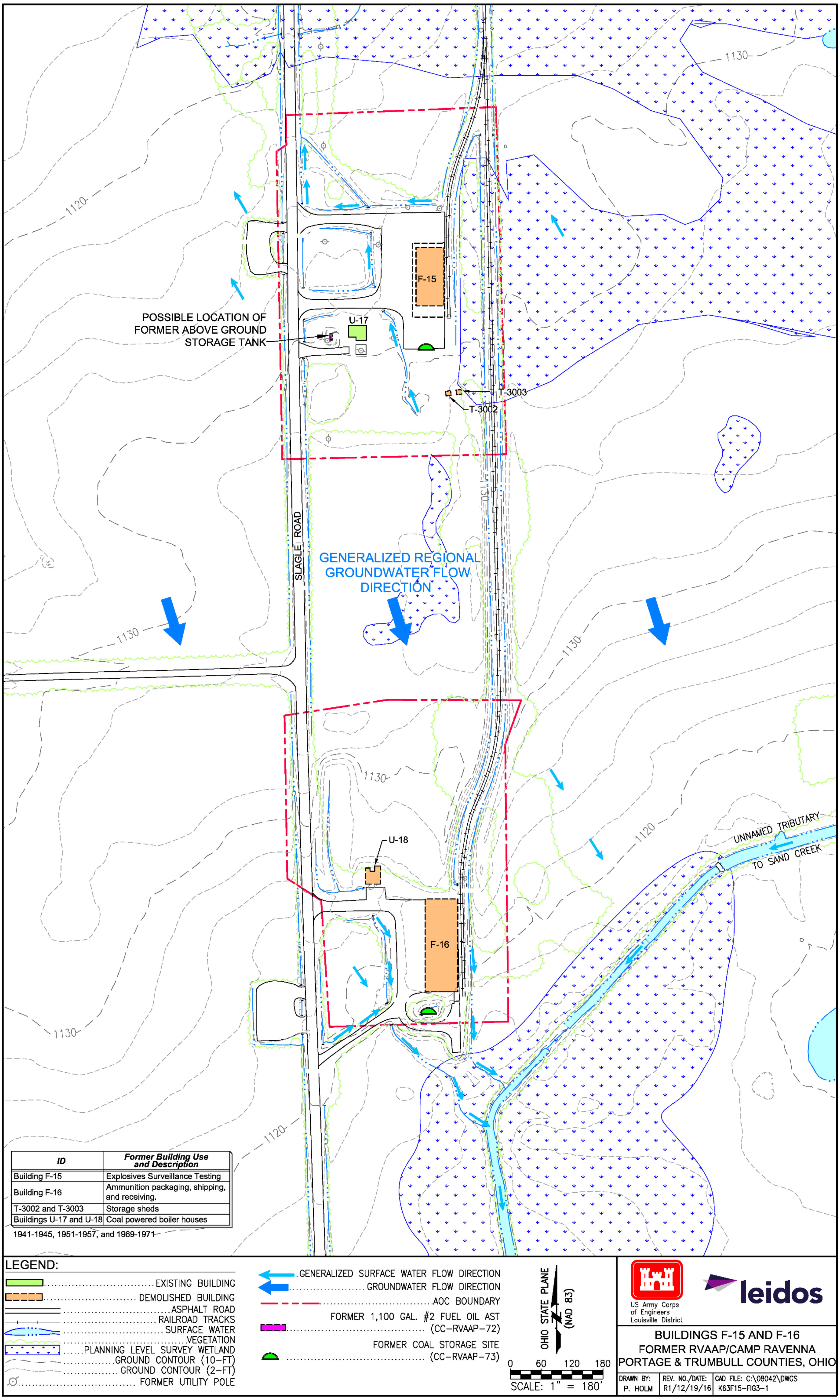

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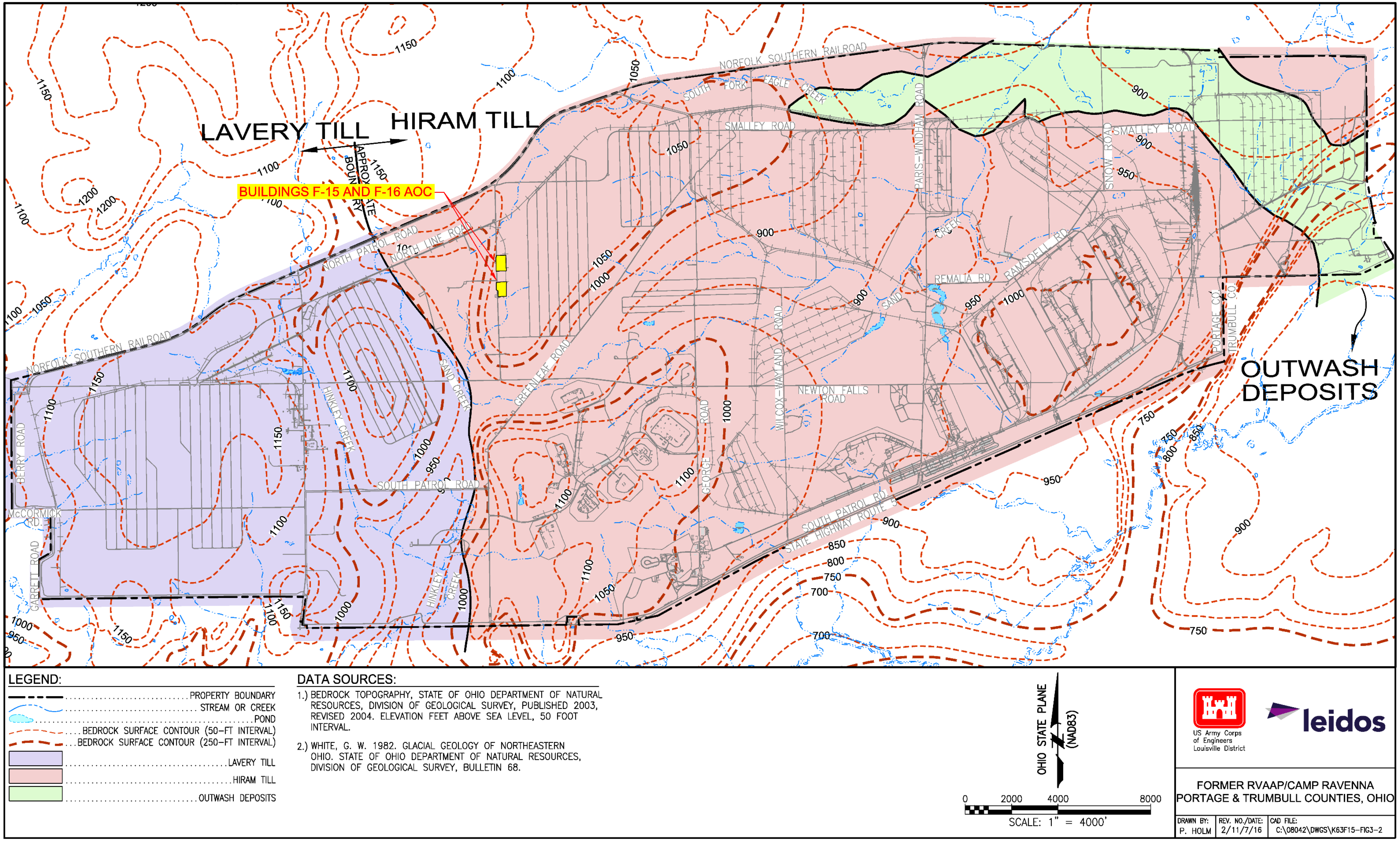
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

Figure 3–1. Topography, Groundwater Flow, and Surface Water Flow at Buildings F-15 and F-16 AOC

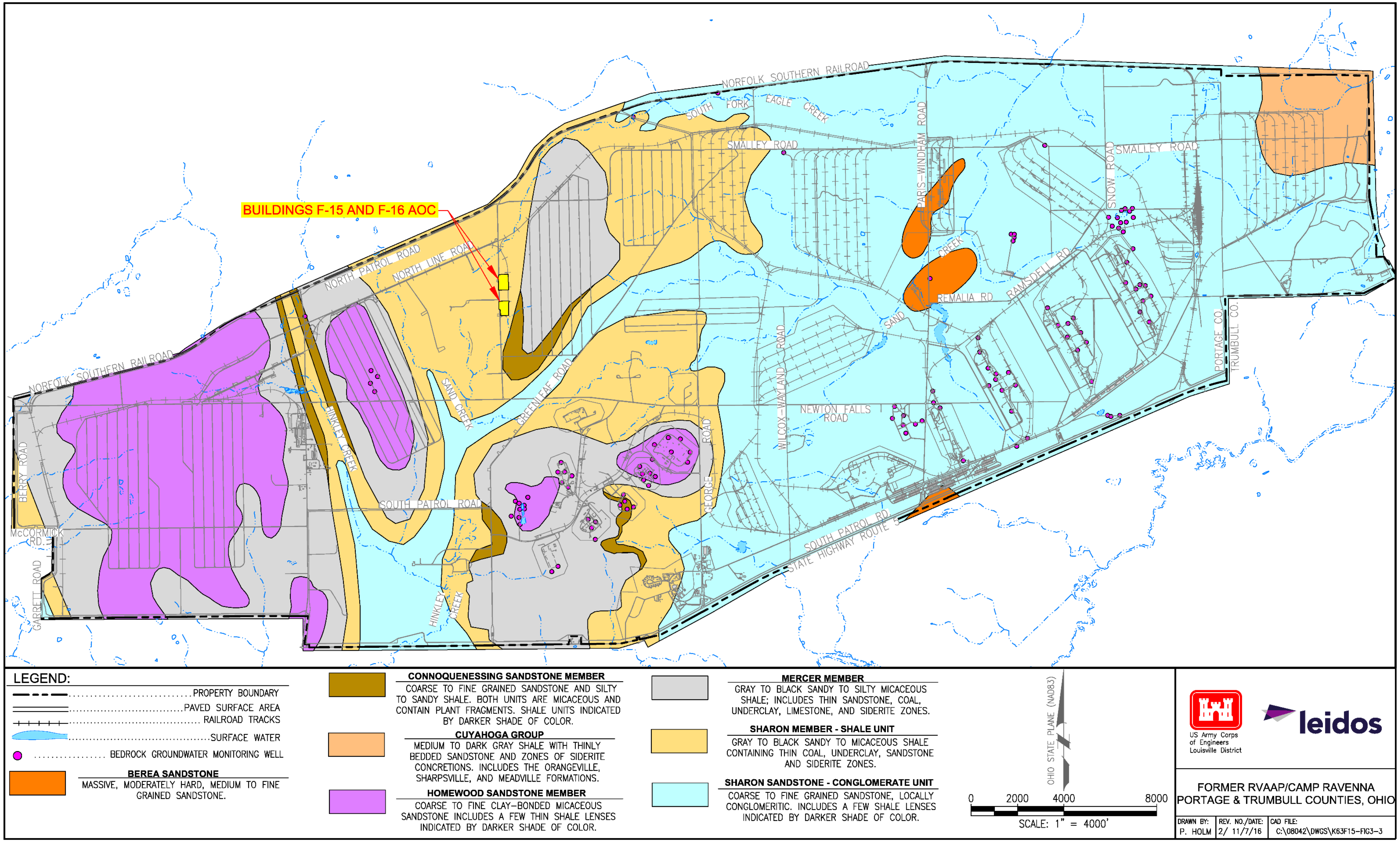


DATA SOURCES:

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



LEGEND:

- PROPERTY BOUNDARY
- PAVED SURFACE AREA
- RAILROAD TRACKS
- SURFACE WATER
- ● BEDROCK GROUNDWATER MONITORING WELL

BEREA SANDSTONE
MASSIVE, MODERATELY HARD, MEDIUM TO FINE GRAINED SANDSTONE.

CONNOQUENESSING SANDSTONE MEMBER
COARSE TO FINE GRAINED SANDSTONE AND SILTY TO SANDY SHALE. BOTH UNITS ARE MICACEOUS AND CONTAIN PLANT FRAGMENTS. SHALE UNITS INDICATED BY DARKER SHADE OF COLOR.

CUYAHOGA GROUP
MEDIUM TO DARK GRAY SHALE WITH THINLY BEDDED SANDSTONE AND ZONES OF SIDERITE CONCRETIONS. INCLUDES THE ORANGEVILLE, SHARPSVILLE, AND MEADVILLE FORMATIONS.

HOMEWOOD SANDSTONE MEMBER
COARSE TO FINE CLAY-BONDED MICACEOUS SANDSTONE INCLUDES A FEW THIN SHALE LENSES INDICATED BY DARKER SHADE OF COLOR.

MERCER MEMBER
GRAY TO BLACK SANDY TO SILTY MICACEOUS SHALE; INCLUDES THIN SANDSTONE, COAL, UNDERCLAY, LIMESTONE, AND SIDERITE ZONES.

SHARON MEMBER - SHALE UNIT
GRAY TO BLACK SANDY MICACEOUS SHALE CONTAINING THIN COAL, UNDERCLAY, SANDSTONE AND SIDERITE ZONES.

SHARON SANDSTONE - CONGLOMERATE UNIT
COARSE TO FINE GRAINED SANDSTONE, LOCALLY CONGLOMERITIC. INCLUDES A FEW SHALE LENSES INDICATED BY DARKER SHADE OF COLOR.

FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P. HOLM	2/ 11/7/16	C:\08042\DWGS\K63F15-FIG3-3

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

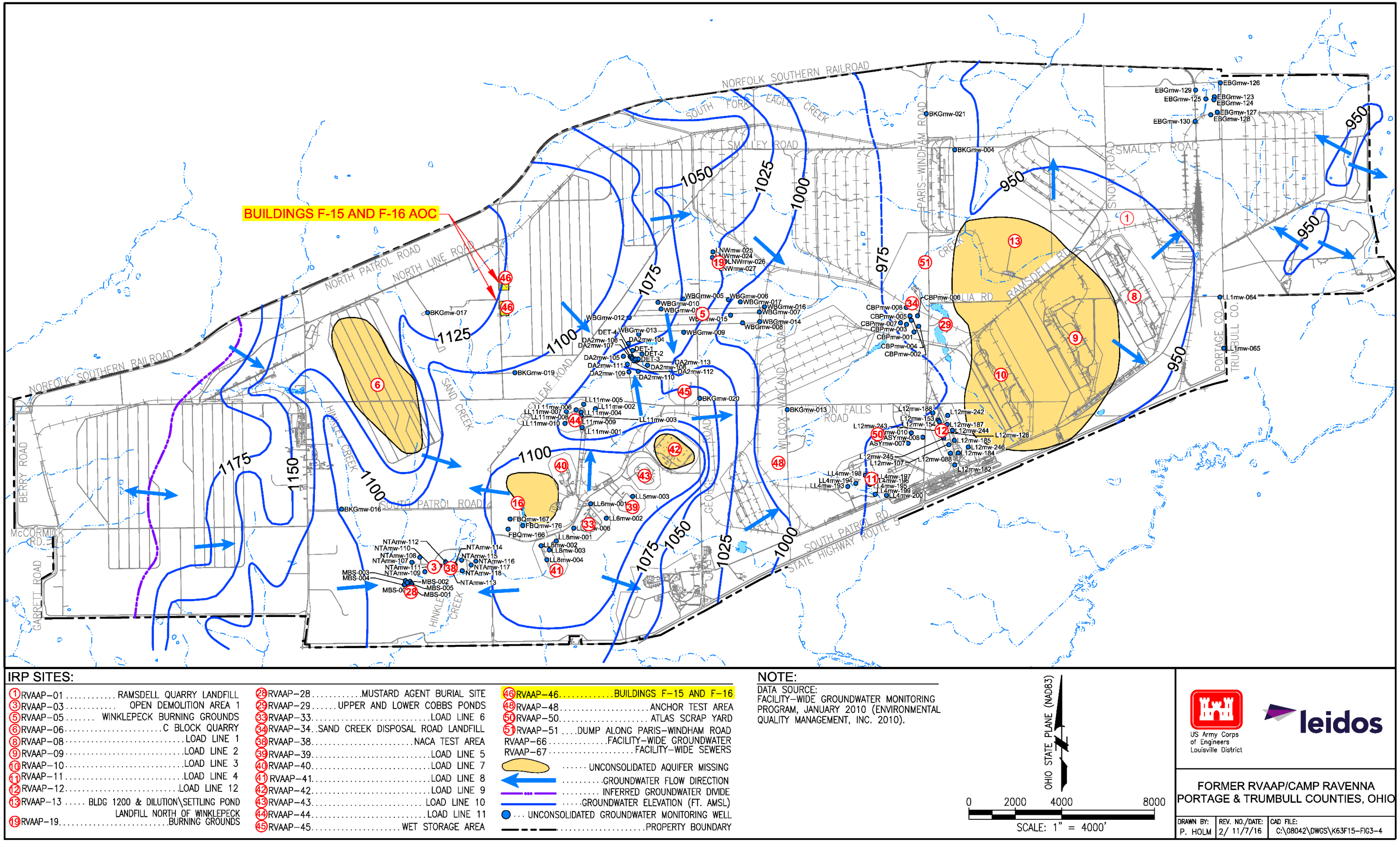


Figure 3–4. Potentiometric Surface of Unconsolidated Aquifer at Camp Ravenna

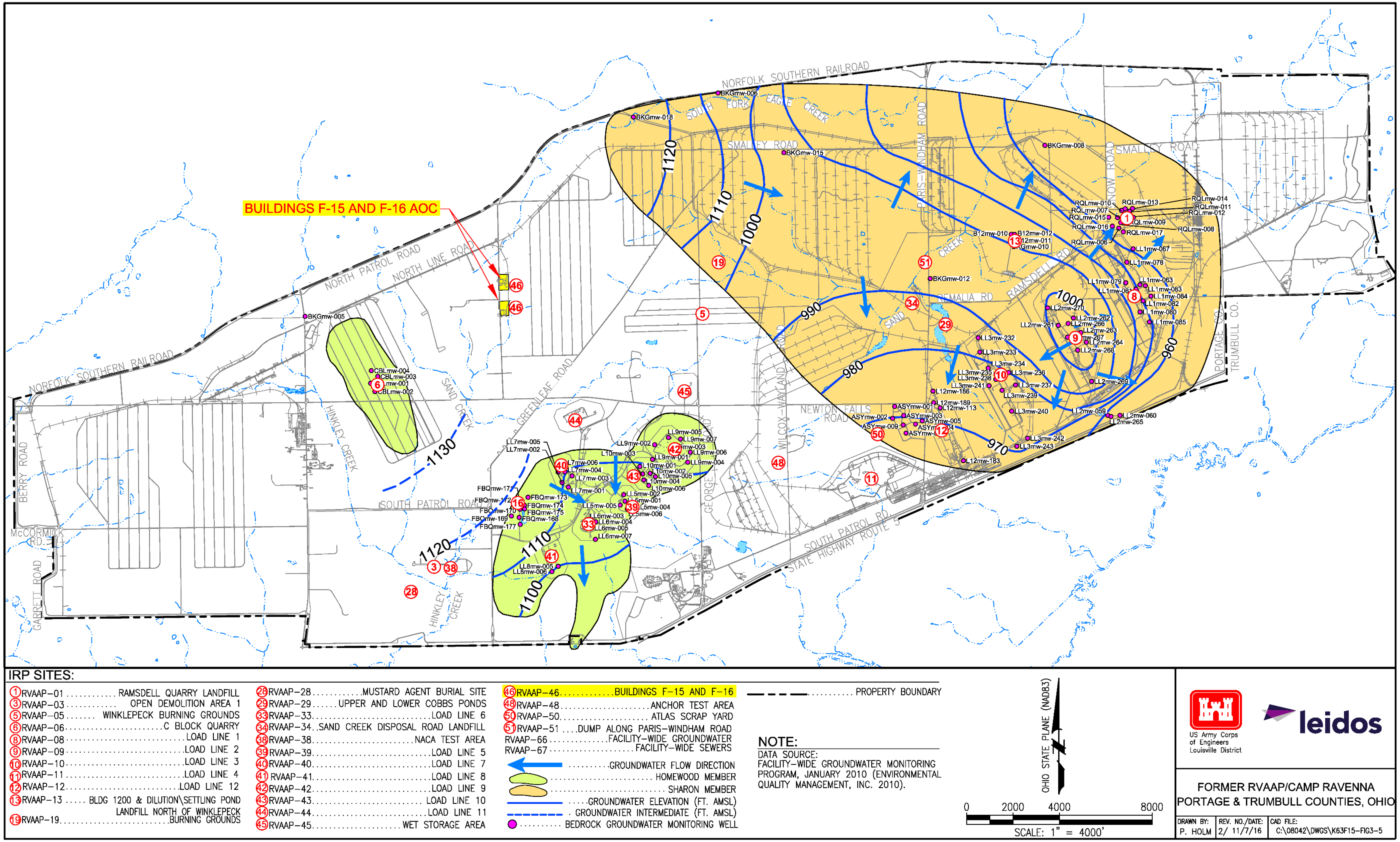


Figure 3–5. Potentiometric Surface of Bedrock Aquifers at Camp Ravenna

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4.0 SITE ASSESSMENTS, INVESTIGATIONS, AND DATA ASSEMBLY

This section summarizes all previous site assessments and investigations conducted at the Buildings F-15 and F-16 AOC. These previous activities include assessments to prioritize the AOC and investigations that collected data used in support of this RI.

4.1 PREVIOUS ASSESSMENTS AND EVALUATIONS

This section summarizes previous assessments and evaluations conducted at the Buildings F-15 and F-16 AOC. 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 the Buildings F-15 and F-16 AOC as part of the assessment. The assessment identified the following conditions at RVAAP as applicable to the AOC (USATHAMA 1978):

- The AOC was identified as one of seven proof and surveillance testing areas;
- Building F-15 was used during World War II, the Korean War, and the Vietnam War to test miscellaneous explosives and propellants; quantities tested are unknown;
- Explosives and propellants were identified as the potential contaminants; and
- No environmental stress was identified at RVAAP.

4.1.2 Relative Risk Site Evaluation for Newly Added Sites

In 1998, the U.S. Army Center for Health Promotion and Preventative Medicine 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 soil samples at the Buildings F-15 and F-16 AOC. 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 Report. However, as stated in Appendix L, Section 1.2 of the *Final Sampling and Analysis Plan Addendum for the Characterization of 14 RVAAP AOCs* (MKM 2004), "The results of the assessment and evaluation plus knowledge about the processes conducted at these two buildings were used to select sampling locations, determine sample media, identify the analyses and determine the number of samples to be collected for this characterization activity."

The RRSE evaluated the soil pathway (human receptor endpoint) using data from the five surface soil samples collected near the former Buildings F-15 and F-16 (RV-461, RV-462, and RV-464 to RV-466). Two samples were collected just outside of the foundations of each of the buildings. One sediment sample (RV-463) was collected from a drainage ditch near Building F-16 that leads to Sand Creek to evaluate the sediment pathway for human and ecological receptor endpoints. These samples were analyzed for explosives and metals. Subsurface soil, surface water, and groundwater were not evaluated at the AOC as part of this RRSE.

Several inorganic chemicals were detected in surface soil and sediment. Analyte concentrations detected in surface soil are presented in Appendix D of the RRSE (USACHPPM 1998).

The surface soil and sediment pathways were evaluated as follows:

1. Groundwater
    a. Not evaluated.
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. This area is not used for production and is not populated with workers. However, this area is not surrounded by a fence, and hunters, scrappers, and firewood cutters may have access to the site.
3. Sediment
    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. This area is not used for production and is not populated with workers. However, this area is not surrounded by a fence; hunters, scrappers, and firewood cutters may have access to the site.
4. Surface water
    a. Not evaluated. Surface water was not identified during the RRSE at this AOC.

Human receptor endpoints were evaluated based on the available surface soil and sediment data. The RRSE scored the Buildings F-15 and F-16 AOC as a "high" priority AOC and recommended additional investigative sampling (USACHPPM 1998).

4.2 REMEDIAL INVESTIGATIONS

This section summarizes previous investigations conducted at the Buildings F-15 and F-16 AOC. 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 Characterization of 14 AOCs report (MKM 2007) 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 RI Report; however, an updated screening process and the addition of new data and information from the 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and 2010 PBA08 RI may result in a different list of SRCs and/or COPCs.

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

4.2.1 Characterization of 14 AOCs

The Characterization of 14 AOCs data quality objectives (DQOs) were developed to collect and provide sufficient, high-quality data for all applicable media such that future actions (i.e., HHRAs and ERAs) can be efficiently planned and accomplished at each AOC. Data generated by the characterization activities were used to determine if residual contaminants remain at the AOCs; if contaminants impact soil, sediment, surface water, or groundwater; if there is a need for more extensive risk assessments; and if remedial actions are appropriate.

In 2004, sampling was conducted at the Buildings F-15 and F-16 AOC in accordance with the *Final Sampling and Analysis Plan Addendum for the Characterization of 14 RVAAP AOCs* (MKM 2004) (herein referred to as the Characterization of 14 AOCs SAP).

The Characterization of 14 AOCs investigation was performed to accomplish the following:

- Provide data for future assessments that may be conducted,
- Develop a conceptual site model (CSM),
- Identify key elements to be considered in future actions,
- Assess potential sources of contamination,
- Identify whether releases of contamination extend beyond the AOC boundary,
- Provide an initial assessment of the nature and lateral extent of contamination, and
- Provide a preliminary human health risk screening (HHRS) evaluation and ecological risk screening (ERS) evaluation.

Results of this characterization are presented in the Characterization of 14 AOCs report (MKM 2007) and are summarized below.

4.2.1.1 <u>Field Activities</u>

The following investigation field activities were conducted from October through November 2004 to assess potential impacts from former operations at the Buildings F-15 and F-16 AOC (MKM 2007):

- Collected 18 multi-increment (MI) surface soil (0–1 ft bgs) samples, several of which were collected from dry ditches;
- Collected 2 MI sediment samples from drainage pathways;
- Collected 2 surface water samples from drainage pathways;
- Collected 2 discrete surface soil (0–1 ft bgs) samples for VOCs; and
- Completed sampling location survey.

The Characterization of 14 AOCs utilized MI samples. This sampling technique is currently referred to as ISM. Areas adjacent to Buildings F-15 and F-16, the railway adjacent to Buildings F-15 and F-16, and the dry drainage ditches within the AOC were divided into 18 ISM samples. All surface soil samples were analyzed for TAL metals and explosives, with the exception of two samples that were analyzed for RVAAP full-suite analytes. In addition, two discrete surface soil samples were collected from two ISM sample areas for VOC analyses to fulfill requirements to conduct a full-suite analysis for 10% of the MI sample population. Both sediment samples collected were analyzed for TAL metals and explosives. One sediment sample was also analyzed for total organic carbon and grain size. One surface water sample was collected from an unnamed tributary to Sand Creek, southeast of former Building F-16. A second surface water sample was collected from a small ponded area south of Building F-16. Figure 4-1 presents the locations sampled under the Characterization of 14 AOCs.

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 Characterization of 14 AOCs SAP (MKM 2004), and USACE Louisville Chemistry Guideline (USACE 2002). DQOs were established for the Characterization of 14 AOCs 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 (90% complete), was usable, and that it satisfied the DQOs for the project.

Table 4-1 presents the ISM sample locations, associated operations, and suite of chemicals analyzed as part of the Characterization of 14 AOCs. Tables 4-2, 4-3, and 4-4 present the results of the analytes detected from surface soil, sediment, and surface water samples collected during the Characterization of 14 AOCs.

4.2.1.2 <u>Nature and Extent of Contamination</u>

The nature of contamination for the Buildings F-15 and F-16 AOC was characterized in surface soil (0–1 ft bgs) media only. Twenty-two of the surface soil contaminants were inorganic chemicals that were detected above RVAAP background concentrations and/or USEPA Region 9 residential preliminary remediation goal (PRG) screening values at that time, and one SVOC was also detected above screening criteria. A total of 15 inorganic chemicals were detected in sediment and 10 metals were detected in surface water above RVAAP background concentrations and/or Region 9 residential PRG screening values at that time. Figure 4-6 presents locations that exceed current screening criteria.

4.2.1.3 Human Health Risk Screening

The HHRS compared chemical concentrations detected in the AOC surface soil samples to RVAAP screening criteria in effect at that time, which included facility-wide background concentrations for inorganic constituents and USEPA Region 9 residential PRGs. Constituents were retained if they did not have screening values. The results of the HHRS identified contaminants above screening criteria in surface soil, as summarized in Table 4-5.

4.2.1.4 Ecological Risk Screening

The ERS compared chemical concentrations detected in surface soil to RVAAP facility-wide background concentrations (Table 4-18) for inorganic chemicals and ecological screening values (ESVs). The ERS 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 2003a). Chemicals were retained if they did not have screening values. Table 4-6 presents the chemicals identified in the ERS as exceeding screening values for the Buildings F-15 and F-16 AOC surface soil.

4.2.1.5 Results and Conclusions

Four metals, four SVOCs, and one propellant were identified as COPCs in surface soil. All VOCs and PCBs were below USEPA Region 9 residential PRGs and/or laboratory detection limits. Two metals and one explosive were identified as COPCs in surface water. There were no COPCs detected in sediment. The Characterization of 14 AOCs report recommended that full HHRAs and ERAs should be considered to assist in the overall risk management decisions for the Buildings F-15 and F-16 AOC.

4.2.2 2009 Under Slab Sampling

In 2009, two surface soil ISM samples and three QA/QC samples were collected from the footprints of former Buildings F-15 and F-16.

These samples were collected and analyzed to accomplish the following:

- Identify any contaminants remaining in the under slab surface soil,
- Quantify any contaminants identified,
- Determine if any residual contaminants were present at concentrations posing unacceptable risk to future receptors (end users) by comparing their concentrations to selected criteria applicable at the time of the investigation,
- Assess results and identify areas where additional characterization may be needed, and
- Provide recommendations for further activities.

Results of this characterization are presented in the *Final Sampling and Analysis of Soils Below Floor Slabs at RVAAP-08 Load Line 1 and Other Building Locations, Ravenna Army Ammunition Plant* (USACE 2010c) and are summarized in the following subsections.

4.2.2.1 Field Activities

This investigation was performed after the buildings and structures at the AOC were demolished and removed (except Building U-17). Two ISM samples (plus three QA/QC samples) were collected from the footprints of former Buildings F-15 and F-16 to assess potential impact to surface soil. Each building consisted of one ISM grid. All ISM samples collected were analyzed for TAL metals, explosives, and propellants. Eight discrete core samples (four from each building footprint) were also collected for field screening for TNT and RDX.

4.2.2.2 Results and Conclusions

The investigation compared the analytical results to USEPA Region 9 residential PRG and RVAAP background concentrations. The list below presents a summary of results.

- Numerous metals were detected above laboratory reporting limits.
- One propellant compound (nitrocellulose) was detected in the sample collected from Building F-15 at a concentration of 2.5 mg/kg. This result was an estimated concentration.
- No VOCs, explosives, PCBs, or pesticides were detected in under slab surface soil.
- No exceedances of TNT or RDX CUGs were detected during the field screening

The report concluded that there were no COPCs and did not recommend further remedial excavation within the former building footprints.

Figure 4-2 presents the locations sampled during the 2009 Under Slab Sampling. Table 4-8 presents the results of the analytes detected from the associated samples collected during the 2009 Under Slab Sampling.

4.2.3 2009 USACE ISM Surface Soil Sampling

In December 2009, USACE conducted surface soil sampling at the Buildings F-15 and F-16 AOC as part of a larger investigation of Load Lines 1, 2, 3, and 4 (Prudent 2011). Samples were collected and analyzed at the AOC to accomplish the following:

1. Determine if contamination was spread during building demolition, and
2. Assess potential contamination from the former presence of coal in the coal storage areas.

Surface soil ISM samples F15ss-040-0001-SO and F16ss-030-0001-SO were collected around the building footprints and analyzed only for explosives. Surface soil ISM samples FWCss-007 and FWCss-008 were collected from the coal storage areas and analyzed for TAL metals and SVOCs.

Results were documented in the *Final Sampling Report of Surface and Subsurface Incremental Sampling Methodology at Load Lines 1, 2, 3, and 4 (RVAAP-08, 09, 10, and 11)* (Prudent 2011). Explosives were not detected in any of the samples collected from the perimeter of the former Buildings F-15 and F-16 footprints. No metals or SVOCs exceeded their respective CUGs in the coal storage area samples.

Figure 4-3 presents the locations sampled during the 2009 USACE ISM Surface Soil Sampling. Table 4-9 presents the results of the analytes detected from the associated samples collected during the 2009 USACE ISM Surface Soil Sampling.

4.2.4 PBA08 Remedial Investigation

In November 2008, Science Applications International Corporation (SAIC) scientists performed a site walk of the Buildings F-15 and F-16 AOC. The site walk was conducted to develop the *Performance-based Acquisition 2008 Supplemental Investigation Sampling and Analysis Plan Addendum No. 1* (PBA08 SAP) (USACE 2009a), which supplemented historical data in this RI Report and completed the RI phase of the CERCLA process. The PBA08 SAP considered the prior investigations and changes in AOC conditions when developing the DQOs and sampling scheme for completing the Buildings F-15 and F-16 AOC RI. Section 4.4.4 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 4-4 and 4-5, respectively. The screening approach presented in the PBA08 SAP compared sample results from previous investigations at the AOC 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 *RVAAP Facility-wide Human Health Risk Assessors Manual - Amendment 1* (USACE 2005a) (herein referred to as the FWHHRAM). The most protective FWCUGs for the Resident Receptor (Adult and Child) and National Guard Trainee were referred to as “screening criteria.” Previous results were also compared to FWCUGs at the higher TR of 1E-05, HQ of 1 to facilitate identifying potential source areas that may require additional sampling to refine the extent of contamination. Table 4-7 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 soil using ISM and discrete sampling techniques, subsurface soil and surface water using discrete sampling techniques, and sediment using composite sampling techniques. The results of the PBA08 RI sampling, combined with the results of the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, and 2009 USACE ISM Surface Soil Sampling 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.

4.2.4.1 Surface Soil Sampling Rationale – Source Area Investigation

Samples were collected at the AOC 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 Buildings F-15 and F-16 or within sediment accumulation areas such as ditches). Table 4-10 presents the specific rationale for each ISM surface soil sample collected during the PBA08 RI in February and March 2010. Table 4-11 presents the results of the analytes detected from ISM surface soil samples collected during the PBA08 RI. All PBA08 RI and historical sample locations used in this evaluation are presented on Figure 4-8.

Two ISM samples were collected around historical ISM sample areas to further delineate surface soil above historical screening criteria presented in Table 4-7 (Figure 4-6). All surface soil samples collected during the PBA08 RI were collected using ISM sampling techniques, except at soil boring locations. ISM samples were analyzed for TAL metals, explosives, and SVOCs. One sample (15% of the total number of ISM samples collected) was analyzed for RVAAP full-suite analytes.

4.2.4.2 Surface Soil Sampling Rationale – Chromium Speciation

As part of the PBA08 RI, three 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). Two samples were collected from areas previously identified as having elevated total chromium concentrations (F16ss-025 and F16ss-034), and one sample was collected from an area previously identified as having a total chromium concentration near background concentrations (F16ss-024). The rationale for the chromium speciation samples collected as part of the PBA08 RI is summarized in Table 4-12. The locations of these samples are presented in Figure 4-6 and results are presented in Table 4-13.

4.2.4.3 Subsurface Soil Sampling Rationale and Methods

The PBA08 RI used discrete samples from soil borings to characterize 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 two objectives:

- Borings were located at locations where previous surface soil sampling results exceeded screening criteria and vertical delineation was warranted.
- Borings were located at locations where previous surface soil sampling results only slightly exceeded screening criteria to confirm that contaminant concentrations did not increase with depth.

Soil samples from five soil borings installed in historical ISM areas with historical screening criteria exceedances were collected to further delineate the vertical extent of contamination in subsurface soil at the AOC (Figure 4-6). Table 4-15 presents the specific rationale for each subsurface soil sample collected for the PBA08 RI. Results of detected analytes are presented in Table 4-16, except for discrete surface soil (0–1 ft bgs), which are presented in Table 4-13.

The subsurface soil sampling depth intervals were documented in the PBA08 SAP. Each soil boring was sampled at 0–1, 1–4, 4–7, and 7–13 ft bgs. These sample intervals were selected to evaluate surface and subsurface exposure depths for the Resident Receptor (0–1 and 1–13 ft bgs) and National Guard Trainee (0–4 and 4–7 ft bgs). The sample collected from the 7–13 ft bgs 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, if any chemical concentration exceeded screening criteria in the 4–7 ft bgs sample, the 7-13 ft bgs sample was analyzed. One of the archived 7–13 ft bgs samples was analyzed because there were preliminary screening criteria exceedances for arsenic (24.3 mg/kg) in the 4–7 ft bgs sample interval from F16sb-021. In addition, at least 10% of all subsurface samples from 7–13 ft bgs were submitted for laboratory analysis to adequately characterize the subsurface soil to 13 ft bgs. One sample collected from the 7–13 ft bgs sample interval from F15sb-033 was submitted for laboratory analysis for this purpose.

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. Two QC field duplicates and two QA split samples were collected to satisfy the QA/QC sample requirements of 10% frequency for subsurface soil samples.

Two geotechnical samples were collected from one boring location to provide soil data for fate and transport modeling. Geotechnical data is provided in Appendix D. A pilot boring was installed with a Geoprobe at sample location F16sb-023 to a depth of 12 ft bgs to allow lithological characterization of the soil and determine the appropriate geotechnical sample intervals (Appendix A). The geotechnical sample location was offset from the pilot boring and drilled with hollow stem auger attachments. Geotechnical samples were collected beneath the hollow stem augers directly into the Shelby tube. Undisturbed Shelby tube samples were collected from 4–5 and 8–8.8 ft bgs, directly above the only moist zones observed in the pilot boring. The Shelby tubes were sealed with wax, capped, and submitted for laboratory geotechnical analysis for porosity, bulk density, moisture content, total organic carbon, grain size fraction analysis, and permeability.

4.2.4.4 Surface Water and Sediment Characterization

No surface water or sediment samples were collected during the PBA08 RI at the Buildings F-15 and F-16 AOC, as surface water is not a permanent feature at the AOC. Surface water was not present at the AOC during the PBA08 RI.

4.2.4.5 Changes from the Work Plan

Significant changes to the PBA08 SAP are documented in the field change requests provided in Appendix B. Changes made in the field based on AOC-specific conditions are not documented on field change requests 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 field sampling logs.

4.2.4.6 October 2010 Chromium Reassessment

An initial assessment of the chromium concentrations was performed immediately after samples results from February 2010 were received. The preliminary sample results showed unexpectedly high concentrations of total chromium at sample locations F15ss-035M, F15ss-036M, and F15ss-037M. Potential laboratory contamination from the grinding process was suspected for ISM samples collected at this AOC.

The grinder used for ISM processing in February 2010 was a standard kitchen quality coffee grinder. The coffee grinder blades were chipped, bent, and could not sustain the soil grinding process, so the laboratory switched to an agricultural grade grinder for processing the remainder of the PBA08 RI ISM samples. It was speculated that metal chips from low-grade stainless steel blades could contribute to elevated chromium results in samples. The corrosion resistance of stainless steel is due to a thin layer of trivalent chromium. Potential contamination from deteriorating blades used during sample grinding would increase the trivalent and total chromium concentrations, but not necessarily impact hexavalent chromium concentrations.

Therefore, as presented in Table 4-17, the following activities took place in October 2010:

1. Three PBA08 RI ISM areas (F15ss-035M, F15ss-036M, and F15ss-037M) were re-sampled for total chromium because original results were rejected due to suspected laboratory contamination. These ISM samples had the highest total chromium concentrations from February 2010.
2. Three additional discrete sample locations (F16ss-026, F16ss-027, and F15ss-036) were sampled to expand upon the existing chromium speciation data set for the AOC and verify preliminary speciation results. After completing this sampling event, six chromium speciation samples were collected to analyze this AOC. The chromium speciation assessment is presented in Section 7.2.4.1.

New ISM samples were recollected in October 2010 using the same field sample equipment and techniques that were used in February 2010, but a stone mortar and pestle was used to process the samples in the laboratory instead of a low-grade coffee grinder with metal blades. A comparison of the February and October 2010 total chromium results is presented in Table 4-14. The total chromium results are much lower in the samples processed with the mortar and pestle, so the results from samples collected in February 2010 and processed with the low-grade metal grinder were rejected and replaced by those collected in October 2010.

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 background values are currently being reassessed, but the background valued developed in 1998 are used throughout this report.

The facility-wide background values developed in 1998 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 and fate and transport). Background locations were selected using aerial photographs and during 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 to determine background concentrations.

Soil samples were collected from each of the background monitoring well locations at 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 soil samples were analyzed for TAL metals, cyanide, SVOCs, total organic carbon, pesticides, PCBs, and VOCs.

Seven stream locations upstream of RVAAP activities were sampled for sediment and surface water to characterize background conditions. Seven locations were selected for sampling sediment and surface water representative of background conditions along Hinkley, Sand, and Eagle Creeks. 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 analysis 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 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 facility-wide background concentrations would only be applicable for inorganics. All organic analytes (e.g., PAHs, VOCs, or 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 or inorganics are presented in Table 4-18.

4.4 DATA EVALUATION METHOD

Data evaluation methods for the Buildings F-15 and F-16 AOC are consistent with those established in the FWCUG Report and 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

The Buildings F-15 and F-16 AOC data were aggregated in three ways to evaluate contaminant nature and extent and complete 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 the Buildings F-15 and F-16 AOC are as follows:

- **Surface Soil (0–1 ft bgs) –** This medium was subdivided into two data aggregates (Building F-15 aggregate and Building F-16 aggregate) due to the distance between the areas and the lack of interconnectedness between the two former operational areas. Each data aggregate encompasses the immediate vicinity of their respective former building and adjacent dry storm drainage conveyances.
- **Subsurface Soil (greater than 1 ft bgs) –** This medium was subdivided into two data aggregates on the same basis as surface soil.
- **Sediment –** No sediment is present at the AOC. Sediment samples collected off-AOC are evaluated to assess potential impacts of surface drainage sourced from the AOC.
- **Surface Water –** No surface water is present at the AOC. Surface water samples collected off-AOC are evaluated to assess potential impacts of surface drainage sourced from the AOC.

4.4.2 Data Verification, Reduction, and Screening

4.4.2.1 Data Verification

Data verification was performed on 36 surface and subsurface soil samples (including QC duplicates) collected during the PBA08 RI in February through March 2010. Data from the Characterization of 14 AOCs, 2009 Under Slab Sampling, and 2009 USACE ISM Surface Soil Sampling were verified and completed as presented in the summary report. 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.
- “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 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 Data Reduction

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. 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 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 Data Screening

After reduction, the data were screened to identify SRCs using the processes outlined below. The ISM and associated discrete (for VOC analysis) samples were used in the SRC screening process for surface soil (0–1 ft bgs). All subsurface soil samples collected under the PBA08 RI were discrete samples screened for SRCs.

Additional screening of identified SRCs against applicable criteria (e.g., USEPA 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 4-7 illustrates the screening process to identify SRCs and COPCs at the Buildings F-15 and F-16 AOC in accordance with the FWCUG Report. The steps involved in the SRC screening process are summarized below. All chemicals that were not eliminated during the screening steps were retained as SRCs.

- **Data quality assessment –** Review the usability of the RI data set with respect to established DQOs as discussed in Section I.3.5 of Appendix I.
- **Background screening –** The maximum detected concentrations (MDCs) of naturally occurring inorganic chemicals were compared to background concentrations. If background concentrations were exceeded, the respective inorganic chemicals were retained as SRCs. No background concentrations were established for organic chemicals. As such, all detected organic chemicals were retained as SRCs.
- **Screening of essential human nutrients –** Chemicals that are 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 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 were 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) were eliminated as SRCs.

- **Frequency of detection/WOE screening –** The FWCUG Report and *Final (Revised) USACE RVAAP Position Paper for the Application and Use of Facility-Wide Human Health Cleanup Goals* (USACE 2012a) (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 (except for explosives and propellants) detected in less than 5% of the discrete samples are screened out from further consideration if the sample population consists of 20 or more samples and evidence exists that the analyte is not AOC related. The WOE evaluated magnitude and location (clustering) of detected results and if the distribution of detected results indicated a potential source of the chemical. If the detected results for a chemical showed: (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 were considered spurious, and the chemical was eliminated from further consideration. This screening was applied to all organic and inorganic chemicals, except for explosives and propellants, which were considered SRCs regardless of frequency of detection. Frequency of detection/WOE screening was not applied as no data set was comprised of 20 or more samples.

4.4.3 Data Presentation

Data summary statistics and screening results for SRCs in surface and subsurface soil at the Buildings F-15 and F-16 AOC are presented for each medium and spatial aggregate. Analytical results for SRCs are also presented in the following data summary tables: Tables 4-20 and 4-21 for surface soil, and Tables 4-22 and 4-23 for subsurface soil.

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 data packages associated with different AOCs. All samples have sample IDs beginning with “F15” or “F16.”

The tables in Appendix D present the analytical results for samples collected during the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and PBA08 RI. Sample locations from the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and PBA08 RI are presented on Figure 4-8.

Analytical results are grouped by media (e.g., surface soil, subsurface soil, sediment, and surface water) and class of analyte (e.g., explosives and 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 RI under two primary considerations: representativeness with respect to current AOC conditions and sample collection methods (e.g., discrete vs. ISM). Table 4-24 presents the designated use for all available samples.

4.4.4.1 Surface Soil

Surface soil samples at the AOC were collected during 2004–2005 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and the 2010 PBA08 RI. Samples from the Characterization of 14 AOCs and the 2009 Under Slab Sampling were evaluated to determine if conditions changed substantively between earlier characterization efforts and the PBA08 RI activities. In 2004 and 2007–2009, buildings at the AOC were demolished and removed. The samples collected in 2004 during the Characterization of 14 AOCs were from within dry ditch lines peripheral to the former buildings and in other areas adjacent to the now-demolished buildings (e.g., gravel parking areas). The 2009 Under Slab Sampling was conducted within the footprints of the demolished buildings, following slab removal and exposure of the underlying surface soil. Therefore, both of these data sets were considered representative of current conditions within and surrounding the footprints of the former buildings. No samples from the 2004 and 2009 data sets were eliminated from the SRC screening process.

Four ISM surface soil samples, one from each building perimeter and one from each former coal pile area (F15ss-040-0001-SO, F16ss-030-0001-SO, FWCss-007-0001-SO, and FWCss-008-0001-SO), collected during the 2009 USACE ISM Surface Soil Sampling were previously excluded because the data were not yet in REIMS; however, these samples have been added to the ISM surface soil screen.

The RRSE samples RV-461, RV-462, RV-464 to RV-466 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."

Two types of surface soil samples were collected during the investigation of the AOC: discrete and ISM samples. Discrete surface soil samples were collected to evaluate VOCs and as part of the first interval (0-1 ft bgs) of a soil boring. The discrete surface soil samples collected to evaluate VOCs that were considered representative of the ISM sample in which they were taken were used in the SRC screening process and carried forward into the risk assessment along with their corresponding ISM sample. Discrete samples from the 0–1 ft bgs shallow soil interval collected from co-located subsurface soil boring locations during the PBA08 RI were retained for nature and extent evaluation only.
None of the ISM surface soil samples from the PBA08 RI were eliminated from the SRC screening process.

4.4.4.2 Subsurface Soil

The SRC data set for subsurface soil is comprised only of PBA08 RI samples. All subsurface soil samples were applicable for use in this assessment and are included in the SRC screening data set. Additionally, two subsurface soil samples (from one soil boring) were collected during the PBA08 RI for geotechnical analysis only.

4.4.4.3 Sediment and Surface Water

Sediment and surface water samples were collected downstream and off-AOC during the Characterization of 14 AOCs to assess the migration of contaminants in runoff sourced from the AOC. The two sediment and two surface water samples were retained for nature and extent evaluation only because surface water is intermittent at the sample locations and no perennial surface water exists within the AOC boundaries. However, the location of 2004 sediment sample F16sd-001M coincides with the more recent 2009 sample FWCss-008 at the coal storage area. Sample FWCss-008 is included in the risk assessment data set.

No sediment or surface water samples were collected under the PBA08 RI activities, as these media were not present at the AOC.

The RRSE sediment sample RV-463 was 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."

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Table 4–1. Characterization of 14 AOCs Sample Locations

Characterization of 14 AOCs Sample Location	Sample Depth (ft bgs)	Analytes	Potential Sources or Areas for Investigation	Previous Use and/or Description	Documented Release	Potential Contaminants from Use
F15ss-001M	0–1	Metals, Explosives	Drainage ditch northwest of Building F-15	1941–1945, 1951-1957, and 1969-1971: Former Building F-15 was used as the inspector’s workshop where surveillance testing occurred.	None	Metals, Explosives
F15ss-002M	0–1	Metals, Explosives	Drainage ditch north of Building F-15	1941–1945, 1951-1957, and 1969-1971: Former Building F-15 was used as the inspector’s workshop where surveillance testing occurred.	None	Metals, Explosives
F15ss-003M	0–1	Metals, Explosives	Drainage ditch east of Building F-15 and railroad tracks	1941–1945, 1951-1957, and 1969-1971: Former Building F-15 was used as the inspector’s workshop where surveillance testing occurred.	None	Metals, Explosives
F15ss-004M	0–1	Metals, Explosives	Building U-18	1941–1945, 1951-1957, and 1969-1971: Building U-18 was the coal-powered boiler house for former Building F-16.	None	Metals, Explosives, PAHs
F15ss-005M	0–1	Metals, Explosives	Drainage ditch west of T-3002 and T-3003	1941–1945, 1951-1957, and 1969-1971: Former Buildings T-3002 and T-3003 were storage sheds located south of former Building F-15	None	Metals, Explosives
F15ss-006D	0–1	VOCs	North of Building F-15 between access road and drainage ditch	1941–1945, 1951-1957, and 1969-1971: Former Building F-15 was used as the inspector’s workshop where surveillance testing occurred. Ballast was removed to allow access to the sampling location.	None	Metals, Explosives
F15ss-006M	0–1	Full suite			None	Metals, Explosives
F15ss-007M	0–1	Metals, Explosives	Railway East of Building F-15	1941–1945, 1951-1957, and 1969-1971: Former Building F-15 was used as the inspector’s workshop where surveillance testing occurred. Ballast was removed to allow access to the sampling location	None	Metals, Explosives
F15ss-008M	0–1	Metals, Explosives	West of Building F-15 between access road and dry ditch	1941–1945, 1951-1957, and 1969-1971: Former Building F-15 was used as the inspector’s workshop where surveillance testing occurred.	None	Metals, Explosives
F15ss-009M	0–0.5	Metals, Explosives	Building U-17	1941–1945, 1951-1957, and 1969-1971: Building U-17 was the coal powered boiler house for former Building F-15. Building U-17 is only remaining feature at the AOC.QC sample collected.	None	Metals, Explosives, PAHs
	0–0.5	Metals, Explosives				
F15ss-010M	0–1	Metals, Explosives	South of Building F-15, Northside of T-3002	1941–1945, 1951-1957, and 1969-1971: Former Building F-15 was used as the inspector’s workshop where surveillance testing occurred. Former Buildings T-3002 was storage shed located south of former Building F-15.	None	Metals, Explosives
F15ss-011M	0–1	Metals, Explosives	Buildings T-3002 and T-3003	1941–1945, 1951-1957, and 1969-1971: Former Buildings T-3002 and T-3003 were storage sheds located south of former Building F-15	None	Metals, Explosives
F16ss-001M	0–0.5	Metals, Explosives	Drainage ditch west of Building F-16	1941–1945, 1951-1957, and 1969-1971: Former Building F-16 was used for ammunition packaging, shipping, and receiving.	None	Metals, Explosives
F16ss-002M	0–0.5	Metals, Explosives	Drainage ditch discharging Building F-16 area to unnamed tributary to Sand Creek	1941–1945, 1951-1957, and 1969-1971: Former Building F-16 was used for ammunition packaging, shipping, and receiving.	None	Metals, Explosives
F16ss-003M	0–0.5	Metals, Explosives	Drainage ditch from southern access road to Building F-16, discharging to unnamed tributary to Sand Creek	1941–1945, 1951-1957, and 1969-1971: Former Building F-16 was used for ammunition packaging, shipping, and receiving.	None	Metals, Explosives
F16ss-004M	0–1	Metals, Explosives	North of Building F-16 gravel parking area	1941–1945, 1951-1957, and 1969-1971: Former Building F-16 was used for ammunition packaging, shipping, and receiving.	None	Metals, Explosives
F16ss-005D	0–0.5	VOCs	Northside of Building F-16	1941–1945, 1951-1957, and 1969-1971: Former Building F-16 was used for ammunition packaging, shipping, and receiving.	None	Metals, Explosives
F16ss-005M	0–0.5	Full suite				
F16ss-006M	0–1	Metals, Explosives	Railway East of Building F-16	1941–1945, 1951-1957, and 1969-1971: Former Building F-16 was used for ammunition packaging, shipping, and receiving.	None	Metals, Explosives
F16ss-007M	0–0.5	Metals, Explosives	West of Building F-16 between access road and dry ditch	1941–1945, 1951-1957, and 1969-1971: Former Building F-16 was used for ammunition packaging, shipping, and receiving.	None	Metals, Explosives
F16sd-001M	0–0.5	Metals, Explosives	Small ponded area south of Building F-16 (former coal storage area)	1941–1945, 1951-1957, and 1969-1971: Former Building F-16 was used for ammunition packaging, shipping, and receiving.	None	Metals, Explosives, PAHs
	0–0.5	Metals, Explosives		QC sample collected.		
F16sw-001-SW	NA	Full suite		Co-located surface water sample		
F16sd-002M	0–0.5	Metals, Explosives	Unnamed tributary to Sand Creek, downstream of Building F-16	1941–1945, 1951-1957, and 1969-1971: Former Building F-16 was used for ammunition packaging, shipping, and receiving.	None	Metals, Explosives
F16sw-002	NA	Full suite		Co-located surface water sample		
	NA	Full suite		QC sample collected		

AOC = Area of concern.
bgs = Below ground surface.
ft = Feet.
QC= Quality control.
VOC = Volatile organic compound.

Table 4–2. Analytes Detected in Characterization of 14 AOCs ISM Surface Soil Samples

Aggregate		**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**
Station		**F15ss-001M**	**F15ss-002M**	**F15ss-003M**	**F15ss-004M**	**F15ss-005M**	**F15ss-006D**	**F15ss-006M**	**F15ss-007M**	**F15ss-008M**	**F15ss-009M**
Sample ID		**F15ss-001M-SO**	**F15ss-002M-SO**	**F15ss-003M-SO**	**F15ss-004M-SO**	**F15ss-005M-SO**	**F15ss-006D-SO**	**F15ss-006M-SO**	**F15ss-007M-SO**	**F15ss-008M-SO**	**F15ss-009M-SO**
Date		**10/28/04**	**10/28/04**	**10/28/04**	**10/27/04**	**10/28/04**	**10/28/04**	**10/28/04**	**10/28/04**	**10/28/04**	**10/28/04**
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 - 0.5**
Parameters Analyzed **Analyte**	**Background Criteria**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**VOCs**	**TAL Metals, Explosives, Pesticides/PCBs, SVOCs**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**
						Metals (mg/kg)					
Aluminum	17700	12000	14000	13000	14000	12000	NR	16000	16000	11000	11000
Antimony	0.96	<1.3U	<1.5U	<1.4U	<1.4 R	<1.3U	NR	<1.5U	<1.4U	<1.4U	0.54
Arsenic	15.4	10	11	10	12	**16***	NR	12	10	9.4	12
Barium	88.4	85	81	**90***	**100***	72	NR	79	76	83	86
Beryllium	0.88	0.85	0.86	0.75	**1.2***	0.81	NR	0.86	0.78	0.83	**0.99***
Cadmium	0	<0.22U	<0.27U	**0.38***	<0.25UJ	<0.46U	NR	<0.24U	<0.49U	<0.23U	<0.25U
Calcium	15800	**20000***	3300	3200	9200	3000	NR	2800	4200	**29000***	8600
Chromium	17.4	**21***	**20***	**22***	**29***	**20***	NR	**24***	**24***	**19***	**22***
Cobalt	10.4	**11***	**11***	8.9	**11***	**11***	NR	**11***	8.2	**11***	7.3
Copper	17.7	**25***	**18***	**18***	**18***	**19***	NR	**22***	15	**23***	17
Iron	23100	23000	**25000***	23000	**27000***	**27000***	NR	**26000***	**25000***	23000	21000
Lead	26.1	20	16	24	20	16	NR	22	13	17	**33***
Magnesium	3030	**5400***	**3200***	2800	**3700***	**3200***	NR	**3100***	3000	**6600***	2900
Manganese	1450	370	360	420	870	390	NR	480	360	390	550
Mercury	0.036	**0.05***	**0.04***	**0.05***	**0.05***	0.03	NR	**0.06***	**0.04***	0.03	**0.04***
Nickel	21.1	**26***	**23***	21	**25***	**26***	NR	21	18	**27***	17
Potassium	927	**1900***	**1300***	**1100***	**1800J***	**1400***	NR	**1400***	**1300***	**2000***	**960***
Selenium	1.4	0.39	<1.6U	<1.4U	<1.5U	<1.4U	NR	<1.5U	<1.5U	<1.4U	0.5
Sodium	123	**290***	**250***	**260***	**430***	**390***	NR	**390***	**350***	**300***	**270***
Thallium	0	<0.55U	<0.66U	<0.61U	**0.25***	<0.56U	NR	<0.63U	**0.2***	<0.6U	<0.53U
Vanadium	31.1	22	24	23	26	20	NR	29	29	20	21
Zinc	61.8	**110***	57	**63***	**68***	**64***	NR	61	49	**75***	**70***
						Explosives and Propellants (mg/kg)					
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	**0.93***	NR	NR	NR
Nitroglycerin	None	NR	NR	NR	NR	NR	NR	<0.5U	NR	NR	NR
						SVOCs (mg/kg)					
2-Methylnaphthalene	None	NR	NR	NR	NR	NR	NR	**0.053***	NR	NR	NR
Anthracene	None	NR	NR	NR	NR	NR	NR	<0.034U	NR	NR	NR
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR	**0.036***	NR	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR	**0.031J***	NR	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	**0.041***	NR	NR	NR
Benzenemethanol	None	NR	NR	NR	NR	**0.62J***	NR	NR	NR	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	**5.5***	NR	NR	NR	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	**7.3***	NR	NR	NR	NR	NR
Benzo(ghi)perylene	None	NR	NR	NR	NR	**3.7***	NR	NR	NR	NR	NR

Table 4–2. Analytes Detected in Characterization of 14 AOCs ISM Surface Soil Samples (continued)

Aggregate		**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**
Station		**F15ss-001M**	**F15ss-002M**	**F15ss-003M**	**F15ss-004M**	**F15ss-005M**	**F15ss-006D**	**F15ss-006M**	**F15ss-007M**	**F15ss-008M**	**F15ss-009M**
Sample ID		**F15ss-001M-SO**	**F15ss-002M-SO**	**F15ss-003M-SO**	**F15ss-004M-SO**	**F15ss-005M-SO**	**F15ss-006D-SO**	**F15ss-006M-SO**	**F15ss-007M-SO**	**F15ss-008M-SO**	**F15ss-009M-SO**
Date		**10/28/04**	**10/28/04**	**10/28/04**	**10/27/04**	**10/28/04**	**10/28/04**	**10/28/04**	**10/28/04**	**10/28/04**	**10/28/04**
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 - 0.5**
Parameters Analyzed **Analyte**	**Background Criteria**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**VOCs**	**TAL Metals, Explosives, Pesticides/PCBs, SVOCs**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**
SVOCs (mg/kg)(continued)											
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR	**0.026J***	NR	NR	NR
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR	NR	<0.17U	NR	NR	NR
Carbazole	None	NR	NR	NR	NR	NR	NR	<0.17U	NR	NR	NR
Chrysene	None	NR	NR	NR	NR	NR	NR	**0.051***	NR	NR	NR
Dibenzofuran	None	NR	NR	NR	NR	NR	NR	**0.017J***	NR	NR	NR
Fluoranthene	None	NR	NR	NR	NR	NR	NR	**0.059***	NR	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	NR	NR	**0.019J***	NR	NR	NR
Naphthalene	None	NR	NR	NR	NR	NR	NR	**0.038***	NR	NR	NR
Phenanthrene	None	NR	NR	NR	NR	NR	NR	**0.05J***	NR	NR	NR
Pyrene	None	NR	NR	NR	NR	NR	NR	**0.056***	NR	NR	NR
Pesticides/PCBs (mg/kg)											
4,4'-DDE	None	NR	NR	NR	NR	NR	NR	<0.0041U	NR	NR	NR
4,4'-DDT	None	NR	NR	NR	NR	NR	NR	<0.0035U	NR	NR	NR
PCB-1260	None	NR	NR	NR	NR	NR	NR	<0.034U	NR	NR	NR

Table 4–2. Analytes Detected in Characterization of 14 AOCs ISM Surface Soil Samples (continued)

Aggregate		**F-15**	**F-15**	**F-16**	**F-16**	**F-16**	**F-16**	**F-16**	**F-16**	**F-16**	**F-16**
Station		**F15ss-010M**	**F15ss-011M**	**F16ss-001M**	**F16ss-002M**	**F16ss-003M**	**F16ss-004M**	**F16ss-005D**	**F16ss-005M**	**F16ss-006M**	**F16ss-007M**
Sample ID		**F15ss-010M-SO**	**F15ss-011M-SO**	**F16ss-001M-SO**	**F16ss-002M-SO**	**F16ss-003M-SO**	**F16ss-004M-SO**	**F16ss-005D-SO**	**F16ss-005M-SO**	**F16ss-006M-SO**	**F16ss-007M-SO**
Date		**10/28/04**	**10/28/04**	**11/03/04**	**11/03/04**	**11/03/04**	**11/03/04**	**11/03/04**	**11/03/04**	**10/28/04**	**11/03/04**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 1.0**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 1.0**	**0.0 - 0.5**
Parameters Analyzed		**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**VOCs**	**TAL Metals, Explosives, Pesticides/PCBs, SVOCs**	**TAL Metals, Explosives**	**TAL Metals, Explosives**
Analyte	**Background Criteria**										
						Metals (mg/kg)					
Aluminum	17700	12000	7300	11000	14000	12000	11000	NR	11000	16000	14000
Antimony	0.96	<1.4U	<1.3U	<1.5U	<1.4U	<1.4U	<1.5U	NR	0.56	<1.4U	**1***
Arsenic	15.4	11	**20***	12	11	11	**18***	NR	11	12	10
Barium	88.4	**100***	80	**96***	83	**89***	81	NR	**110***	**91***	**200***
Beryllium	0.88	**1.1***	**1.4***	0.86	0.8	0.84	**0.93***	NR	**1.5***	**0.94***	**2.9***
Cadmium	0	<0.24U	**0.21***	<0.26U	**0.25***	<0.26U	<0.27U	NR	**0.36***	<0.54U	**2.5***
Calcium	15800	3000	5200	3700	5300	8900	5700	NR	13000	9200	**25000***
Chromium	17.4	**20***	**24***	**27***	**23***	**24***	**27***	NR	**38J***	**24***	**55***
Cobalt	10.4	**12***	5.9	**11***	10	9.9	8.9	NR	6.5	**12***	4.6
Copper	17.7	**21***	**24***	**28***	**200***	**20***	**31***	NR	**32***	**20***	**40***
Iron	23100	**24000***	**25000***	**24000***	**25000***	**24000***	**24000***	NR	22000	**26000***	**28000***
Lead	26.1	20	**58***	**34***	**34***	23	**31***	NR	**60J***	13	**120***
Magnesium	3030	**3200***	1100	3000	**4100***	**3500***	2800	NR	**3300***	**4600***	**4000***
Manganese	1450	340	260	340	400	320	650	NR	710	420	1200
Mercury	0.036	**0.07***	**0.05***	**0.05***	0.03	**0.04***	**0.05***	NR	**0.04***	**0.04***	<0.05U
Nickel	21.1	**27***	19	**27***	**25***	**26***	**25***	NR	**26***	**28***	**25***
Potassium	927	**1200***	680	1300*	**1900***	**1700***	**1400***	NR	**1500J***	**2100***	**1400***
Selenium	1.4	<1.5U	0.44	<1.5U	<1.5U	<1.6U	<1.6U	NR	<1.7U	<1.6U	**1.7***
Sodium	123	**310***	**260***	**320***	**340***	**340***	**330***	NR	**450***	**400***	**710***
Thallium	0	<0.59U	**0.59***	<0.63U	<0.6U	<0.61U	<0.63U	NR	**0.33***	**0.2***	<0.65U
Vanadium	31.1	21	19	21	24	22	20	NR	19	26	21
Zinc	61.8	58	**100***	**110***	**100***	**82***	**99***	NR	**81***	60	**130***
						Explosives and Propellants (mg/kg)					
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	NR	**2.1***	NR	NR
Nitroglycerin	None	NR	NR	NR	NR	NR	NR	NR	**0.52***	NR	NR
						SVOCs (mg/kg)					
2-Methylnaphthalene	None	NR	NR	NR	NR	NR	NR	NR	**1***	NR	NR
Anthracene	None	NR	NR	NR	NR	NR	NR	NR	**0.053***	NR	NR
Benz(a)anthracene	None	NR	NR	NR	NR	NR	NR	NR	**0.14***	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.11***	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	**0.13***	NR	NR
Benzenemethanol	None	NR	NR	NR	NR	NR	NR	NR	**0.095***	NR	NR
Benzo(a)pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.1***	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	**0.13J***	NR	NR
Benzo(ghi)perylene	None	NR	NR	NR	NR	NR	NR	NR	**0.038J***	NR	NR

Table 4–2. Analytes Detected in Characterization of 14 AOCs ISM Surface Soil Samples (continued)

Aggregate		**F-15**	**F-15**	**F-16**	**F-16**	**F-16**	**F-16**	**F-16**	**F-16**	**F-16**	**F-16**
Station		**F15ss-010M**	**F15ss-011M**	**F16ss-001M**	**F16ss-002M**	**F16ss-003M**	**F16ss-004M**	**F16ss-005D**	**F16ss-005M**	**F16ss-006M**	**F16ss-007M**
Sample ID		**F15ss-010M-SO**	**F15ss-011M-SO**	**F16ss-001M-SO**	**F16ss-002M-SO**	**F16ss-003M-SO**	**F16ss-004M-SO**	**F16ss-005D-SO**	**F16ss-005M-SO**	**F16ss-006M-SO**	**F16ss-007M-SO**
Date		**10/28/04**	**10/28/04**	**11/03/04**	**11/03/04**	**11/03/04**	**11/03/04**	**11/03/04**	**11/03/04**	**10/28/04**	**11/03/04**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 1.0**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 1.0**	**0.0 - 0.5**
Parameters Analyzed		**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**	**VOCs**	**TAL Metals, Explosives, Pesticides/PCBs, SVOCs**	**TAL Metals, Explosives**	**TAL Metals, Explosives**
Analyte	**Background Criteria**										
SVOCs (mg/kg)(continued)											
Benzo(k)fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	**0.1***	NR	NR
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR	NR	NR	NR	**0.13J***	NR	NR
Carbazole	None	NR	NR	NR	NR	NR	NR	NR	**0.038J***	NR	NR
Chrysene	None	NR	NR	NR	NR	NR	NR	NR	**0.2***	NR	NR
Dibenzofuran	None	NR	NR	NR	NR	NR	NR	NR	**0.26***	NR	NR
Fluoranthene	None	NR	NR	NR	NR	NR	NR	NR	**0.26***	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.073***	NR	NR
Naphthalene	None	NR	NR	NR	NR	NR	NR	NR	**0.73***	NR	NR
Phenanthrene	None	NR	NR	NR	NR	NR	NR	NR	**0.52***	NR	NR
Pyrene	None	NR	NR	NR	NR	NR	NR	NR	**0.3***	NR	NR
Pesticides/PCBs (mg/kg)											
4,4'-DDE	None	NR	NR	NR	NR	NR	NR	NR	**0.012J***	NR	NR
4,4'-DDT	None	NR	NR	NR	NR	NR	NR	NR	**0.019J***	NR	NR
PCB-1260	None	NR	NR	NR	NR	NR	NR	NR	**0.12***	NR	NR

AOC = Area of concern.
DDE = Dichlorodiphenyldichloroethylene.
DDT = Dichlorodiphenyltrichloroethane.
ft = Feet.
ID = Identification.
ISM = Incremental sampling methodology.
J = Estimated value less than reporting limits.
mg/kg = Milligrams per kilogram.
NR = Not reported/not analyzed.
PCB = Polychlorinated biphenyl.
SVOC = Semi-volatile organic compound.
TAL = Target analyte list.
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.

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Table 4–3. Analytes Detected in Characterization of 14 AOCs Sediment Samples

Aggregate		**NA**	**NA**	**NA**
Station		**F16sd-001M**	**F16sd-001M**	**F16sd-002M**
Sample ID		**F16sd-001M-DUP**	**F16sd-001M-SD**	**F16sd-002M-SD**
Date		**11/03/04**	**11/03/04**	**11/03/04**
Depth (ft)		**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**
Parameters Analyzed		**TAL Metals, Explosives**	**TAL Metals, Explosives**	**TAL Metals, Explosives**
Analyte	**Background Criteria**			
Metals (mg/kg)				
Aluminum	13900	12000	13000	13000
Arsenic	19.5	11	12	8
Barium	123	65	71	93
Beryllium	0.38	**0.72***	**0.7***	**0.91***
Cadmium	0	**0.18***	<0.32U	**0.24***
Calcium	5510	2700	2300	**17000***
Chromium	18.1	17	**20***	18
Cobalt	9.1	8.8	8	**11***
Copper	27.6	19	19	19
Iron	28200	22000	25000	24000
Lead	27.4	**28***	**29***	17
Magnesium	2760	2600	2700	**4700***
Manganese	1950	410	410	460
Mercury	0.059	0.03	0.03	0.04
Nickel	17.7	**20***	**20***	**25***
Potassium	1950	1400	1400	**2000***
Sodium	112	**330***	**320***	**420***
Vanadium	26.1	21	22	23
Zinc	532	120	87	100
Aluminum	13900	12000	13000	13000
Arsenic	19.5	11	12	8
Barium	123	65	71	93

[a] Only detected site-related contaminants are presented in the table.

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

AOC = Area of concern.

ft = Feet.

ID = Identification.

mg/kg = Milligrams per kilogram.

NA = Not applicable

TAL = Target analyte list.

U = Not detected.

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

< = Less than.

Table 4–4. Analytes Detected in Characterization of 14 AOCs Surface Water Samples

Aggregate		**NA**	**NA**	**NA**
Station		**F16sw-001**	**F16sw-002**	**F16sw-002**
Sample ID		**F16sw-001-SW**	**F16sw-002-DUP**	**F16sw-002-SW**
Date		**11/03/04**	**11/03/04**	**11/03/04**
Depth (ft)		**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**	**RVAAP Full-suite analytes**
Parameters Analyzed	**Background Criteria**			
Analyte		**Total**	**Total**	**Total**
		Metals (mg/kg)		
Aluminum	3.37	0.3	0.52	0.53
Arsenic	0.0032	**0.0068 ***	<0.002 U	<0.002 U
Barium	0.0475	0.039	0.024	0.024
Calcium	41.4	**97 ***	31	31
Chromium	0	**0.0016 ***	<0.01 U	<0.01 U
Cobalt	0	**0.002 ***	<0.005 U	<0.005 U
Copper	0.0079	0.0016	<0.01 U	<0.01 U
Iron	2.56	**3.6 ***	0.75	0.75
Lead	0	**0.0015 ***	<0.003 U	<0.003 U
Magnesium	10.8	**13 ***	8	8
Manganese	0.391	**4.6 ***	0.072	0.073
Nickel	0	**0.0019 ***	<0.01 U	<0.01 U
Potassium	3.17	**7.1 ***	2.2	2.2
Sodium	21.3	3.1	3	2.9
		Explosives and Propellants (mg/kg)		
1,3,5-Trinitrobenzene	None	**0.00014 J***	<0.0003 U	<0.00031 U
4-Amino-2,6-Dinitrotoluene	None	**0.00053 ***	<0.0005 U	<0.00051 U
Nitroglycerin	None	**0.0021 ***	<0.0015 U	<0.0015 U
RDX	None	**0.00014 J***	<0.0003 U	<0.00031 U
		SVOCs (mg/kg)		
4-Methylphenol	None	**0.00065 J***	<0.0019 U	<0.0019 U
Phenol	None	**0.00062 J***	<0.0048 U	<0.0048 U
		VOCs (mg/kg)		
Acetone	None	**0.016 ***	<0.01 U	<0.01 U

[a] Only detected site-related contaminants are presented in the table.

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

AOC = Area of concern.
ft = Feet.
ID = Identification.
J = Estimated value less than reporting limits.
mg/kg = Milligrams per kilogram.
NA = Not applicable.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
RVAAP = Ravenna Army Ammunition Plant.
SVOC= Semi-volatile organic compound.
U = Not detected.
VOC = Volatile organic compound.
* = Result exceeds background criteria or no background criteria was available.
< = Less than.

Table 4–5. Human Health Chemicals of Potential Concern per the Characterization of 14 AOCs Report

Soil	Sediment	Surface Water	Groundwater
Arsenic Chromium Iron Thallium 2-Methylnapthalene Benzo(a)pyrene Benzo(ghi)perylene Phenanthrene Nitrocellulose	No COPCs detected.	Arsenic Manganese 4-Amino-2,6-dinitrotoluene	Not evaluated – no monitoring wells present at the AOC at time of investigation.

Adapted from Table F-15/F-16 -15, Characterization of 14 AOCs at the Ravenna Army Ammunition Plant (MKM 2007).
AOC = Area of concern.
COPC = Chemical of potential concern.

Table 4–6. Chemicals Exceeding Ecological Screening Values per the Characterization of 14 AOCs Report

Soil	Sediment	Surface Water	Groundwater
Arsenic Copper Chromium Iron Lead Selenium Zinc Mercury 4,4-DDT Aroclor 1260 Carbazole Dibenzofuran Naphthalene Nitrocellulose Nitroglycerin	Beryllium	Iron Manganese Acetone	Not evaluated – no monitoring wells present at the AOC at time of investigation.

Adapted from Table F-15/F-16 -16, Characterization of 14 AOCs at the Ravenna Army Ammunition Plant (MKM 2007).
AOC = Area of concern.
DDT = Dichlorodiphenyltrichloroethane.

Table 4–7. Chemicals Detected at Concentrations above Screening Criteria in Previous Investigations

Surface Soil	Subsurface Soil	Sediment	Surface Water
Arsenic Chromium Cobalt Benzo(a)pyrene	Not previously sampled	Chromium	Arsenic Manganese

Note: This table was generated using data from the Characterization of 14 AOCs at the Ravenna Army Ammunition Plant (MKM 2007).

Table 4–8. Analytes Detected in 2009 Under Slab Sampling Samples

Aggregate	Background Criteria	F-15	F-15	F-15	F-16
Station		**F15ss-012M**	**F15ss-012M**	**F15ss-012M**	**F16ss-008M**
Sample ID		**F15ss-012M-0502-SO**	**F15ss-012M-0500-SO**	**F15ss-012M-0503-SO**	**F16ss-008M-0504-SO**
Date		**11/04/09**	**11/04/09**	**11/04/09**	**11/04/09**
Depth (ft)		**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, Explosives**
Analyte					
Metals (mg/kg)					
Aluminum	17700	11600J	12200J	11600J	9410J
Antimony	0.96	0.278J	0.444J	0.441J	0.423J
Arsenic	15.4	9.18J	10J	10J	11.8
Barium	88.4	76.7J	76.1J	80J	58.4J
Beryllium	0.88	0.578	0.588	0.592	0.495
Cadmium	0	**1.06***	**1.03***	**1.09***	**0.987***
Calcium	15800	5760	5690	6150	6870
Chromium	17.4	**19.8J***	**21.9J***	**18.5J***	15.8J
Cobalt	10.4	6.33	6.83	6.58	6.13
Copper	17.7	16.3	16.9	17.2	15.9
Iron	23100	22600J	22800J	**23200J***	20700J
Lead	26.1	18	16.9	19.8	15.2
Magnesium	3030	**3190J***	**3300J***	**3410J***	**3420J***
Manganese	1450	340J	330J	366J	340J
Mercury	0.036	**0.0361J***	0.03J	**0.0366J***	0.0224J
Nickel	21.1	**35.5J***	**30.6J***	**35.3J***	**29.6J***
Potassium	927	859J	**981J***	848J	826J
Selenium	1.4	0.307J	0.367J	0.36J	0.408
Sodium	123	85.9	102	91.8	54.8
Thallium	0	**0.143J***	**0.143J***	**0.155J***	**0.137J***
Vanadium	31.1	21.8J	22J	21.6J	16.8J
Zinc	61.8	56.5J	56J	58.9J	53.8J
Explosives and Propellants (mg/kg)					
Nitrocellulose	None	**2.65J***	<2.5U	**2.87J***	<2.49U

[a] Only detected site-related contaminants 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.

NR = Not reported/not analyzed.

TAL = Target analyte list.

U = Not detected.

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

< = Less than.

Table 4–9. Analytes Detected in 2009 USACE ISM Surface Soil Sampling Samples

Aggregate		**F-15**	**F-15**	**F-16**	**F-16**
Station		**F15ss-040**	**FWCss-007**	**F16ss-030**	**FWCss-008**
Sample ID		**F15ss-040-0001-SO**	**FWCss-007-0001-SO**	**F16ss-030-0001-SO**	**FWCss-008-0001-SO**
Date		**12/02/09**	**12/02/09**	**12/02/09**	**12/02/09**
Depth (ft)		**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**
Parameters Analyzed		**Explosives**	**TAL Metals, SVOCs**	**Explosives**	**TAL Metals, SVOCs**
Analyte	**Background Criteria**				
Metals (mg/kg)					
Aluminum	17700	NR	15900	NR	11500
Antimony	0.96	NR	**1.4J-***	NR	**1.5J-***
Arsenic	15.4	NR	2.7	NR	14
Barium	88.4	NR	88.1J	NR	74.9J
Beryllium	0.88	NR	0.78J	NR	0.7J
Calcium	15800	NR	5260	NR	8070
Chromium	17.4	NR	**58.4***	NR	**52***
Cobalt	10.4	NR	7J-	NR	7J-
Copper	17.7	NR	12.4J-	NR	14.4J-
Iron	23100	NR	**27900J***	NR	**29300J***
Lead	26.1	NR	**27.7J+***	NR	**31J+***
Magnesium	3030	NR	**3250J-***	NR	**3680J-***
Manganese	1450	NR	516J	NR	588J
Mercury	0.036	NR	**0.042***	NR	0.019
Nickel	21.1	NR	**22.9J-***	NR	**21.8J-***
Potassium	927	NR	**1560J-***	NR	**1440J-***
Selenium	1.4	NR	0.86J	NR	0.8J
Sodium	123	NR	80.8	NR	68.1
Vanadium	31.1	NR	24.3J-	NR	16.9J-
Zinc	61.8	NR	47.6J-	NR	48.7J-
SVOCs (mg/kg)					
2-Methylnaphthalene	None	NR	**0.098J***	NR	**0.088J***
Anthracene	None	NR	**0.023***	NR	**0.024***
Benz(a)anthracene	None	NR	**0.016J***	NR	**0.022J***
Benzo(a)pyrene	None	NR	**0.028J***	NR	**0.033J***
Benzo(b)fluoranthene	None	NR	<0.33U	NR	**0.05***
Benzo(ghi)perylene	None	NR	<0.33U	NR	**0.035***

Table 4–9. Analytes Detected in 2009 USACE ISM Surface Soil Sampling Samples (continued)

Aggregate		**F-15**	**F-15**	**F-16**	**F-16**
Station		**F15ss-040**	**FWCss-007**	**F16ss-030**	**FWCss-008**
Sample ID		**F15ss-040-0001-SO**	**FWCss-007-0001-SO**	**F16ss-030-0001-SO**	**FWCss-008-0001-SO**
Date		**12/02/09**	**12/02/09**	**12/02/09**	**12/02/09**
Depth (ft)		**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**
Parameters Analyzed					
Analyte	**Background Criteria**	**Explosives**	**TAL Metals, SVOCs**	**Explosives**	**TAL Metals, SVOCs**
Benzo(k)fluoranthene	None	NR	<0.33U	NR	**0.028J***
Chrysene	None	NR	**0.014J***	NR	**0.018J***
Fluoranthene	None	NR	**0.046***	NR	**0.052***
Indeno(1,2,3-cd)pyrene	None	NR	<0.33U	NR	**0.039***
Naphthalene	None	NR	**0.064J***	NR	**0.054J***

[a] Only detected site-related contaminants 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.
ISM = Incremental sampling methodology.
J = Estimated value less than reporting limits.
J+ = Result is estimated-biased high.
J- = Result is estimated- biased low.
mg/kg = Milligrams per kilogram.
NR = Not reported/not analyzed.
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 4–10. PBA08 RI Surface Soil Samples and Rationales

PBA08 RI Station	Targeted Area	Purpose	Analyses Performed				
			Metals	Explosives	VOCs	Pesticides/ PCBs	SVOC
F15ss-035M	Drainage ditch north of Building U-17 (Boiler House) and F15ss-009M	Complete characterization of ditch and define lateral extent of previously identified surface contamination	Y	Y	N	N	Y
		QA/QC	Y	Y	N	N	Y
			Y	Y	N	N	Y
F15ss-036M	Drainage ditch downstream of Building F-15 operational area	Complete characterization of ditch and define lateral extent of previously identified surface contamination	Y	Y	N	N	Y
F15ss-037M	ISM area around F15ss-011M	Delineate lateral extent of previously identified surface contamination	Y	Y	N	N	Y
F15ss-038M	Building F-15 footprint	Complete characterization of former Building footprint	N	N	N	N	Y
F16ss-026M	Drainage ditches around F16ss-004M and former Building U-18	Delineate lateral extent of previously identified surface contamination; Analyzed for RVAAP full-suite analytes	Y	Y	Y	Y	Y
F16ss-027M	Drainage ditch southwest of Building F-16 near Slagle Road	Complete characterization of ditch and define lateral extent of previously identified surface contamination	Y	Y	N	N	Y
F16ss-028M	Building F-16 footprint	Complete characterization of former Building footprint	N	N	N	N	Y

PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
PCB = Polychlorinated biphenyl.
ISM = Incremental sampling methodology.
QA = Quality assurance.
QC = Quality control.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
VOC = Volatile organic compound.

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

Aggregate		**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-16**
Station		**F15ss-035M**	**F15ss-035M**	**F15ss-035M**	**F15ss-036M**	**F15ss-036M**	**F15ss-037M**	**F15ss-037M**	**F15ss-038M**	**F16ss-026M**
Sample ID		**F15ss-035M-6121-FD**	**F15ss-035M-5428-SO**	**F15ss-035M-5812-SO**	**F15ss-036M-5427-SO**	**F15ss-036M-5813-SO**	**F15ss-037M-5429-SO**	**F15ss-037M-5815-SO**	**F15ss-038M-5430-SO**	**F16ss-026M-5431-SO**
Date		**02/24/10**	**02/24/10**	**10/19/10**	**02/24/10**	**10/19/10**	**02/24/10**	**10/19/10**	**02/24/10**	**02/24/10**
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[a] **Analyte**	**Background Criteria**[b]	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**Chromium**	**TAL Metals, Explosives, SVOCs**	**Chromium**	**TAL Metals, Explosives, SVOCs**	**Chromium**	**SVOCs**	**RVAAP Full-suite analytes**
Metals (mg/kg)										
Aluminum	17700	12200J	14000J	NR	9950J	NR	11000J	NR	NR	13700J
Antimony	0.96	0.18J	0.16J	NR	0.16J	NR	0.3J	NR	NR	0.18J
Arsenic	15.4	10.1	10	NR	10.4	NR	10.1	NR	NR	13.4
Barium	88.4	**91.2***	**99.3***	NR	87.3	NR	78.3	NR	NR	**106***
Beryllium	0.88	0.87	**0.97***	NR	0.78	NR	0.58	NR	NR	0.78
Cadmium	0	**0.16J***	**0.17J***	NR	**0.23***	NR	**0.41***	NR	NR	**0.17J***
Calcium	15800	10600	12200	NR	6740	NR	3620	NR	NR	5760
Chromium	17.4	68.5R	101R	**18***	86.2R	16.5	96.8R	**19.4***	NR	**58.5***
Cobalt	10.4	9.4	9.9	NR	9.3	NR	9.5	NR	NR	**11.5***
Copper	17.7	**24***	**21.1***	NR	**38.4***	NR	14.4	NR	NR	**20.8***
Iron	23100	**23500***	**24100***	NR	**24500***	NR	**24800***	NR	NR	**26800***
Lead	26.1	21.1	**31.1***	NR	19.6	NR	18	NR	NR	16.7
Magnesium	3030	**4280***	**4270***	NR	2790	NR	2520	NR	NR	**3620***
Manganese	1450	485	591	NR	830	NR	646	NR	NR	686
Mercury	0.036	**0.044J***	**0.059J***	NR	**0.072J***	NR	**0.05J***	NR	NR	**0.048J***
Nickel	21.1	**42.4***	55*	NR	**47.3***	NR	**54.4***	NR	NR	**39.6***
Potassium	927	922	**1150***	NR	767	NR	907	NR	NR	**1310***
Selenium	1.4	1.1	1.3	NR	1.2	NR	0.88	NR	NR	1.2
Silver	0	**0.034J***	**0.037J***	NR	**0.043J***	NR	**0.043J***	NR	NR	**0.034J***
Sodium	123	96.5J	**125***	NR	77.3J	NR	47.9J	NR	NR	67.5J
Thallium	0	**0.17J***	**0.17J***	NR	**0.14J***	NR	**0.18J***	NR	NR	**0.18J***
Vanadium	31.1	18.3	18.3	NR	16.9	NR	18.6	NR	NR	20.8
Zinc	61.8	57.2	**67.9***	NR	**74.3***	NR	49	NR	NR	**68.7***
Explosives and Propellants (mg/kg)										
Nitrocellulose	None	NR	NR	NR	NR	NR	NR	NR	NR	**1.1J***
SVOCs (mg/kg)										
2-Methylnaphthalene	None	NR	NR	NR	NR	NR	NR	NR	NR	**0.14J***
Acenaphthene	None	<0.027U	<0.027U	NR	**0.08***	NR	<0.0068U	NR	<0.027U	<0.2U
Acenaphthylene	None	<0.027U	<0.027U	NR	**0.022***	NR	<0.0068U	NR	<0.027U	<0.2U
Anthracene	None	**0.048***	**0.029***	NR	**0.13***	NR	<0.0068U	NR	<0.027U	<0.2U
Benz(a)anthracene	None	**0.14***	**0.12***	NR	**0.49***	NR	**0.013***	NR	<0.027U	<0.2U
Benzo(a)pyrene	None	**0.14***	**0.13***	NR	**0.48***	NR	**0.014***	NR	<0.027U	<0.2U
Benzo(b)fluoranthene	None	**0.22***	**0.21***	NR	**0.69***	NR	**0.026***	NR	<0.027U	**0.031J***
Benzo(ghi)perylene	None	**0.11***	**0.1***	NR	**0.33***	NR	**0.012***	NR	<0.027U	<0.2U
Benzo(k)fluoranthene	None	**0.07***	**0.072***	NR	**0.26***	NR	**0.01***	NR	<0.027U	<0.2U
Chrysene	None	**0.18***	**0.15***	NR	**0.54***	NR	**0.019***	NR	<0.027U	**0.031J***

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

Aggregate		**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-16**
Station		**F15ss-035M**	**F15ss-035M**	**F15ss-035M**	**F15ss-036M**	**F15ss-036M**	**F15ss-037M**	**F15ss-037M**	**F15ss-038M**	**F16ss-026M**
Sample ID		**F15ss-035M-6121-FD**	**F15ss-035M-5428-SO**	**F15ss-035M-5812-SO**	**F15ss-036M-5427-SO**	**F15ss-036M-5813-SO**	**F15ss-037M-5429-SO**	**F15ss-037M-5815-SO**	**F15ss-038M-5430-SO**	**F16ss-026M-5431-SO**
Date		**02/24/10**	**02/24/10**	**10/19/10**	**02/24/10**	**10/19/10**	**02/24/10**	**10/19/10**	**02/24/10**	**02/24/10**
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 [a]	**Background Criteria [b]**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**Chromium**	**TAL Metals, Explosives, SVOCs**	**Chromium**	**TAL Metals, Explosives, SVOCs**	**Chromium**	**SVOCs**	**RVAAP Full-suite analytes**
Analyte										
					SVOCs (mg/kg), continued					
Dibenz(a,h)anthracene	None	**0.029***	<0.027U	NR	**0.089***	NR	<0.0068U	NR	<0.027U	<0.2U
Fluoranthene	None	**0.32***	**0.25***	NR	**1.2***	NR	**0.028***	NR	<0.027U	**0.04J***
Fluorene	None	<0.027U	<0.027U	NR	**0.062***	NR	<0.0068U	NR	<0.027U	<0.2U
Indeno(1,2,3-cd)pyrene	None	**0.094***	**0.085***	NR	**0.3***	NR	**0.011***	NR	<0.027U	<0.2U
Naphthalene	None	**0.18***	**0.13***	NR	**0.095***	NR	**0.043***	NR	<0.027U	**0.069J***
Phenanthrene	None	**0.25***	**0.19***	NR	**0.71***	NR	**0.029***	NR	<0.027U	**0.057J***
Pyrene	None	**0.23***	**0.19***	NR	**0.85***	NR	**0.02***	NR	<0.027U	**0.034J***
					VOCs (mg/kg)					
Chloroform	None	NR	NR	NR	NR	NR	NR	NR	NR	**0.00068J***

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

Aggregate		**F-16**	**F-16**
Station		**F16ss-027M**	**F16ss-028M**
Sample ID		**F16ss-027M-5432-SO**	**F16ss-028M-5433-SO**
Date		**02/24/10**	**02/24/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed [a]		**TAL Metals,**	
Analyte	**Background Criteria** [b]	**Explosives, SVOCs**	**SVOCs**
Metals (mg/kg)			
Aluminum	17700	12900J	NR
Antimony	0.96	0.17J	NR
Arsenic	15.4	9.8	NR
Barium	88.4	71.4	NR
Beryllium	0.88	0.84	NR
Cadmium	0	**0.23***	NR
Calcium	15800	7690	NR
Chromium	17.4	**65.3***	NR
Cobalt	10.4	8.6	NR
Copper	17.7	**18.2***	NR
Iron	23100	**29100***	NR
Lead	26.1	17.8	NR
Magnesium	3030	**3310***	NR
Manganese	1450	642	NR
Mercury	0.036	**0.045J***	NR
Nickel	21.1	**37.3***	NR
Potassium	927	**1140***	NR
Selenium	1.4	1.1	NR
Silver	0	**0.048J***	NR
Sodium	123	92.3J	NR
Thallium	0	**0.19J***	NR
Vanadium	31.1	20.9	NR
Zinc	61.8	**67***	NR
Explosives and Propellants (mg/kg)			
Nitrocellulose	None	NR	NR
SVOCs (mg/kg)			
2-Methylnaphthalene	None	NR	NR
Acenaphthene	None	<0.027U	<0.0068R
Acenaphthylene	None	<0.027U	<0.0068R
Anthracene	None	<0.027U	<0.0068R
Benz(a)anthracene	None	**0.075***	**0.007J***
Benzo(a)pyrene	None	**0.07***	**0.0071J***
Benzo(b)fluoranthene	None	**0.12***	**0.0093J***
Benzo(ghi)perylene	None	**0.054***	<0.0068R
Benzo(k)fluoranthene	None	**0.039***	<0.0068R
Chrysene	None	**0.086***	**0.0079J***

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

Aggregate		**F-16**	**F-16**
Station		**F16ss-027M**	**F16ss-028M**
Sample ID		**F16ss-027M-5432-SO**	**F16ss-028M-5433-SO**
Date		**02/24/10**	**02/24/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed [a]		**TAL Metals,**	
Analyte	**Background Criteria** [b]	**Explosives, SVOCs**	**SVOCs**
SVOCs (mg/kg), continued			
Dibenz(a,h)anthracene	None	<0.027U	<0.0068R
Fluoranthene	None	**0.19***	**0.012J***
Fluorene	None	<0.027U	<0.0068R
Indeno(1,2,3-cd)pyrene	None	**0.043***	<0.0068R
Naphthalene	None	**0.088***	<0.0068R
Phenanthrene	None	**0.14***	<0.0068R
Pyrene	None	**0.14***	**0.0096J***
VOCs (mg/kg)			
Chloroform	None	NR	NR

[a] Only detected site-related contaminants 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.
ISM = Incremental sampling methodology.
J = Estimated value less than reporting limits.
mg/kg = Milligrams per kilogram.
NR = Not reported/not analyzed.
PBA08 RI = Performance-Based Acquisition 2008 Remedial Investigation.
R = Rejected
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
TAL = Target analyte list.
U = Non-detectable concentration.
VOC = Volatile organic compound.
* = Result exceeds background criteria or no background criteria was available.
< = Less than.

Table 4–12. Chromium Speciation Samples under PBA08 RI

PBA08 RI Location	Rationale for Sample Selection
F15ss-034	Discrete sample collected to assess chromium speciation. Previous chromium result represents elevated chromium concentration (F15ss-004M at 29 mg/kg)
F16ss-024	Discrete sample collected to assess chromium speciation. Previous chromium result represents near background chromium concentration (F15ss-005M at 20 mg/kg)
F16ss-025	Discrete sample collected to assess chromium speciation. Previous chromium result represents elevated chromium concentration (F15ss-007M at 24 mg/kg)
F15ss-035M	Recollected for total Cr only to verify preliminary result of 101 mg/kg. Original results were rejected due to suspected laboratory contamination from ISM processing/grinding device.
F15ss-036M	Recollected for total Cr only to verify preliminary result of 86.2 mg/kg. Original results were rejected due to suspected laboratory contamination from ISM processing/grinding device.
F15ss-037M	Recollected for total Cr only to verify preliminary results of 96.8 mg/kg. Original results were rejected due to suspected laboratory contamination from ISM processing/grinding device.
F15ss-036	Recollected for total and hexavalent Cr to verify preliminary speciation result of 86.2 mg/kg at F15ss-036M
F16ss-026	Recollected for total and hexavalent Cr to verify preliminary speciation results of 58.5 mg/kg at F16ss-026M
F16ss-027	Recollected for total and hexavalent Cr to verify preliminary speciation results of 65.3 mg/kg at F16ss-027M

Cr = Chromium.
ISM = Incremental sampling methodology.
mg/kg = Milligrams per kilogram.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.

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

Aggregate		F-15	F-15	F-15	F-15	F-15	F-16	F-16	F-16	F-16
Station		**F15sb-031**	**F15sb-032**	**F15sb-033**	**F15ss-034**	**F15ss-036**	**F16sb-021**	**F16sb-021**	**F16sb-022**	**F16ss-024**
Sample ID		**F15sb-031-5405-SO**	**F15sb-032-5409-SO**	**F15sb-033-5413-SO**	**F15ss-034-5436-SO**	**F15ss-036-5814-SO**	**F16sb-021-6122-FD**	**F16sb-021-5417-SO**	**F16sb-022-5421-SO**	**F16ss-024-5434-SO**
Date		**03/02/10**	**03/02/10**	**03/02/10**	**02/24/10**	**10/19/10**	**03/02/10**	**03/02/10**	**03/02/10**	**02/24/10**
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 [a] **Analyte**	**Background Criteria [b]**	**RVAAP Full-suite analytes**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**Chromium Speciation**	**Chromium Speciation**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**Chromium Speciation**
Metals (mg/kg)										
Aluminum	17700	14900	13000	15300	NR	NR	8050	15600	15800	NR
Antimony	0.96	0.31 J	0.12 J	0.2 J	NR	NR	0.81 J	0.53 J	0.24 J	NR
Arsenic	15.4	11.7	10.4	11.6	NR	NR	**62.5 ***	**31.3 ***	14.6	NR
Barium	88.4	**117 ***	79.8	**94.7 ***	NR	NR	**107 ***	**149 ***	**192 ***	NR
Beryllium	0.88	0.85	0.55	0.78	NR	NR	0.77	**1.1 ***	**2.6 ***	NR
Cadmium	0	**0.12 J***	**0.094 J***	**0.23 J***	NR	NR	**0.44 ***	**0.29 J***	**0.32 ***	NR
Calcium	15800	5970	2600	5020	NR	NR	3780	3760	**58500 ***	NR
Chromium	17.4	16.6	15.8	**19.5 ***	**18.4 ***	**21.9 ***	15.1	**23.7 ***	13.2	**21 ***
Chromium, hexavalent	None	NR	NR	NR	<1.2 U	**0.4 J***	NR	NR	NR	**2.2 ***
Cobalt	10.4	**10.8 J***	8.2 J	8.5 J	NR	NR	6.7	**15.7 J***	3.6 J	NR
Copper	17.7	11.7 J	13.8 J	**18.6 J***	NR	NR	**31.5 ***	**28.3 J***	16.7 J	NR
Iron	23100	**28400 ***	**24300 ***	**26300 ***	NR	NR	**28000 ***	**31900 ***	20400	NR
Lead	26.1	15.5	14.1	**28.5 ***	NR	NR	**52.5 J***	**27.9 ***	**40.8 ***	NR
Magnesium	3030	**3120 ***	2470	**3430 ***	NR	NR	1720	**4510 ***	**8940 ***	NR
Manganese	1450	804	480	341	NR	NR	421	620	**2140 ***	NR
Mercury	0.036	**0.044 J***	**0.048 J***	**0.047 J***	NR	NR	**0.14 ***	**0.039 J***	**0.081 J***	NR
Nickel	21.1	17.3 J	15.4 J	**21.6 J***	NR	NR	20.1	**37 J***	11.4 J	NR
Potassium	927	851 J	883 J	**1070 J***	NR	NR	716	**1360 J***	**1020 J***	NR
Selenium	1.4	**1.4 ***	1	1.2	NR	NR	**3.3 ***	**2.5 ***	**2.9 ***	NR
Silver	0	<0.039 UJ	<0.033 UJ	**0.035 J***	NR	NR	**0.11 J***	**0.065 J***	**0.034 J***	NR
Sodium	123	65.5 J	40.6 J	62.5 J	NR	NR	38 J	58.1 J	**390 ***	NR
Thallium	0	**0.19 J***	**0.15 J***	**0.19 J***	NR	NR	**0.95 ***	**0.69 ***	**0.64 ***	NR
Vanadium	31.1	26.5 J	23.2 J	23.7 J	NR	NR	16.4 J	26.3 J	12.1 J	NR
Zinc	61.8	42.6	40.2	58.7	NR	NR	**86.5 J***	**76.9 ***	**75 ***	NR
Explosives (mg/kg)										
2,6-Dinitrotoluene	None	<0.24 U	<0.25 U	<0.24 U	NR	NR	<0.24 U	**0.017 J***	<0.24 U	NR
SVOCs (mg/kg)										
2-Methylnaphthalene		**0.63 ***	NR	NR	NR	NR	NR	NR	NR	NR
Acenaphthene	None	<0.063 U	<0.0089 U	<0.0089 U	NR	NR	<0.0086 U	**0.014 ***	<0.0086 U	NR
Anthracene	None	**0.02 J***	<0.0089 U	<0.0089 U	NR	NR	<0.0086 U	**0.016 ***	**0.057 ***	NR
Benz(a)anthracene	None	**0.066 ***	<0.0089 U	**0.019 ***	NR	NR	<0.0086 U	**0.052 ***	**0.16 ***	NR
Benzo(a)pyrene	None	**0.18 ***	<0.0089 U	**0.017 ***	NR	NR	**0.024 ***	**0.046 ***	**0.17 ***	NR
Benzo(b)fluoranthene	None	**0.088 ***	<0.0089 U	**0.027 ***	NR	NR	**0.036 ***	**0.067 ***	**0.39 ***	NR
Benzo(ghi)perylene	None	<0.063 U	<0.0089 U	**0.016 ***	NR	NR	**0.019 ***	**0.03 ***	**0.16 ***	NR
Benzo(k)fluoranthene	None	**0.13 ***	<0.0089 U	**0.013 ***	NR	NR	<0.0086 U	**0.022 ***	**0.17 ***	NR
Bis(2-ethylhexyl)phthalate	None	**0.029 J***	NR	NR	NR	NR	NR	NR	NR	NR

Table 4–13. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Aggregate		**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-16**	**F-16**	**F-16**	**F-16**
Station		**F15sb-031**	**F15sb-032**	**F15sb-033**	**F15ss-034**	**F15ss-036**	**F16sb-021**	**F16sb-021**	**F16sb-022**	**F16ss-024**
Sample ID		**F15sb-031-5405-SO**	**F15sb-032-5409-SO**	**F15sb-033-5413-SO**	**F15ss-034-5436-SO**	**F15ss-036-5814-SO**	**F16sb-021-6122-FD**	**F16sb-021-5417-SO**	**F16sb-022-5421-SO**	**F16ss-024-5434-SO**
Date		**03/02/10**	**03/02/10**	**03/02/10**	**02/24/10**	**10/19/10**	**03/02/10**	**03/02/10**	**03/02/10**	**02/24/10**
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 [a]	**Background Criteria** [b]	**RVAAP Full-suite analytes**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**Chromium Speciation**	**Chromium Speciation**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**Chromium Speciation**
Analyte										
SVOCs (mg/kg), continued										
Chrysene	None	**0.092 ***	<0.0089 U	**0.024 ***	NR	NR	<0.0086 U	**0.075 ***	**0.29 ***	NR
Dibenzofuran	None	**0.098 J***	NR	NR	NR	NR	NR	NR	NR	NR
Fluoranthene	None	**0.093 ***	<0.0089 U	**0.034 ***	NR	NR	**0.038 ***	**0.084 ***	**0.25 ***	NR
Fluorene	None	<0.063 U	<0.0089 U	<0.0089 U	NR	NR	<0.0086 U	**0.012 ***	<0.0086 U	NR
Indeno(1,2,3-cd)pyrene	None	<0.063 U	<0.0089 U	<0.0089 U	NR	NR	<0.0086 U	**0.02 ***	**0.12 ***	NR
Naphthalene	None	**0.33 ***	<0.0089 U	**0.06 ***	NR	NR	**0.096 ***	**0.25 ***	**0.5 ***	NR
Phenanthrene	None	**0.18 ***	<0.0089 U	**0.046 ***	NR	NR	**0.097 ***	**0.28 ***	**0.62 ***	NR
Pyrene	None	**0.11 ***	<0.0089 U	**0.03 ***	NR	NR	**0.038 ***	**0.083 ***	**0.24 ***	NR
Chrysene	None	**0.092 ***	<0.0089 U	**0.024 ***	NR	NR	<0.0086 U	**0.075 ***	**0.29 ***	NR

Table 4–13. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Aggregate		F-16	F-16	F-16
Station		**F16ss-025**	**F16ss-026**	**F16ss-027**
Sample ID		**F16ss-025-5435-SO**	**F16ss-026-5816-SO**	**F16ss-027-5817-SO**
Date		**02/24/10**	**10/18/10**	**10/18/10**
Depth (ft)		**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Parameters Analyzed [a]		**Chromium Speciation**	**Chromium Speciation**	**Chromium Speciation**
Analyte	**Background Criteria [b]**			
Metals (mg/kg)				
Aluminum	17700	NR	NR	NR
Antimony	0.96	NR	NR	NR
Arsenic	15.4	NR	NR	NR
Barium	88.4	NR	NR	NR
Beryllium	0.88	NR	NR	NR
Cadmium	0	NR	NR	NR
Calcium	15800	NR	NR	NR
Chromium	17.4	**21.4 ***	16.1	**19.1 ***
Chromium, hexavalent	None	**0.4 J***	<0.95 U	<1 U
Cobalt	10.4	NR	NR	NR
Copper	17.7	NR	NR	NR
Iron	23100	NR	NR	NR
Lead	26.1	NR	NR	NR
Magnesium	3030	NR	NR	NR
Manganese	1450	NR	NR	NR
Mercury	0.036	NR	NR	NR
Nickel	21.1	NR	NR	NR
Potassium	927	NR	NR	NR
Selenium	1.4	NR	NR	NR
Silver	0	NR	NR	NR
Sodium	123	NR	NR	NR
Thallium	0	NR	NR	NR
Vanadium	31.1	NR	NR	NR
Zinc	61.8	NR	NR	NR
Explosives (mg/kg)				
2,6-Dinitrotoluene	None	NR	NR	NR
SVOCs (mg/kg)				
2-Methylnaphthalene		NR	NR	NR
Acenaphthene	None	NR	NR	NR
Anthracene	None	NR	NR	NR
Benz(a)anthracene	None	NR	NR	NR
Benzo(a)pyrene	None	NR	NR	NR
Benzo(b)fluoranthene	None	NR	NR	NR
Benzo(ghi)perylene	None	NR	NR	NR
Benzo(k)fluoranthene	None	NR	NR	NR
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR

Table 4–13. Analytes Detected in PBA08 RI Discrete Surface Soil Samples (continued)

Aggregate		F-16	F-16	F-16
Station		F16ss-025	F16ss-026	F16ss-027
Sample ID		F16ss-025-5435-SO	F16ss-026-5816-SO	F16ss-027-5817-SO
Date		02/24/10	10/18/10	10/18/10
Depth (ft)		0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Parameters Analyzed [a]		Chromium Speciation	Chromium Speciation	Chromium Speciation
Analyte	Background Criteria [b]			
SVOCs (mg/kg), continued				
Chrysene	None	NR	NR	NR
Dibenzofuran	None	NR	NR	NR
Fluoranthene	None	NR	NR	NR
Fluorene	None	NR	NR	NR
Indeno(1,2,3-cd)pyrene	None	NR	NR	NR
Naphthalene	None	NR	NR	NR
Phenanthrene	None	NR	NR	NR
Pyrene	None	NR	NR	NR
Chrysene	None	NR	NR	NR

[a] Only detected site-related contaminants are presented in the table.

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

AOC = Area of concern.
ft = Feet.
ID = Identification.
J = Estimated value less than reporting limits.
mg/kg = Milligrams per kilogram.
NR = Not reported/not analyzed.
PBA08 RI = Performance-Based Acquisition 2008 Remedial Investigation.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
TAL = Target analyte list.
U = Non-detectable concentration.
UJ = Not detected, reporting limit estimated.
* = Result exceeds background criteria or no background criteria was available.
< = Less than.

Table 4–14. Total Chromium Concentration Comparison

Location	Concentration (mg/kg) of Samples Processed with Low-grade Metal Blade 02/24/2010	Concentration (mg/kg) of Samples Processed with Mortar and Pestle 10/19/2010
F15ss-035M	101	18
F15ss-036M	86.2	21.9
F15ss-037M	96.8	19.4

mg/kg= Milligrams per kilogram.

Table 4–15. Subsurface Soil Rationale and Analyses

PBA08 RI Location	Comments/Rationale	Sample Type	Depth (ft bgs)	Analyses Performed				
				Metals	Explosives	VOCs	Pesticides/ PCBs	SVOC
F15sb-031	Delineate vertical extent of previously identified contamination at F15ss-011M; Analyzed for RVAAP full-suite analytes	Discrete	0–1	Y	Y	Y	Y	Y
		Discrete	1–4	Y	Y	Y	Y	Y
		Discrete	4–7	Y	Y	Y	Y	Y
		NA	7–13	N	N	N	N	N
F15sb-032	Delineate vertical extent of previously identified contamination at F15ss-005M	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	7–13	N	N	N	N	N
F15sb-033	Delineate vertical extent of previously identified contamination at F15ss-002M	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[b]	7–13	Y	Y	N	N	PAH
F16sb-021	Delineate vertical extent of previously identified contamination at F16ss-007M	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]	7–13	Y	Y	N	N	PAH
	QA/QC	Discrete	0–1	Y	Y	N	N	PAH
		Discrete	1–4	Y	Y	N	N	PAH
		Discrete	0–1	Y	Y	N	N	PAH
		Discrete	1–4	Y	Y	N	N	PAH
F16sb-022	Delineate vertical extent of previously identified contamination at F16ss-004M around former Building U-18	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	7–13	N	N	N	N	N
F16sb-023	Geotechnical evaluation	Discrete	4-5	N	N	N	N	N
		Discrete	8-8.8	N	N	N	N	N

[a] Sample analyzed by the laboratory based on exceedance of preliminary screening criteria of the 4–7 ft bgs sample interval.

[b] One sample (10%) from 7–13 ft bgs was submitted for laboratory analysis to characterize subsurface soil to 13 ft bgs.

bgs = Below ground surface.
ft = Feet.
NA = Sample not analyzed by the laboratory based on preliminary screening criteria results of the 4–7 ft bgs sample interval.
NS = Not sampled due to refusal.
PAH = Polycyclic aromatic hydrocarbon.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
PCB = Polychlorinated biphenyl.
QA = Quality assurance.
QC = Quality control.
RVAAP = Ravenna Army and Ammunition Plant.
SVOC = Semi-volatile organic compound.
VOC = Volatile organic compound.

Table 4–16. Analytes Detected in PBA08 RI Subsurface Soil Samples

Aggregate	**Background Criteria [b]**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-15**	**F-16**	**F-16**
Station		**F15sb-031**	**F15sb-031**	**F15sb-032**	**F15sb-032**	**F15sb-033**	**F15sb-033**	**F15sb-033**	**F16sb-021**	**F16sb-021**
Sample ID		**F15sb-031-5406-SO**	**F15sb-031-5407-SO**	**F15sb-032-5410-SO**	**F15sb-032-5411-SO**	**F15sb-033-5414-SO**	**F15sb-033-5415-SO**	**F15sb-033-5416-SO**	**F16sb-021-6123-FD**	**F16sb-021-5418-SO**
Date		**03/02/10**	**03/02/10**	**03/02/10**	**03/02/10**	**03/02/10**	**03/02/10**	**03/02/10**	**03/02/10**	**03/02/10**
Depth (ft)		**1.0 - 4.0**	**4.0 - 7.0**	**1.0 - 4.0**	**4.0 - 7.0**	**1.0 - 4.0**	**4.0 - 7.0**	**7.0 - 13.0**	**1.0 - 4.0**	**1.0 - 4.0**
Parameters Analyzed [a]		**RVAAP Full-suite analytes**	**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**
Analyte										
Metals (mg/kg)										
Aluminum	19500	14000	11800	15100	12500	16200	13700	11000 J	10500	10200
Antimony	0.96	<0.62 UJ	<0.59 R	<0.61 UJ	<0.59 R	0.089 J	<0.6 R	0.077 J	0.075 J	<0.63 UJ
Arsenic	19.8	9.5	12.2 J	7	9.3 J	10.4	9.9 J	9.8 J	17.1	13.7
Barium	124	118	69.9	76.8	93.9	67.5	106	70.1 J	46.3	46
Beryllium	0.88	0.78	0.56	0.45	0.6	0.57	0.65	0.61 J	0.51	0.48
Cadmium	0	**0.13 J***	**0.064 J***	**0.027 J***	**0.068 J***	**0.077 J***	**0.058 J***	**0.057 J***	**0.055 J***	**0.085 J***
Calcium	35500	3160	34000	3390	**49100 ***	1980	15700	**38600 J***	22500	30300
Chromium	27.2	17.6	17.6	17.7	19.2	18.6	20.1	19.3 J	15.6	14.7
Cobalt	23.2	**25 J***	14.5 J	5.5 J	11.1 J	8.7 J	10.6 J	9.7	10.1	9.6 J
Copper	32.3	12.4 J	19.9	13.8 J	19.3	12.1 J	21.4	19.2 J	19.1	17.1 J
Iron	35200	27100	26700	18700	26500	24600	27700	24500	26700	24100
Lead	19.1	16.4	12.1	10	9.8	12.3	10.1	10.8	11.4 J	12.2
Magnesium	8790	2940	7230	2930	**9050 ***	2610	5950	**8910 J***	5070	4280
Manganese	3030	1800	522	115	391	229	303	322	263	297
Mercury	0.044	0.036 J	0.022 J	0.029 J	<0.12 U	**0.052 J***	0.018 J	<0.12 U	<0.018 UJ	0.021 J
Nickel	60.7	21.6 J	33.2	16.4 J	28.5	16.9 J	29.4	27.1 J	24.3	24.3 J
Potassium	3350	828 J	1500 J	961 J	1970 J	767 J	1580 J	2170 J	1130	1020 J
Selenium	1.5	1.5	1.1	0.76	1.5	1.1	1.4	0.75 J	0.72	1.1
Silver	0	**0.069 J***	<0.02 UJ	<0.038 UJ	<0.028 UJ	**0.04 J***	<0.033 UJ	<0.028 UJ	**0.027 J***	<0.033 UJ
Sodium	145	58.3 J	86.6 J	107 J	121	52.2 J	81.8 J	101 J	63 J	67 J
Thallium	0.91	0.21 J	0.21 J	0.17 J	0.21 J	0.2 J	0.19 J	0.19 J	0.15 J	0.14 J
Vanadium	37.6	26.7 J	19.3 J	22.1 J	22.6 J	29.7 J	21.5 J	21.5 J	16 J	15 J
Zinc	93.3	60.7	53.2	38.1	53.6	46.5	65.1	52.2	61 J	57.5
SVOCs (mg/kg)										
Acenaphthene	None	<0.062 U	<0.059 U	<0.0081 U	<0.0079 U	<0.0083 U	<0.008 U	<0.0078 U	<0.0079 U	<0.0083 U
Benzo(ghi)perylene	None	<0.062 U	<0.059 U	<0.0081 U	<0.0079 U	<0.0083 U	<0.008 U	<0.0078 U	<0.0079 U	<0.0083 U
Bis(2-ethylhexyl)phthalate	None	<0.41 U	0.028 J*	NR	NR	NR	NR	NR	NR	NR
Fluorene	None	<0.062 U	<0.059 U	<0.0081 U	<0.0079 U	<0.0083 U	<0.008 U	<0.0078 U	<0.0079 U	<0.0083 U
Naphthalene	None	<0.062 U	<0.059 U	<0.0081 U	<0.0079 U	<0.0083 U	<0.008 U	<0.0078 U	<0.0079 U	<0.0083 U
Phenanthrene	None	<0.062 U	<0.059 U	<0.0081 U	<0.0079 U	<0.0083 U	<0.008 U	<0.0078 U	<0.0079 U	<0.0083 U
Pyrene	None	<0.062 U	<0.059 U	<0.0081 U	<0.0079 U	<0.0083 U	<0.008 U	<0.0078 U	<0.0079 U	<0.0083 U

Table 4–16. Analytes Detected in PBA08 RI Subsurface Soil Samples (continued)

Aggregate		**F-16**	**F-16**	**F-16**	**F-16**
Station		**F16sb-021**	**F16sb-021**	**F16sb-022**	**F16sb-022**
Sample ID		**F16sb-021-5419-SO**	**F16sb-021-5420-SO**	**F16sb-022-5422-SO**	**F16sb-022-5423-SO**
Date		**03/02/10**	**03/02/10**	**03/02/10**	**03/02/10**
Depth (ft)		**4.0 - 7.0**	**7.0 - 13.0**	**1.0 - 4.0**	**4.0 - 7.0**
Parameters Analyzed [a]		**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**	**TAL Metals, Explosives, SVOCs**
Analyte	**Background Criteria** [b]				
Metals (mg/kg)					
Aluminum	19500	6240	5710 J	10800	8060
Antimony	0.96	0.087 J	0.11 J	<0.59 UJ	<0.59 R
Arsenic	19.8	**24.3 J***	11.3 J	17.1	14.8 J
Barium	124	27.3	16.1	52.6	30.7
Beryllium	0.88	0.34	0.36 J	0.56	0.42
Cadmium	0	**0.061 J***	**0.067 J***	<0.043 UJ	**0.066 J***
Calcium	35500	5380	8340 J	5890	7910
Chromium	27.2	9.9	11.9	15.2	13
Cobalt	23.2	7.9 J	7.3	10.7 J	9.8 J
Copper	32.3	19	16.4 J	20.1 J	19.5
Iron	35200	22000	23200	27900	23700
Lead	19.1	12.8	11.1	10.8	10.5
Magnesium	8790	2800	4220 J	4010	3300
Manganese	3030	417	274	364	349
Mercury	0.044	0.016 J	<0.12 U	**0.047 J***	0.019 J
Nickel	60.7	19.1	17.8 J	25.7 J	23.2
Potassium	3350	805 J	1030 J	1020 J	1000 J
Selenium	1.5	1	0.67 J	1.2	1
Silver	0	<0.02 UJ	<0.024 UJ	<0.018 UJ	<0.019 UJ
Sodium	145	44.5 J	66.1 J	70.4 J	53.1 J
Thallium	0.91	0.12 J	0.11 J	0.14 J	0.12 J
Vanadium	37.6	11.5 J	11.1 J	16.6 J	13.2 J
Zinc	93.3	52.5	49.4	55.8	59.6
SVOCs (mg/kg)					
Acenaphthene	None	<0.0076 U	<0.0077 U	<0.0079 U	**0.2 ***
Benzo(ghi)perylene	None	<0.0076 U	**0.016 ***	<0.0079 U	<0.0078 U
Bis(2-ethylhexyl)phthalate	None	NR	NR	NR	NR
Fluorene	None	<0.0076 U	<0.0077 U	<0.0079 U	**0.16 ***
Naphthalene	None	<0.0076 U	**0.0078 ***	<0.0079 U	<0.0078 U
Phenanthrene	None	<0.0076 U	**0.014 ***	<0.0079 U	**0.66 ***
Pyrene	None	<0.0076 U	**0.011 ***	<0.0079 U	**0.025 ***

[a] Only detected site-related contaminants 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.
NR = Not reported/not analyzed.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
RVAAP = Ravenna Army Ammunition Plant.
SVOC = Semi-volatile organic compound.
TAL = Target analyte list.
U = Not detected.
UJ = Not detected, reporting limit estimated.
* = Result exceeds background criteria or no background criteria was available.
< = Less than.

Table 4–17. Changes from the PBA08 SAP

Location	Effected Sample ID	Date Sampled	Changes/Rationale
F16ss-025	F16ss-025-5435-SO	2/24/2010	Location moved 4 ft west because original location was in the middle of an asphalt road.
F16ss-026M	F16ss-026M-5431-SO	2/24/2010	Several nodes were re-located because they were incorrect compared to the map.
F16ss-027M	F16ss-027M-5432-SO	2/24/2010	Several nodes were re-located because they were incorrect compared to the map.
F15sb-033	F15sb-033-5413-SO	3/2/2010	Location moved 6 ft northeast to be closer to the ditch.
F15ss-035M	F15ss-035M-5812-SO	10/19/2010	Recollected for total Cr because original results were rejected due to suspected laboratory contamination from ISM processing/grinding device.
F15ss-036M	F15ss-036M-5813-SO	10/19/2010	Recollected for total Cr because original results were rejected due to suspected laboratory contamination from ISM processing/grinding device.
F15ss-037M	F15ss-037M-5815-SO	10/192010	Recollected for total Cr because original results were rejected due to suspected laboratory contamination from ISM processing/grinding device.
F15ss-036	F15ss-036-5814-SO	10/19/2010	Recollected for total and hexavalent Cr to verify preliminary speciation results
F16ss-026	F16ss-026-5816-SO	10/18/2010	Recollected for total and hexavalent Cr to verify preliminary speciation results
F16ss-027	F16ss-027-5817-SO	10/18/2010	Recollected for total and hexavalent Cr to verify preliminary speciation results

Cr = chromium
ft = Feet.
ID= identification
ISM = Incremental Sampling Methodology
PBA08 SAP = Performance-Based Acquisition 2008 Supplemental Investigation Sampling and Analysis Plan Addendum No. 1.

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

Background concentrations are published in the Phase II Remedial Investigation Report for Winklepeck Burning Grounds (USACE 2001b).
mg/kg = Milligrams per kilogram.
mg/L = Milligrams per liter.
NA = Not available. Aluminum results were rejected in validation.
RVAAP = Ravenna Army Ammunition Plant.

Table 4–19. Recommended Dietary Allowances/Reference Daily Intake 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 dietary allowance.
RDI= Reference 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 Building F-15 Aggregate 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	16/16	7300	16000	12600	17700	No	Below background
Antimony	**7440-36-0**	**6/15**	**0.16**	**1.4**	**0.617**	**0.96**	**Yes**	**Exceeds background**
Arsenic	**7440-38-2**	**16/16**	**2.7**	**20**	**11**	**15.4**	**Yes**	**Exceeds background**
Barium	**7440-39-3**	**16/16**	**72**	**100**	**85.1**	**88.4**	**Yes**	**Exceeds background**
Beryllium	**7440-41-7**	**16/16**	**0.58**	**1.4**	**0.883**	**0.88**	**Yes**	**Exceeds background**
Cadmium	**7440-43-9**	**6/16**	**0.17**	**1.03**	**0.266**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	16/16	2800	29000	7810	15800	No	Essential Nutrient
Chromium	**7440-47-3**	**16/16**	**16.5**	**58.4**	**23.7**	**17.4**	**Yes**	**Exceeds background**
Cobalt	**7440-48-4**	**16/16**	**5.9**	**12**	**9.43**	**10.4**	**Yes**	**Exceeds background**
Copper	**7440-50-8**	**16/16**	**12.4**	**38.4**	**20.2**	**17.7**	**Yes**	**Exceeds background**
Iron	7439-89-6	16/16	21000	27900	24600	23100	No	Essential Nutrient
Lead	**7439-92-1**	**16/16**	**13**	**58**	**23.3**	**26.1**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	16/16	1100	6600	3400	3030	No	Essential Nutrient
Manganese	7439-96-5	16/16	260	870	481	1450	No	Below background
Mercury	**7439-97-6**	**16/16**	**0.03**	**0.072**	**0.0477**	**0.036**	**Yes**	**Exceeds background**
Nickel	**7440-02-0**	**16/16**	**17**	**55**	**28.8**	**21.1**	**Yes**	**Exceeds background**
Potassium	7440-09-7	16/16	680	2000	1280	927	No	Essential Nutrient
Selenium	7782-49-2	8/16	0.367	1.3	0.74	1.4	No	Below background
Silver	**7440-22-4**	**3/15**	**0.037**	**0.043**	**0.43**	**0**	**Yes**	**Exceeds background**
Sodium	7440-23-5	16/16	47.9	430	246	123	No	Essential Nutrient
Thallium	**7440-28-0**	**7/16**	**0.14**	**0.59**	**0.315**	**0**	**Yes**	**Exceeds background**
Vanadium	7440-62-2	16/16	16.9	29	22.1	31.1	No	Below background
Zinc	**7440-66-6**	**16/16**	**47.6**	**110**	**66.9**	**61.8**	**Yes**	**Exceeds background**
Explosives and Propellants								
Nitrocellulose	**9004-70-0**	**1/2**	**0.93**	**0.93**	**1.09**	**None**	**Yes**	**Detected organic**

Table 4–20. SRC Screening Summary for Building F-15 Aggregate 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**	**2/2**	**0.053**	**0.098**	**0.0755**	**None**	**Yes**	**Detected organic**
Acenaphthene	**83-32-9**	**1/6**	**0.08**	**0.08**	**0.0487**	**None**	**Yes**	**Detected organic**
Acenaphthylene	**208-96-8**	**1/6**	**0.022**	**0.022**	**0.0391**	**None**	**Yes**	**Detected organic**
Anthracene	**120-12-7**	**3/6**	**0.023**	**0.13**	**0.036**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**56-55-3**	**5/6**	**0.013**	**0.49**	**0.115**	**None**	**Yes**	**Detected organic**
Benzo(a)pyrene	**50-32-8**	**5/6**	**0.014**	**0.48**	**0.116**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**205-99-2**	**4/6**	**0.026**	**0.69**	**0.191**	**None**	**Yes**	**Detected organic**
Benzo(ghi)perylene	**191-24-2**	**4/6**	**0.012**	**0.33**	**0.107**	**None**	**Yes**	**Detected organic**
Benzo(k)fluoranthene	**207-08-9**	**4/6**	**0.01**	**0.26**	**0.0911**	**None**	**Yes**	**Detected organic**
Chrysene	**218-01-9**	**5/6**	**0.014**	**0.54**	**0.131**	**None**	**Yes**	**Detected organic**
Dibenz(a,h)anthracene	**53-70-3**	**1/6**	**0.089**	**0.089**	**0.0502**	**None**	**Yes**	**Detected organic**
Dibenzofuran	**132-64-9**	**1/2**	**0.017**	**0.017**	**0.091**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**5/6**	**0.028**	**1.2**	**0.266**	**None**	**Yes**	**Detected organic**
Fluorene	**86-73-7**	**1/6**	**0.062**	**0.062**	**0.0457**	**None**	**Yes**	**Detected organic**
Indeno(1,2,3-cd)pyrene	**193-39-5**	**4/6**	**0.011**	**0.3**	**0.0989**	**None**	**Yes**	**Detected organic**
Naphthalene	**91-20-3**	**5/6**	**0.038**	**0.13**	**0.0639**	**None**	**Yes**	**Detected organic**
Phenanthrene	**85-01-8**	**5/6**	**0.029**	**0.71**	**0.174**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**5/6**	**0.02**	**0.85**	**0.192**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b). Site-related contaminant screening tables include all available and appropriate data as presented in Section 4.4.4.

CAS = Chemical Abstract Service.

Freq. = Frequency.

mg/kg = Milligrams per kilogram.

SRC = Site-related contaminant.

SVOC = Semi-volatile organic compound

Bold indicates analyte identified as an SRC.

Table 4–21. SRC Screening Summary for Building F-16 Aggregate 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	11/11	9410	16000	12400	17700	No	Below background
Antimony	**7440-36-0**	**6/11**	**0.17**	**1.5**	**0.676**	**0.96**	**Yes**	**Exceeds background**
Arsenic	**7440-38-2**	**11/11**	**9.8**	**18**	**12.2**	**15.4**	**Yes**	**Exceeds background**
Barium	**7440-39-3**	**11/11**	**58.4**	**200**	**96.4**	**88.4**	**Yes**	**Exceeds background**
Beryllium	**7440-41-7**	**11/11**	**0.495**	**2.9**	**1.05**	**0.88**	**Yes**	**Exceeds background**
Cadmium	**7440-43-9**	**6/11**	**0.17**	**2.5**	**0.515**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	11/11	3700	25000	9020	15800	No	Essential Nutrient
Chromium	**7440-47-3**	**11/11**	**15.8**	**65.3**	**37.2**	**17.4**	**Yes**	**Exceeds background**
Cobalt	**7440-48-4**	**11/11**	**4.6**	**12**	**8.74**	**10.4**	**Yes**	**Exceeds background**
Copper	**7440-50-8**	**11/11**	**14.4**	**200**	**40**	**17.7**	**Yes**	**Exceeds background**
Iron	7439-89-6	11/11	20700	29300	25400	23100	No	Essential Nutrient
Lead	**7439-92-1**	**11/11**	**13**	**120**	**36**	**26.1**	**Yes**	**Exceeds background**
Magnesium	7439-95-4	11/11	2800	4600	3580	3030	No	Essential Nutrient
Manganese	7439-96-5	11/11	320	1200	572	1450	No	Below background
Mercury	**7439-97-6**	**10/11**	**0.019**	**0.05**	**0.0372**	**0.036**	**Yes**	**Exceeds background**
Nickel	**7440-02-0**	**11/11**	**21.8**	**39.6**	**28.2**	**21.1**	**Yes**	**Exceeds background**
Potassium	7440-09-7	11/11	826	2100	1460	927	No	Essential Nutrient
Selenium	**7782-49-2**	**5/11**	**0.408**	**1.7**	**0.905**	**1.4**	**Yes**	**Exceeds background**
Silver	**7440-22-4**	**2/10**	**0.034**	**0.048**	**0.478**	**0**	**Yes**	**Exceeds background**
Sodium	7440-23-5	11/11	54.8	710	288	123	No	Essential Nutrient
Thallium	**7440-28-0**	**5/11**	**0.137**	**0.33**	**0.327**	**0**	**Yes**	**Exceeds background**
Vanadium	7440-62-2	11/11	16.8	26	20.8	31.1	No	Below background
Zinc	**7440-66-6**	**11/11**	**48.7**	**130**	**81.8**	**61.8**	**Yes**	**Exceeds background**
Explosives and Propellants								
Nitrocellulose	**9004-70-0**	**2/3**	**1.1**	**2.1**	**1.48**	**None**	**Yes**	**Detected organic**
Nitroglycerin	**55-63-0**	**1/5**	**0.52**	**0.52**	**0.354**	**None**	**Yes**	**Detected organic**

Table 4–21. SRC Screening Summary for Building F-16 Aggregate 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**	**3/3**	**0.088**	**1**	**0.409**	**None**	**Yes**	**Detected organic**
Anthracene	**120-12-7**	**2/4**	**0.024**	**0.053**	**0.0476**	**None**	**Yes**	**Detected organic**
Benz(a)anthracene	**56-55-3**	**4/5**	**0.007**	**0.14**	**0.0688**	**None**	**Yes**	**Detected organic**
Benzo(a)pyrene	**50-32-8**	**4/5**	**0.0071**	**0.11**	**0.064**	**None**	**Yes**	**Detected organic**
Benzo(b)fluoranthene	**205-99-2**	**5/5**	**0.0093**	**0.13**	**0.0681**	**None**	**Yes**	**Detected organic**
Benzo(ghi)perylene	**191-24-2**	**3/4**	**0.035**	**0.095**	**0.071**	**None**	**Yes**	**Detected organic**
Benzo(k)fluoranthene	**207-08-9**	**3/4**	**0.028**	**0.1**	**0.0668**	**None**	**Yes**	**Detected organic**
Bis(2-ethylhexyl)phthalate	**117-81-7**	**1/3**	**0.13**	**0.13**	**0.315**	**None**	**Yes**	**Detected organic**
Carbazole	**86-74-8**	**1/3**	**0.038**	**0.038**	**0.101**	**None**	**Yes**	**Detected organic**
Chrysene	**218-01-9**	**5/5**	**0.0079**	**0.2**	**0.0686**	**None**	**Yes**	**Detected organic**
Dibenzofuran	**132-64-9**	**1/3**	**0.26**	**0.26**	**0.358**	**None**	**Yes**	**Detected organic**
Fluoranthene	**206-44-0**	**5/5**	**0.012**	**0.26**	**0.111**	**None**	**Yes**	**Detected organic**
Indeno(1,2,3-cd)pyrene	**193-39-5**	**3/4**	**0.039**	**0.073**	**0.0638**	**None**	**Yes**	**Detected organic**
Naphthalene	**91-20-3**	**4/4**	**0.054**	**0.73**	**0.235**	**None**	**Yes**	**Detected organic**
Phenanthrene	**85-01-8**	**4/4**	**0.05**	**0.52**	**0.192**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**5/5**	**0.0096**	**0.3**	**0.102**	**None**	**Yes**	**Detected organic**
Pesticides/PCBs								
4,4'-DDE	**72-55-9**	**1/2**	**0.012**	**0.012**	**0.0148**	**None**	**Yes**	**Detected organic**
4,4'-DDT	**50-29-3**	**1/2**	**0.019**	**0.019**	**0.0198**	**None**	**Yes**	**Detected organic**
PCB-1260	**11096-82-5**	**1/2**	**0.12**	**0.12**	**0.0685**	**None**	**Yes**	**Detected organic**
VOCs								
Chloroform	**67-66-3**	**1/2**	**0.00068**	**0.00068**	**0.00199**	**None**	**Yes**	**Detected organic**

[a] Background concentrations are published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b). Site-related contaminant screening tables include all available and appropriate data as presented in Section 4.4.4.

CAS = Chemical Abstract Service.
DDE = Dichlorodiphenyldichloroethylene.
DDT = Dichlorodiphenyltrichloroethane.
Freq. = Frequency.
mg/kg = Milligrams per kilogram.
PCB = Polychlorinated biphenyl.
SRC = Site-related contaminant.
SVOC= Semi-volatile organic compound.
VOC = Volatile organic compound.
Bold indicates analyte identified as an SRC.

Table 4–22. SRC Screening Summary for Building F-15 Aggregate 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	7/7	11000	16200	13500	19500	No	Below background
Antimony	7440-36-0	2/4	0.077	0.089	0.195	0.96	No	Below background
Arsenic	7440-38-2	7/7	7	12.2	9.73	19.8	No	Below background
Barium	7440-39-3	7/7	67.5	118	86	124	No	Below background
Beryllium	7440-41-7	7/7	0.45	0.78	0.603	0.88	No	Below background
Cadmium	**7440-43-9**	**7/7**	**0.027**	**0.13**	**0.0687**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	7/7	1980	49100	20800	35500	No	Essential Nutrient
Chromium	7440-47-3	7/7	17.6	20.1	18.6	27.2	No	Below background
Cobalt	**7440-48-4**	**7/7**	**5.5**	**25**	**12.2**	**23.2**	**Yes**	**Exceeds background**
Copper	7440-50-8	7/7	12.1	21.4	16.9	32.3	No	Below background
Iron	7439-89-6	7/7	18700	27700	25100	35200	No	Essential Nutrient
Lead	7439-92-1	7/7	9.8	16.4	11.6	19.1	No	Below background
Magnesium	7439-95-4	7/7	2610	9050	5660	8790	No	Essential Nutrient
Manganese	7439-96-5	7/7	115	1800	526	3030	No	Below background
Mercury	**7439-97-6**	**5/7**	**0.018**	**0.052**	**0.0396**	**0.044**	**Yes**	**Exceeds background**
Nickel	7440-02-0	7/7	16.4	33.2	24.7	60.7	No	Below background
Potassium	7440-09-7	7/7	767	2170	1400	3350	No	Essential Nutrient
Selenium	7782-49-2	7/7	0.75	1.5	1.16	1.5	No	Below background
Silver	**7440-22-4**	**2/7**	**0.04**	**0.069**	**0.0261**	**0**	**Yes**	**Exceeds background**
Sodium	7440-23-5	7/7	52.2	121	86.8	145	No	Essential Nutrient
Thallium	7440-28-0	7/7	0.17	0.21	0.197	0.91	No	Below background
Vanadium	7440-62-2	7/7	19.3	29.7	23.3	37.6	No	Below background
Zinc	7440-66-6	7/7	38.1	65.1	52.8	93.3	No	Below background
				SVOCs				
Bis(2-ethylhexyl)phthalate	**117-81-7**	**1/2**	**0.028**	**0.028**	**0.117**	**None**	**Yes**	**Detected organic**

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

SRC screening tables include all available and appropriate data as presented in Section 4.4.4.

CAS = Chemical Abstract Service.

Freq. = Frequency.

Mg/kg = Milligrams per kilogram.

SRC = Site-related contaminant.

SVOC = Semi-volatile organic compound.

Bold indicates analyte identified as an SRC.

Table 4–23. SRC Screening Summary for Building F-16 Aggregate 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	5710	10800	8200	19500	No	Below background
Antimony	7440-36-0	2/4	0.087	0.11	0.202	0.96	No	Below background
Arsenic	**7440-38-2**	**5/5**	**11.3**	**24.3**	**16.2**	**19.8**	**Yes**	**Exceeds background**
Barium	7440-39-3	5/5	16.1	52.6	34.5	124	No	Below background
Beryllium	7440-41-7	5/5	0.34	0.56	0.432	0.88	No	Below background
Cadmium	**7440-43-9**	**4/5**	**0.061**	**0.085**	**0.0601**	**0**	**Yes**	**Exceeds background**
Calcium	7440-70-2	5/5	5380	30300	11600	35500	No	Essential nutrient
Chromium	7440-47-3	5/5	9.9	15.2	12.9	27.2	No	Below background
Cobalt	7440-48-4	5/5	7.3	10.7	9.06	23.2	No	Below background
Copper	7440-50-8	5/5	16.4	20.1	18.4	32.3	No	Below background
Iron	7439-89-6	5/5	22000	27900	24200	35200	No	Essential nutrient
Lead	7439-92-1	5/5	10.5	12.8	11.5	19.1	No	Below background
Magnesium	7439-95-4	5/5	2800	4280	3720	8790	No	Essential nutrient
Manganese	7439-96-5	5/5	274	417	340	3030	No	Below background
Mercury	**7439-97-6**	**4/5**	**0.016**	**0.047**	**0.0326**	**0.044**	**Yes**	**Exceeds background**
Nickel	7440-02-0	5/5	17.8	25.7	22	60.7	No	Below background
Potassium	7440-09-7	5/5	805	1030	975	3350	No	Essential nutrient
Selenium	7782-49-2	5/5	0.67	1.2	0.994	1.5	No	Below background
Sodium	7440-23-5	5/5	44.5	70.4	60.2	145	No	Essential nutrient
Thallium	7440-28-0	5/5	0.11	0.14	0.126	0.91	No	Below background
Vanadium	7440-62-2	5/5	11.1	16.6	13.5	37.6	No	Below background
Zinc	7440-66-6	5/5	49.4	59.6	55	93.3	No	Below background

Table 4–23. SRC Screening Summary for Building F-16 Aggregate 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**	**1/5**	**0.2**	**0.2**	**0.0432**	**None**	**Yes**	**Detected organic**
Benzo(ghi)perylene	**191-24-2**	**1/5**	**0.016**	**0.016**	**0.00636**	**None**	**Yes**	**Detected organic**
Fluorene	**86-73-7**	**1/5**	**0.16**	**0.16**	**0.0352**	**None**	**Yes**	**Detected organic**
Naphthalene	**91-20-3**	**1/5**	**0.0078**	**0.0078**	**0.00472**	**None**	**Yes**	**Detected organic**
Phenanthrene	**85-01-8**	**2/5**	**0.014**	**0.66**	**0.137**	**None**	**Yes**	**Detected organic**
Pyrene	**129-00-0**	**2/5**	**0.011**	**0.025**	**0.00958**	**None**	**Yes**	**Detected organic**

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

SRC screening tables include all available and appropriate data as presented in Section 4.4.4.

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. Data Summary and Designated Use for RI

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
Surface and Subsurface Soil										
F15sb-031-5405-SO	D	03/02/10	0–1	PBA08 RI	--	X	--	X	--	
F15sb-031-5406-SO	D	03/02/10	1–4	PBA08 RI	--	X	X	X	--	
F15sb-031-5407-SO	D	03/02/10	4–7	PBA08 RI	--	X	X	X	--	
F15sb-032-5409-SO	D	03/02/10	0–1	PBA08 RI	--	X	--	X	--	
F15sb-032-5410-SO	D	03/02/10	1–4	PBA08 RI	--	X	X	X	--	
F15sb-032-5411-SO	D	03/02/10	4–7	PBA08 RI	--	X	X	X	--	
F15sb-033-5413-SO	D	03/02/10	0–1	PBA08 RI	--	X	--	X	--	
F15sb-033-5414-SO	D	03/02/10	1–4	PBA08 RI	--	X	X	X	--	
F15sb-033-5415-SO	D	03/02/10	4–7	PBA08 RI	--	X	X	X	--	
F15sb-033-5416-SO	D	03/02/10	7–13	PBA08 RI	--	X	X	X	--	
F15ss-001M-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	
F15ss-002M-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	
F15ss-003M-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	
F15ss-004M-SO	ISM	10/27/04	0–1	14 AOCs	--	X	X	X	X	
F15ss-005M-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	
F15ss-006D-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	Discrete sample taken to characterize volatile organics in ISM area.
F15ss-006M-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	
F15ss-007M-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	
F15ss-008M-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	
F15ss-009M-DUP	ISM	10/28/04	0–0.5	14 AOCs	X	--	--	--	--	Field duplicate.
F15ss-009M-SO	ISM	10/28/04	0–0.5	14 AOCs	--	X	X	X	X	
F15ss-010M-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	
F15ss-011M-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	
F15ss-012M-0500-SO	ISM	11/04/09	0–1	Subslab Sampling	--	X	X	X	X	
F15ss-012M-0502-SO	ISM	11/04/09	0–1	Subslab Sampling	X	--	--	--	--	Field duplicate.
F15ss-012M-0503-SO	ISM	11/04/09	0–1	Subslab Sampling	X	--	--	--	--	Field duplicate.
F15ss-034-5436-SO	D	02/24/10	0–1	PBA08 RI	--	X	--	X	--	Sample collected for chromium speciation analysis only.
F15ss-035M-5428-SO	ISM	02/24/10	0–1	PBA08 RI	--	X	X	X	X	
F15ss-035M-5812-SO	ISM	10/19/10	0–1	PBA08 RI	--	X	X	X	X	
F15ss-035M-6121-FD	ISM	02/24/10	0–1	PBA08 RI	X	--	--	--	--	Field duplicate.

Table 4–24. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
F15ss-036-5814-SO	D	10/19/10	0–1	PBA08 RI	--	X	--	X	--	Sample collected for chromium speciation analysis only.
F15ss-036M-5427-SO	ISM	02/24/10	0–1	PBA08 RI	--	X	X	X	X	
F15ss-036M-5813-SO	ISM	10/19/10	0–1	PBA08 RI	--	X	X	X	X	
F15ss-037M-5429-SO	ISM	02/24/10	0–1	PBA08 RI	--	X	X	X	X	
F15ss-037M-5815-SO	ISM	10/19/10	0–1	PBA08 RI	--	X	X	X	X	
F15ss-038M-5430-SO	ISM	02/24/10	0–1	PBA08 RI	--	X	X	X	X	
F15ss-040-0001-SO	ISM	12/02/09	0–0.5	ISM Surface Sampling 2009	--	X	X	X	X	
F16sb-021-5417-SO	D	03/02/10	0–1	PBA08 RI	--	X	--	X	--	
F16sb-021-5418-SO	D	03/02/10	1–4	PBA08 RI	--	X	X	X	--	
F16sb-021-5419-SO	D	03/02/10	4–7	PBA08 RI	--	X	X	X	--	
F16sb-021-5420-SO	D	03/02/10	7–13	PBA08 RI	--	X	X	X	--	
F16sb-021-6122-FD	D	03/02/10	0–1	PBA08 RI	X	--	--	--	--	Field duplicate.
F16sb-021-6123-FD	D	03/02/10	1–4	PBA08 RI	X	--	--	--	--	Field duplicate.
F16sb-022-5421-SO	D	03/02/10	0–1	PBA08 RI	--	X	--	X	--	
F16sb-022-5422-SO	D	03/02/10	1–4	PBA08 RI	--	X	X	X	--	
F16sb-022-5423-SO	D	03/02/10	4–7	PBA08 RI	--	X	X	X	--	
F16ss-001M-SO	ISM	11/03/04	0–0.5	14 AOCs	--	X	X	X	X	
F16ss-002M-SO	ISM	11/03/04	0–0.5	14 AOCs	--	X	X	X	X	
F16ss-003M-SO	ISM	11/03/04	0–0.5	14 AOCs	--	X	X	X	X	
F16ss-004M-SO	ISM	11/03/04	0–1	14 AOCs	--	X	X	X	X	
F16ss-005D-SO	ISM	11/03/04	0–0.5	14 AOCs	--	X	X	X	X	Discrete sample taken to characterize volatile organics in ISM area.
F16ss-005M-SO	ISM	11/03/04	0–0.5	14 AOCs	--	X	X	X	X	
F16ss-006M-SO	ISM	10/28/04	0–1	14 AOCs	--	X	X	X	X	
F16ss-007M-SO	ISM	11/03/04	0–0.5	14 AOCs	--	X	X	X	X	
F16ss-008M-0504-SO	ISM	11/04/09	0–1	Subslab Sampling	--	X	X	X	X	
F16ss-024-5434-SO	D	02/24/10	0–1	PBA08 RI	--	X	--	X	--	Sample collected for chromium speciation analysis only.
F16ss-025-5435-SO	D	02/24/10	0–1	PBA08 RI	--	X	--	X	--	Sample collected for chromium speciation analysis only.

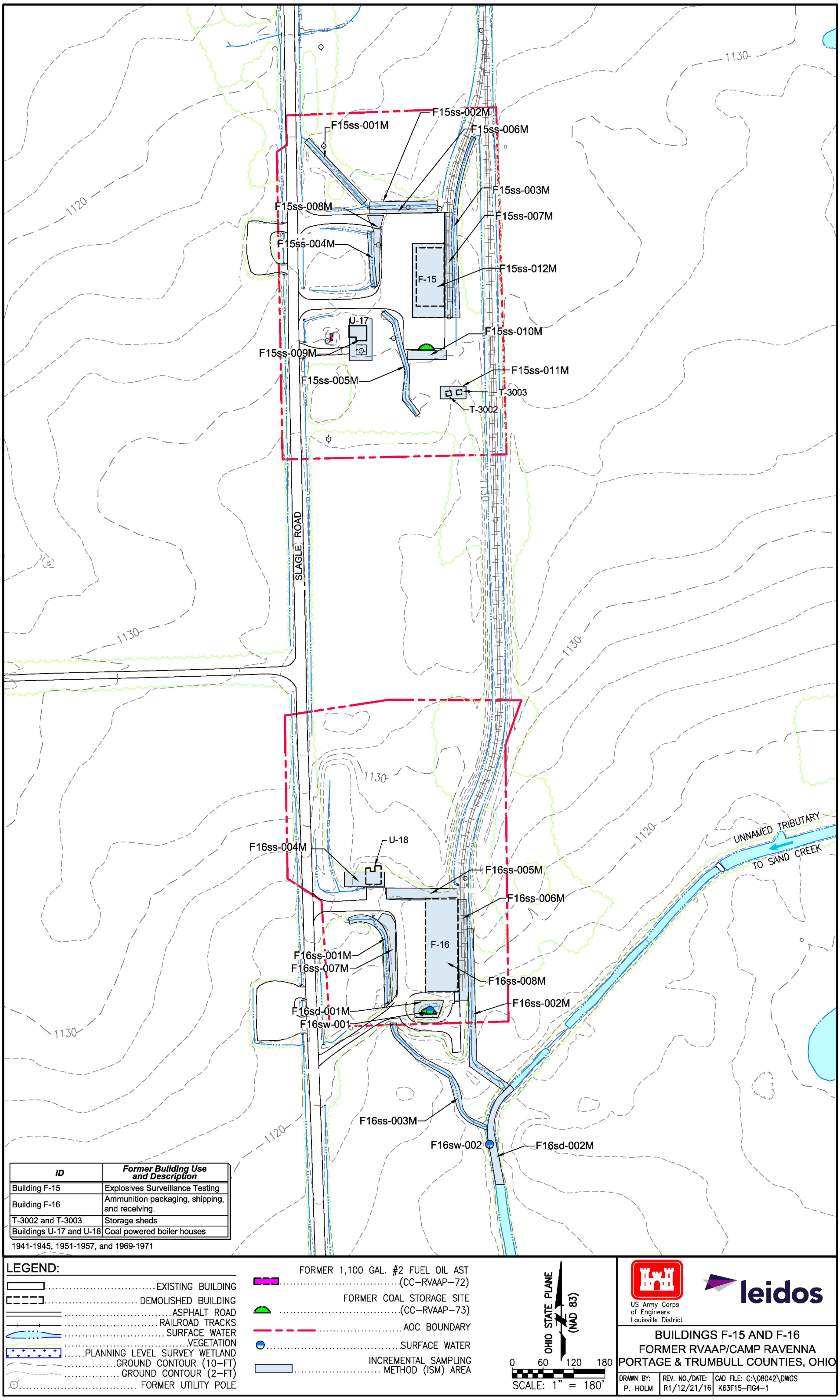
Table 4–24. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
F16ss-026-5816-SO	D	10/18/10	0–1	PBA08 RI	--	X	--	X	--	Sample collected for chromium speciation analysis only.
F16ss-026M-5431-SO	ISM	02/24/10	0–1	PBA08 RI	--	X	X	X	X	
F16ss-027-5817-SO	D	10/18/10	0–1	PBA08 RI	--	X	--	X	--	Sample collected for chromium speciation analysis only.
F16ss-027M-5432-SO	ISM	02/24/10	0–1	PBA08 RI	--	X	X	X	X	
F16ss-028M-5433-SO	ISM	02/24/10	0–1	PBA08 RI	--	X	X	X	X	
F16ss-030-0001-SO	ISM	12/02/09	0–0.5	ISM Surface Sampling 2009	--	X	X	X	X	
FWCss-007-0001-SO	ISM	12/02/09	0–0.5	ISM Surface Sampling 2009	--	X	X	X	X	
FWCss-008-0001-SO	ISM	12/02/09	0–0.5	ISM Surface Sampling 2009	--	X	X	X	X	Sample replaces older sediment sample F16sd-001M in evaluation.
RV-461	D	10/19/98	0–0.5	RRSE 1998	--	--	--	--	--	Used for initial evaluation of site.
RV-462	D	10/19/98	0–0.5	RRSE 1998	--	--	--	--	--	Used for initial evaluation of site.
RV-464	D	10/19/98	0–0.5	RRSE 1998	--	--	--	--	--	Used for initial evaluation of site.
RV-465	D	10/19/98	0–0.5	RRSE 1998	--	--	--	--	--	Used for initial evaluation of site.
RV-466	D	10/19/98	0–0.5	RRSE 1998	--	--	--	--	--	Used for initial evaluation of site.
Sediment										
F16sd-001M-DUP	ISM	11/03/04	0–0.5	14 AOCs	X	--	--	--	--	Field duplicate.
F16sd-001M-SD	ISM	11/03/04	0–0.5	14 AOCs	--	X	--	--	--	Surface water intermittent at AOC. Sediment only evaluated in N&E within report. Location coincides with newer sample FWCss-008-0001-SO that is evaluated in risk assessment.

Table 4–24. Data Summary and Designated Use for RI (continued)

Sample ID	Type	Date	Depth (ft)	Sampling Event	QC	N&E	F&T	HHRA	ERA	Comments
F16sd-002M-SD	ISM	11/03/04	0–0.5	14 AOCs	--	X	--	--	--	Off-AOC sediment sample only evaluated in N&E within report.
RV-463	D	10/19/98	0–0.5	RRSE 1998	--	--	--	--	--	Used for initial evaluation of site.
Surface Water										
F16sw-001-SW	D	11/03/04	0.5–0.5	14 AOCs	--	X	--	--	--	Surface water intermittent at AOC and only evaluated in N&E within report.
F16sw-002-DUP	D	11/03/04	0.5–0.5	14 AOCs	X	--	--	--	--	Field duplicate.
F16sw-002-SW	D	11/03/04	0.5–0.5	14 AOCs	--	X	--	--	--	Off-AOC surface water sample only evaluated in N&E within report.

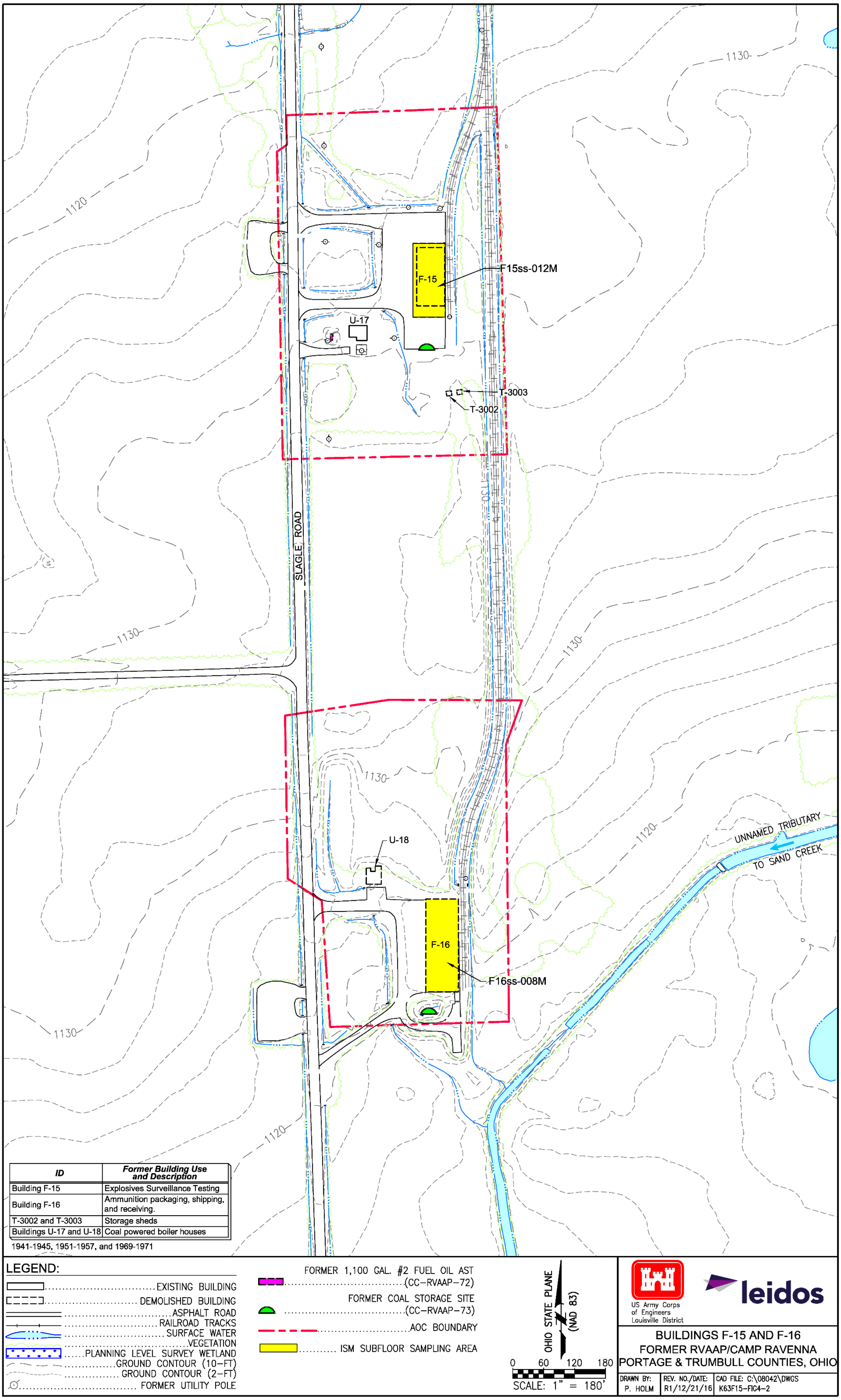
AOC = Area of concern
D = Discrete.
ERA = Ecological risk assessment.
F&T = Fate and transport.
ft = Feet.
HHRA = Human health risk assessment.
ID = Identification.
ISM = Incremental sampling methodology.
N&E = Nature and extent.
PBA08 RI = Performance-based Acquisition 2008 Remedial Investigation.
QC = Quality control.
RI = Remedial investigation.
RRSE = Relative Risk Site Evaluation.



ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

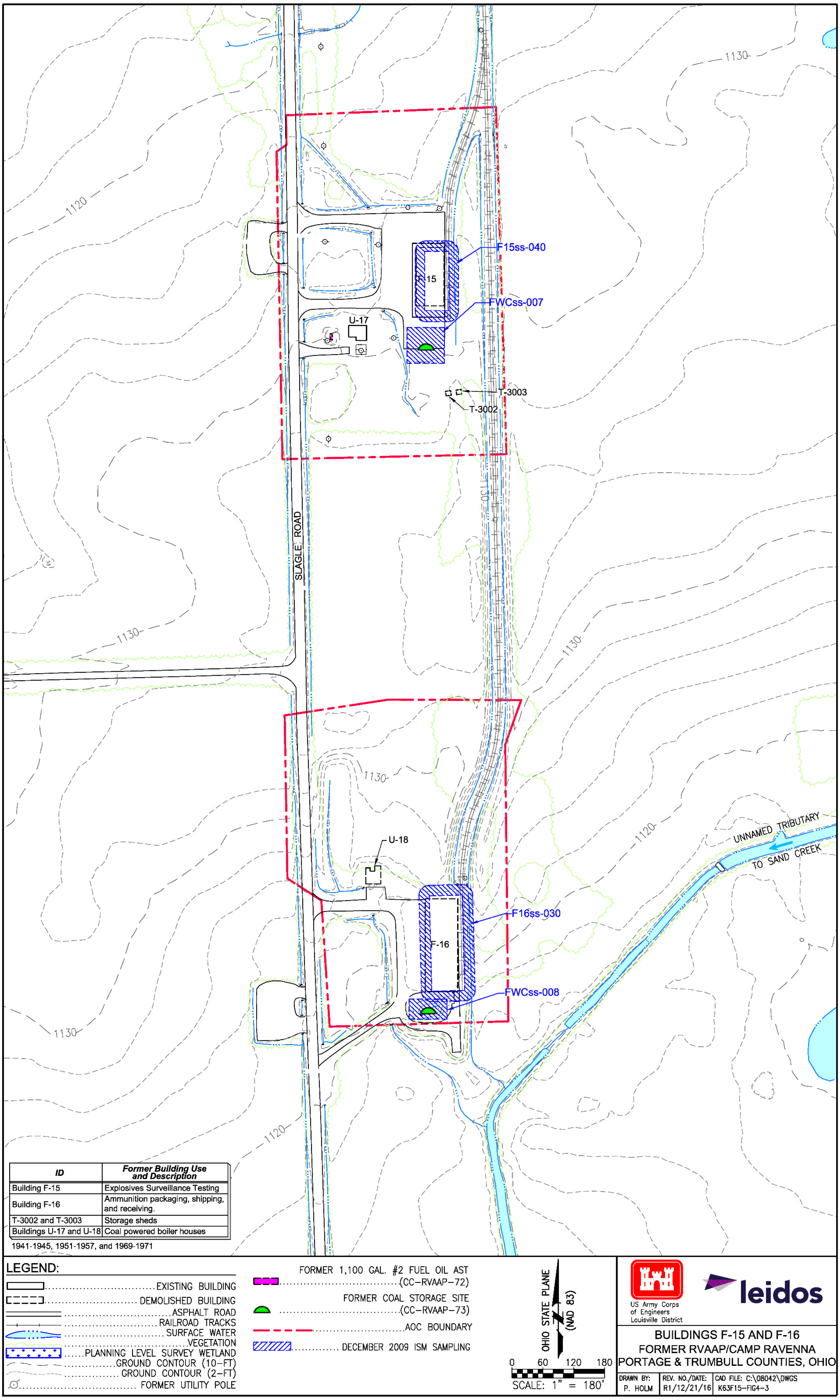
Figure 4–1. Characterization of 14 AOCs Sample Locations



ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

Figure 4–2. 2009 Under Slab Sampling Sample Locations



ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

Figure 4–3. 2009 USACE ISM Surface Soil Sample Locations

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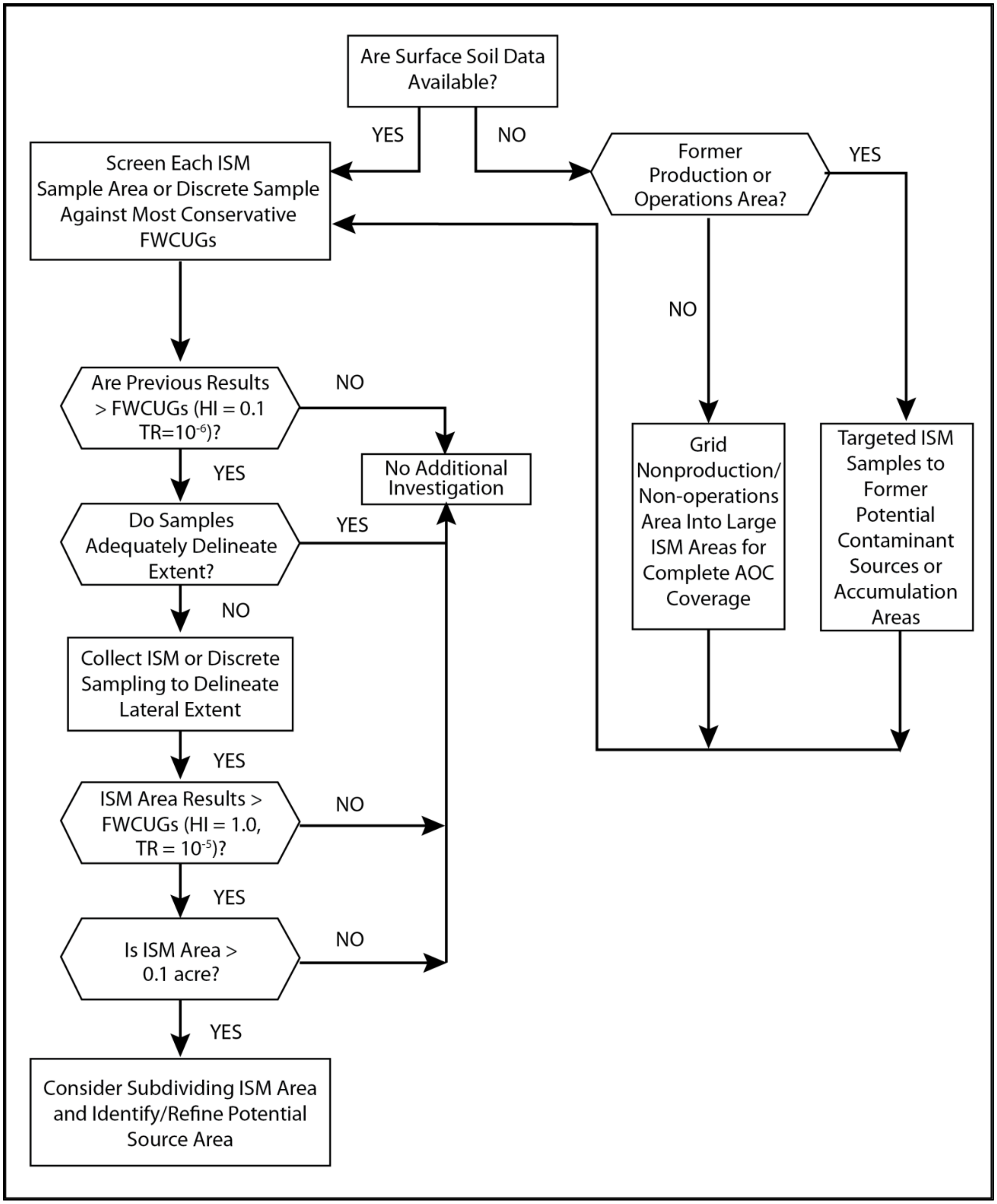


Figure 4–4. PBA08 RI Surface Soil Sampling

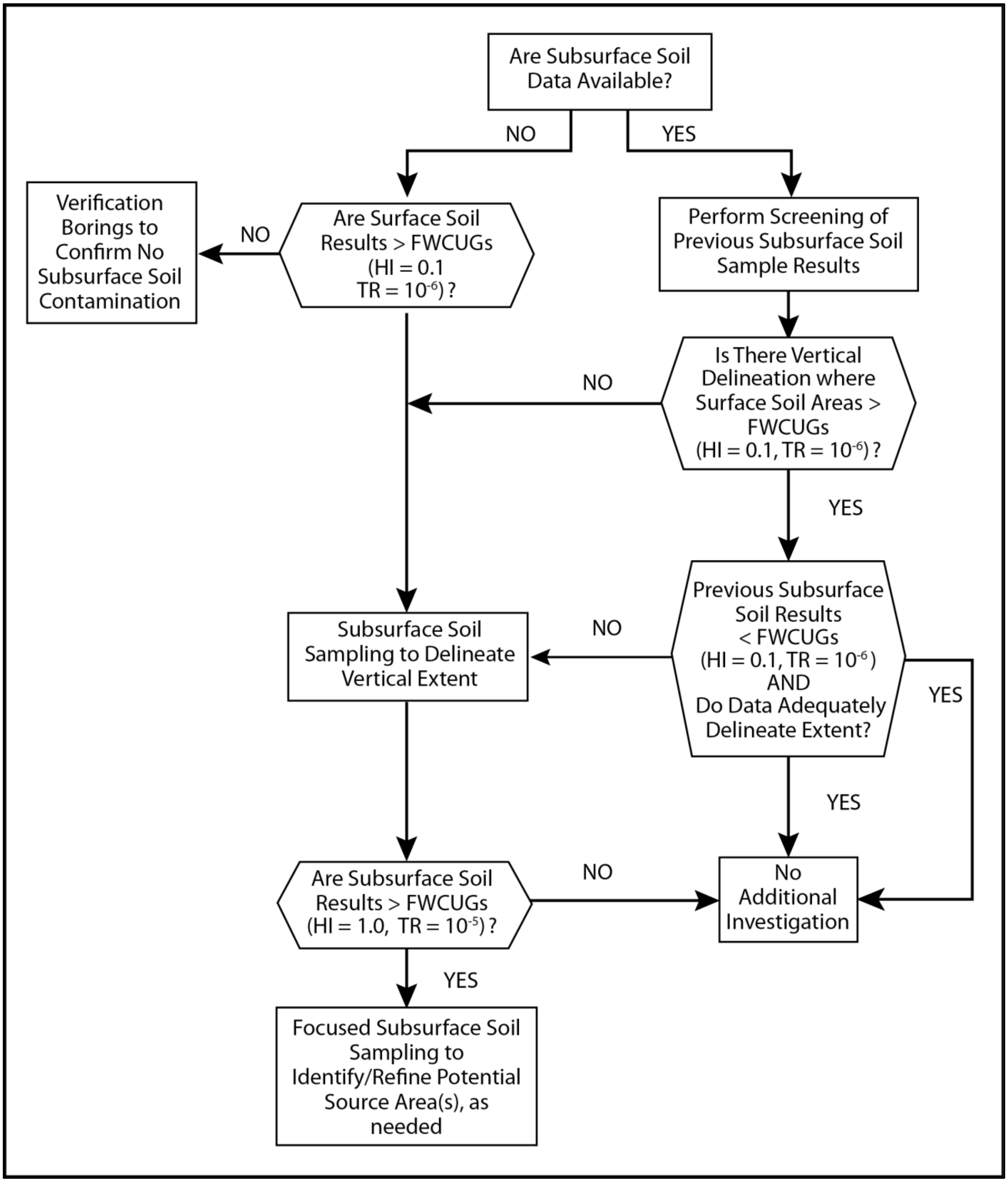
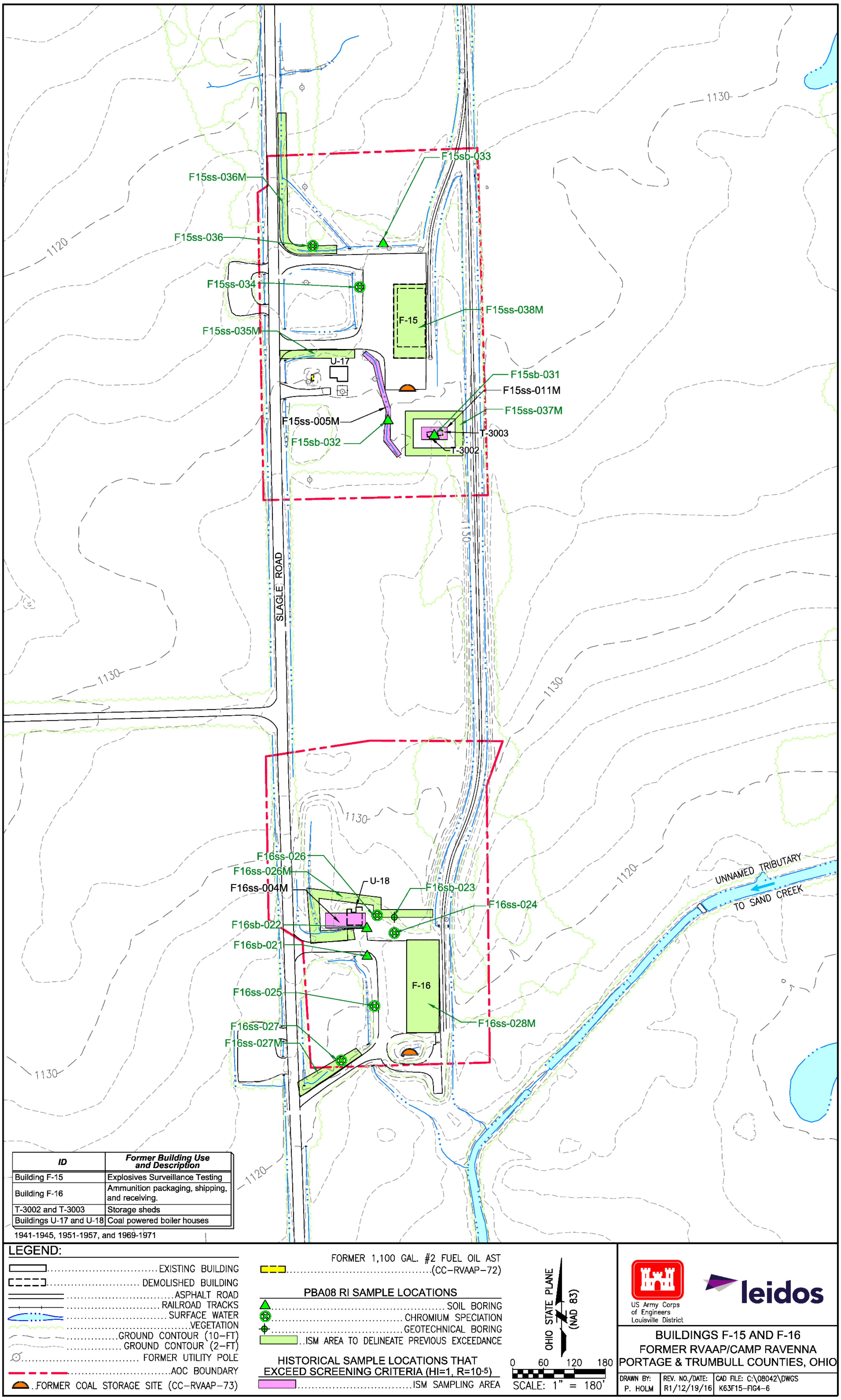


Figure 4–5. PBA08 RI Subsurface Soil Sampling



ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

Figure 4–6. 2010 PBA08 RI Sample Locations

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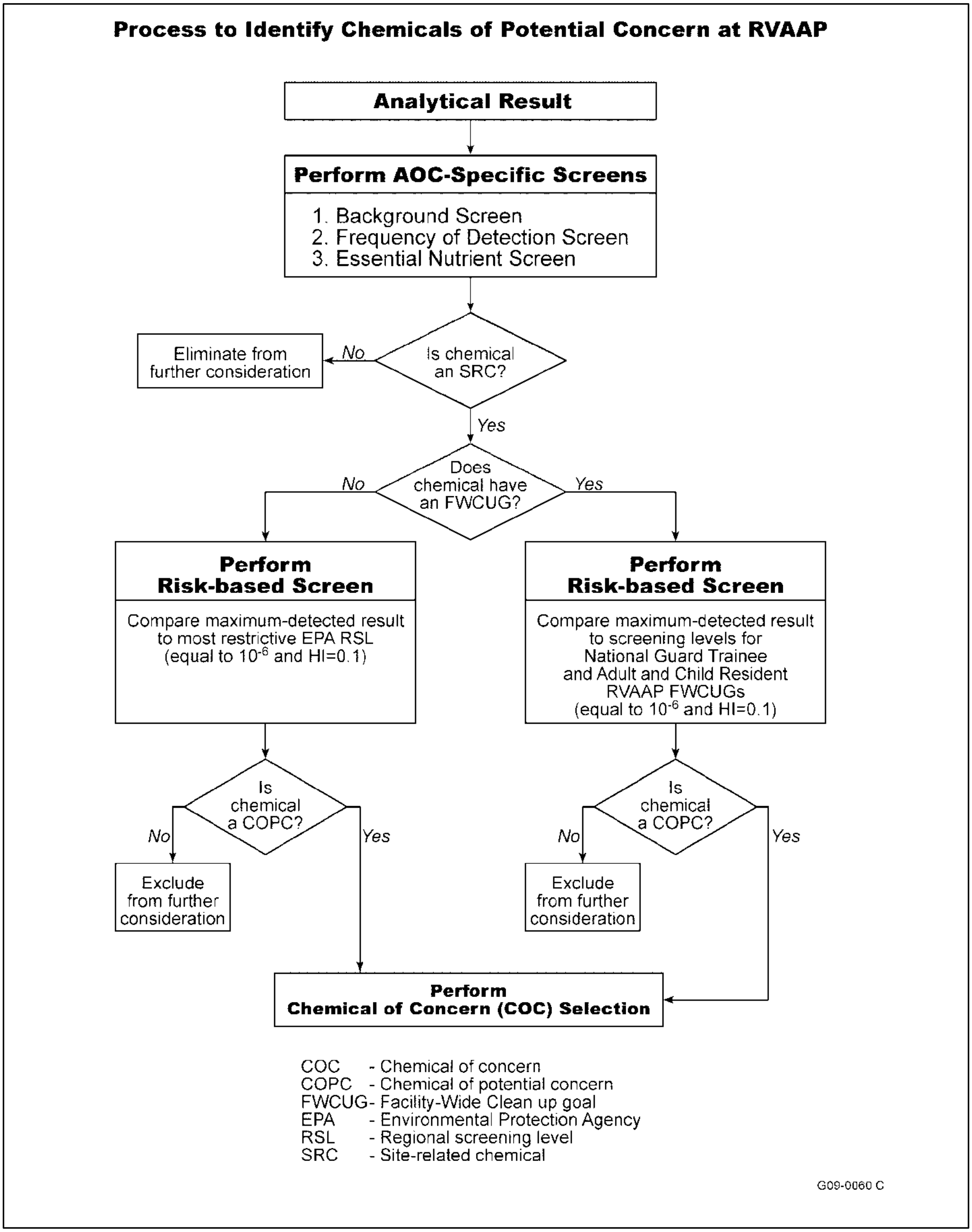

Figure 4–7. Process to Identify RVAAP COPCs in the HHRA (USACE 2010a)

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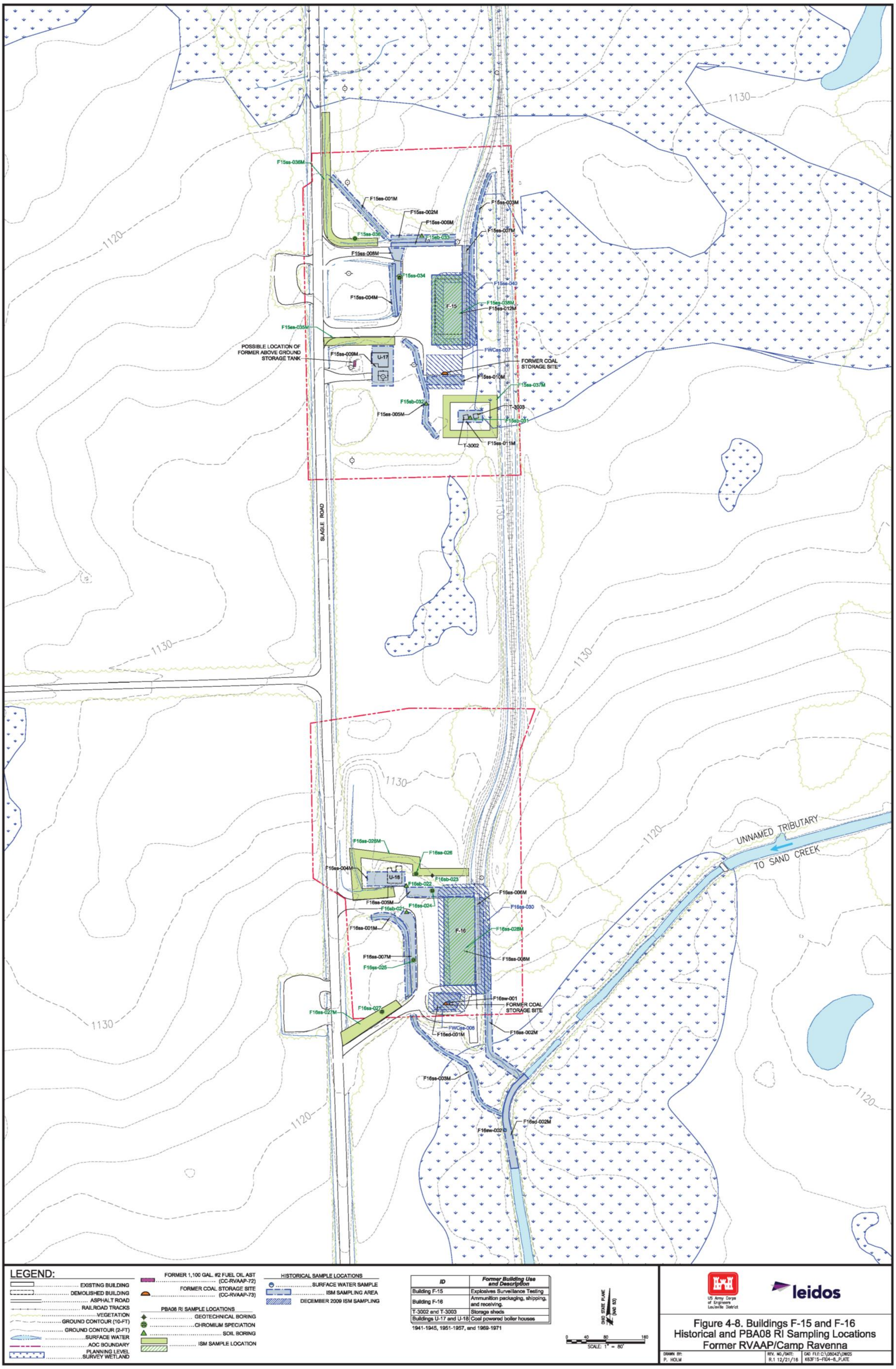

ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

Figure 4–8. All Buildings F-15 and F-16 AOC RI Sample Locations

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5.0 NATURE AND EXTENT OF CONTAMINATION

This section evaluates the nature and extent of contamination at the Buildings F-15 and F-16 AOC. This evaluation includes two types of chemicals: SRCs identified as being previously used during operational activities or that potentially were associated with operations, and SRCs that do not appear to have been used during historical operations but were analyzed during investigations. The evaluation discusses the nature and extent of SRCs in environmental media at the AOC, focusing on chemicals previously used during operational activities and using analytical data results obtained during the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and 2010 PBA08 RI.

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. If there was no FWCUG for a chemical, the USEPA RSL was used as the SL. The following figures illustrate the concentration and distribution of SRCs that exceed SLs.

- Figure 5-1 – Detected Concentrations of Explosives and Propellants in Soil at the Buildings F-15 and F-16 Aggregates
- Figure 5-2 – Exceedances of FWCUG (HQ of 0.1, TR of 1E-06) for Arsenic, Chromium, Lead, Mercury, Cobalt, Manganese, and Thallium in Soil at the Buildings F-15 and F-16 Aggregates
- Figure 5-3 – PAH Exceedances of FWCUG (HQ of 0.1, TR of 1E-06) in Soil at the Buildings F-15 and F-16 Aggregates
- Figure 5-4 – Detected Concentrations of VOCs, Pesticides, and PCBs in Soil at the Buildings F-15 and F-16 Aggregates

As discussed in Section 4.4, data from all eligible samples were combined and screened to identify SRCs representing current conditions at the AOC. All validated data from the RIs (2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and 2010 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 analyte.

5.1 SURFACE SOIL DISCRETE SAMPLE RESULTS FOR CHROMIUM SPECIATION

During the PBA08 RI, surface soil samples were collected from six discrete sample locations and analyzed for hexavalent chromium and total chromium.

In February 2010, two samples were collected from areas previously identified during the 2004 Characterization of 14 AOCs as having elevated total chromium concentrations (F16ss-024 and F16ss-025) and one sample was collected from an area previously identified as having a total chromium concentration near background concentrations (F15ss-034).

As discussed in Section 4.2.4.6, preliminary results of the February 2010 samples indicated elevated chromium concentrations in soil that warranted further assessment in October 2010. In addition to this assessment, three new chromium speciation samples (F16ss-026, F16ss-027, and F15ss-036) were collected. These new samples were collected to expand on the existing chromium speciation data set to evaluate.

The data from these additional speciation samples were used to determine the contribution of hexavalent chromium to total chromium over a range of concentrations in soil at the Buildings F-15 and F-16 AOC for use in the HHRA. All chromium speciation results are shown in Table 5-1.

Five of six samples had total chromium concentrations (18.4–21.9 mg/kg) above the facility-wide background concentration of 17.4 mg/kg, and one sample (F16ss-026) had a total chromium concentration below facility-wide background concentration (16.1 mg/kg). The range of hexavalent chromium concentrations was 0.95U–2.2 mg/kg and did not appear to be correlative to total chromium values.

A detailed assessment of the speciation results respective to the HHRA is presented in Section 7.2.4.1.

5.2 CONTAMINANT NATURE AND EXTENT IN SURFACE SOIL

Table 4-20 presents the results of the SRC screening for surface soil at the Building F-15 aggregate, and Table 4-21 presents the results of the SRC screening for surface soil at the Building F-16 aggregate. The following subsections discuss the concentration and distribution of ISM surface soil results for each building.

5.2.1 Building F-15 Aggregate

5.2.1.1 Explosives and Propellants

Building F-15 was used for munitions testing; therefore, the Building F-15 aggregate was evaluated for explosives during all four of the investigations comprising the RI data set. Specifically, the soil samples around the buildings were analyzed during the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and 2010 PBA08 RI.

RDX and TNT could be potentially related to previous AOC operations; however, no detections of RDX, TNT, or any other explosive were identified in the surface soil samples and were not considered COPCs. One propellant (nitrocellulose) was detected in one ISM surface soil sample and is shown on Figure 5-1. This sample was collected from a ditch at the northern end of the Building F-15 aggregate. The propellant nitrocellulose was detected in only one of the samples (F15ss-006M) where propellants were analyzed. This chemical concentration is below its respective SL; therefore, nitrocellulose is not considered a COPC.

5.2.1.2 Inorganic Chemicals

Arsenic, chromium, lead, and mercury were identified as potential inorganic contaminants from previous site use and were identified as SRCs for the Building F-15 aggregate. However, maximum concentrations of chromium, lead, and mercury were below their SLs. Arsenic was identified as an inorganic SRC related to previous site use at Building F-15.

Arsenic exceeded its background concentration of 15.4 mg/kg in two of the 2004 Characterization of 14 AOCs ISM surface samples collected to evaluate the ditch southwest of (F15ss-005M) and former Buildings T-3002 and T-3003 (F15ss-011M). Figure 5-2 presents the locations with concentrations that exceeded background for arsenic at the Building F-15 aggregate.

Although not identified as previously used during historical operations, 10 other inorganic chemicals were identified as SRCs from the RVAAP screening process, as presented in Table 4-20. Of these constituents, only cobalt exceeded its SL and background concentration.

Cobalt was detected above the background concentration (10.4 mg/kg) in 7 of 16 samples, with concentrations between 11 mg/kg at six locations and 12 mg/kg at F15ss-010M. These concentrations are below the National Guard Trainee FWCUG at a TR of 1E-05, HQ of 1 (70.3 mg/kg). Figure 5-2 also presents exceedances of the SL and background for cobalt in surface soil.

5.2.1.3 Semi-volatile Organic Compounds

SVOCs were identified as potential organic contaminants from previous site use at Building U-17 within the Building F-15 aggregate that was formerly used as coal-powered boiler house. SVOCs do not have background concentrations for comparison to chemical results; consequently, several SVOCs were identified as SRCs. A total of 18 SVOC SRCs were identified as a result of the data screening; of these, 5 were PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] that exceeded their SLs and were identified as COPCs. Figure 5-3 presents PAH exceedances of the SL in the soil samples.

With the exception of one sample location, all PAH concentrations in samples collected in 2004, 2009, and 2010 at the Building F-15 aggregate were less than the Resident Receptor (Adult and Child) FWCUGs at a TR of 1E-05, HQ of 1. One location (F15ss-036M at 0.48 mg/kg) slightly exceeded the benzo(a)pyrene Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1 (0.221 mg/kg). This sample was collected as an ISM surface soil sample during the PBA08 RI from a ditch along Slagle Road northwest of Building F-15.

5.2.1.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

No VOCs, pesticides, or PCBs were detected in surface soil samples collected at the Building F-15 aggregate.

5.2.2 Building F-16 Aggregate

5.2.2.1 <u>Explosives and Propellants</u>

Historical ammunition packaging, shipping, and receiving took place at Building F-16; therefore, the Building F-16 aggregate was evaluated for explosives during all four of the investigations comprising the RI data set. Specifically, the soil samples around the buildings were analyzed during the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and 2010 PBA08 RI.

RDX and TNT could be potentially related to previous AOC operations; however, no detections of RDX, TNT, or any other explosive were identified in the ISM surface soil samples and were not considered COPCs. One explosive, 2,6-DNT, was detected in the discrete surface soil sample taken at F16sb-021 at a concentration (0.017J mg/kg) below its SL. Two propellants (nitrocellulose and nitroglycerin) were detected in two ISM surface soil samples and are shown on Figure 5-1. Samples F16ss-026M and F16ss-005M were collected from ditches located at the northern end of the Building F-16 aggregate. These samples had chemical concentrations below their respective SLs; therefore, nitrocellulose and nitroglycerin are not considered COPCs.

5.2.2.2 <u>Inorganic Chemicals</u>

Arsenic, chromium, lead, and mercury were identified as potential inorganic contaminants from previous site use. However, maximum concentrations of chromium, lead, and mercury were below the SL. Arsenic was identified as a potential inorganic SRC related to previous site use at Building F-16.

Arsenic exceeded its background concentration of 15.4 mg/kg in the 2004 Characterization of 14 AOCs ISM surface sample F16ss-004M (18 mg/kg) collected to evaluate the ditch north of former Building F-15 and PBA08 RI sample location F16sb-021 (31.3 mg/kg) collected from a discrete boring installed in the ditch west of former Building F-16. Figure 5-2 presents the locations with concentrations that exceeded background for arsenic at the Building F-16 aggregate.

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 constituents, only cobalt, manganese, and thallium exceeded their respective SLs and background concentration. Figure 5-2 also presents exceedances of the SL and background for cobalt, manganese, and thallium in the surface soil.

Observations regarding other individual inorganic SRCs that exceeded their respective SLs in the Building F-16 aggregate surface soil are presented below:

- Cobalt was detected above its background concentration (10.4 mg/kg) in 3 of 11 ISM surface soil samples, with concentrations between 11 mg/kg at location F16ss-001M and 12 mg/kg at F16ss-001M. A discrete surface soil sample F16sb-021 exceeded its background concentration at a concentration of 15.7J mg/kg. These concentrations are below the National Guard Trainee FWCUG at a TR of 1E-05, HQ of 1 (70.3 mg/kg). All subsurface samples collected at this location had concentrations of cobalt below the SL.
- Manganese was detected above the background concentration (1,450 mg/kg) and FWCUG at a TR of 1E-05, HQ of 1 (351 mg/kg) in only one of the two discrete samples at a concentration of 2,140 mg/kg at PBA08 RI location F16sb-022. All subsurface samples collected at these locations had concentrations of manganese below the SL.
- Thallium was detected in 5 of the 11 surface soil ISM samples with only two PBA08 RI discrete sample locations (F16sb-022 and F16sb-021) detected above the SL. However, concentrations at both locations (0.64 and 0.69 mg/kg) were below the FWCUG at a TR of 1E-05, HQ of 1 (6.12 mg/kg). All subsurface samples collected at these locations had concentrations of thallium below the SL.

5.2.2.3 Semi-volatile Organic Compounds

SVOCs were identified as potential organic contaminants from previous site use at Building U-18 within the Building F-16 aggregate that was formerly used as a coal-powered boiler house. SVOCs do not have background concentrations for comparison to chemical results; consequently, several SVOCs were identified as SRCs. A total of 16 SVOC SRCs were identified as a result of the data screening; of these, one PAH [benzo(a)pyrene] with a maximum concentration of 0.11 mg/kg exceeded its SL and was identified as a COPC. Benzo(a)pyrene also exceeded the SL in two discrete surface soil samples with a maximum detection of 0.17 mg/kg at F16sb-022. Benzo(b)fluoranthene (0.39 mg/kg) also exceeded the SL (0.221 mg/kg) in the discrete surface soil sample at F16sb-022. All subsurface samples collected at this location had non-detectable concentrations of benzo(a)pyrene. Figure 5-3 presents PAH exceedances of the SL in the surface soil samples.

All PAH concentrations in samples collected in 2004, 2009, and 2010 were less than the Resident Receptor (Adult and Child) FWCUGs at a TR of 1E-05, HQ of 1.

5.2.2.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

PCBs were identified as potential contaminants from previous site use. Figure 5-4 presents detected concentrations of VOCs, pesticides, and PCBs in surface soil. Two pesticides [4,4’-dichlorodiphenyldichloroethylene (DDE) and 4,4’-dichlorodiphenyltrichloroethane (DDT)], one PCB (PCB-1260), and one VOC (chloroform) were identified as SRCs in surface soil at the Building F-16 aggregate, as shown in Table 4-21. Pesticides (4,4’-DDE and 4,4’-DDT) were detected in one of two samples in the RI data set at 2004 Characterization of 14 AOCs ISM sample F16ss-005M at a concentration of 0.012J and 0.019J mg/kg, respectively. PCB-1260 was detected at this sample location at a concentration of 0.12 mg/kg. Chloroform was detected at PBA08 RI sample location F16ss-026M at a concentration of 0.00068J mg/kg. The detected VOC, pesticides, and PCB were all at concentrations below their FWCUGs at a TR of 1E-05, HQ of 1.

5.3 CONTAMINANT NATURE AND EXTENT IN SUBSURFACE SOIL

As discussed in Section 4.4, data from subsurface soil samples were screened to identify SRCs representing subsurface conditions at the AOC. Subsurface soil samples were not collected during the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, or 2009 USACE ISM Surface Soil Sampling; therefore, the SRC screening data set was comprised of 12 discrete samples collected during the 2010 PBA08 RI. As summarized in Table 4-22 for the Building F-15 aggregate and Table 4-23 for the Building F-16 aggregate, all of the subsurface samples collected from 1–4 and 4–7 ft bgs were analyzed for TAL metals, explosives, and PAHs except for the samples collected at F15sb-031. The 1–4 and 4–7 ft bgs samples collected from F15sb-031 were analyzed for RVAAP full-suite analytes.

During the execution of the PBA08 RI, subsurface samples collected from 7–13 ft bgs were archived until samples collected from 4–7 ft bgs were analyzed. Two samples (F-15sb-033 and F16sb-021) had preliminary SL exceedances in the subsurface samples collected from 4–7 ft bgs; therefore, the sample collected from 7–13 ft bgs at both borings were submitted for analysis in accordance with the DQOs. No other 7–13 ft bgs samples required analysis to evaluate vertical nature and extent. Table 4-22 for the Building F-15 aggregate and Table 4-23 for the Building F-16 aggregate present the results of the SRC screening for subsurface soil samples.

5.3.1 Building F-15 Aggregate

5.3.1.1 <u>Explosives and Propellants</u>

RDX and TNT were identified as potential explosive contaminants from previous site use. Seven samples were analyzed for subsurface explosives contamination. There were no detections of any explosives or propellants analyzed (including RDX and TNT) in the subsurface soil samples.

5.3.1.2 <u>Inorganic Chemicals</u>

Arsenic, chromium, lead, and mercury were identified as potential inorganic contaminants from previous site use, as summarized in the list below. The maximum detections of arsenic, chromium, and lead were below the background concentration, and mercury had a maximum concentration below the SL.

Although they were not identified as previously used during historical operations, cadmium, cobalt, and silver also had maximum detections above their respective background concentrations.

- Cadmium has no background concentration. All results were either non-detectable or estimated. The maximum concentration of cadmium was 0.13J mg/kg at F15sb-031 from 1–4 ft bgs and was below the SL.
- Cobalt was detected above the background concentration (23.2 mg/kg) in one of seven subsurface soil samples, with a concentration of 25J mg/kg at location F15sb-031 from 1–4 ft bgs. This concentration is below FWCUG at a TR of 1E-05, HQ of 1 (70.3 mg/kg). The 4–7 ft bgs sample was below the background concentration.
- Silver has no background concentration. All results were either non-detectable or estimated. The maximum concentration of silver was 0.069J mg/kg at F15sb-031 from 1–4 ft bgs and was below the SL.

No apparent vertical trends of increasing or decreasing concentrations with depth were observed for these two inorganic SRCs.

5.3.1.3 Semi-volatile Organic Compounds

One PAH [bis(2-ethylhexyl)phthalate] was identified as an SRC at F15sb-031; however, the concentration (0.028J mg/kg) was detected below the SL (39 mg/kg); therefore, it was not identified as a COPC for surface soil at the Building F-15 aggregate. Benzo(a)pyrene was detected in surface soil (0–1 ft bgs) at PBA08 RI sample location F15sb-031, but was not detected in deeper samples collected from 1–4 and 4–7 ft bgs at F15sb-031.

5.3.1.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

No VOCs, pesticides, or PCBs were detected in subsurface soil at the Building F-15 aggregate.

5.3.2 Building F-16 Aggregate

5.3.2.1 Explosives and Propellants

RDX and TNT were identified as potential explosive contaminants from previous site use. Five samples were analyzed for subsurface explosives contamination. There were no detections of any explosives or propellants (including RDX and TNT) in the subsurface soil samples.

5.3.2.2 Inorganic Chemicals

Arsenic, chromium, lead, and mercury were identified as potential inorganic contaminants from previous site use, as summarized in the list below. The maximum detections of chromium and lead were below the background concentration, and mercury had a maximum concentration below the SL. Arsenic had one detection above the background concentration (19.8 mg/kg). This concentration (24.3J mg/kg at F16sb-021 from 4–7 ft bgs) was qualified as estimated. Further evaluation of the vertical extent at F16sb-021 indicated a potential decreasing concentration profile of 24.3J mg/kg from 4–7 ft bgs and 11.3J mg/kg from 7–13 ft bgs.

Although it was not identified as previously used during historical operations, cadmium also had maximum detections above its background concentration. Cadmium has no background concentration. All results were either non-detectable or estimated. The maximum concentration of cadmium was 0.085J mg/kg at F16sb-021 from 1–4 ft bgs and was below the SL.

No apparent vertical trends of increasing or decreasing concentrations with depth were observed for these two inorganic SRCs.

5.3.2.3 Semi-volatile Organic Compounds

SVOCs do not have background concentrations for comparison to chemical results; consequently, several SVOCs were identified as SRCs. Six SVOC SRCs were identified as a result of the data screening; none of these SRCs exceeded the SL and, therefore, were not identified as COPCs. Figure 5-3 shows that there were no PAH exceedances of the SL in the subsurface soil samples.

5.3.2.4 Volatile Organic Compounds, Pesticides, and Polychlorinated Biphenyls

No VOCs, pesticides, or PCBs were detected in subsurface soil at the Building F-16 aggregate.

5.4 GEOTECHNICAL SUBSURFACE SOIL SAMPLES

One soil boring was completed at the AOC to obtain geotechnical parameters to support vadose zone soil leaching and groundwater transport modeling. A sample was collected from each of the 4–5 and 8–8.8 ft bgs intervals in this boring. Soil boring F16sb-023 was advanced to a total depth of 12 ft bgs, with groundwater encountered at 10.8 ft bgs. Bedrock was not encountered at soil boring location F16sb-023. Table 5-2 summarizes the results of the geotechnical characteristics of the soil. Laboratory analytical data package results are presented in Appendix D.

5.5 CONTAMINANT NATURE AND EXTENT IN SEDIMENT

Sediment is not considered a medium of concern at the Buildings F-15 and F-16 AOC, as surface water is only intermittent at the AOC. However, during the 2004 Characterization of 14 AOCs, two ISM sediment samples (F16sd-001M-SD and F16sd-002M-SD) were collected.

Sediment sample F16sd-001M-SD was collected from the former coal storage area immediately south of former Building F-16. Sample FWCss-008-0001-SO was collected by USACE in 2009 in that same area. The more recent sample (FWCss-008-0001-SO) is used in the risk assessment.

The results from the 2004 sample F16sd-001M-SD are summarized below.

- Only explosives and metals analyses were performed.
- No explosives were detected.
- No metal concentrations exceeded the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 1 or TR of 1E-05.

Sediment sample F16sd-002M-SD was collected downstream of the Building F-16 aggregate in the unnamed tributary to Sand Creek. The results of this sample are summarized below.

- Only explosives and metals analyses were performed.
- No explosives were detected.
- Cobalt at a concentration of 11 mg/kg was the only metal that exceeded the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 0.1 (2.3 mg/kg) but not at HQ of 1 (23 mg/kg).

5.6 CONTAMINANT NATURE AND EXTENT IN SURFACE WATER

Surface water is only present at the Buildings F-15 and F-16 AOC intermittently. Accordingly, surface water is not considered a medium of concern at this AOC. However, during the 2004 Characterization of 14 AOCs, two surface water samples (F16sw-001 and F16sw-002) were collected and analyzed for the RVAAP full-suite analytes.

Surface water sample F16sw-002 was collected downstream of the Building F-16 aggregate in the unnamed tributary to Sand Creek. All the concentrations from this sample were below their background concentration or the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 1 or TR of 1E-05.

Surface water sample F16sw-001 was collected from the former coal storage area immediately south of former Building F-16. Effectively, this was a sample from accumulated, ponded water. The metal, SVOC, VOC, PCB, and pesticide concentrations were either non-detectable or had a concentration below the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 1 or TR of 1E-05. Nitroglycerin at 0.0021 mg/L exceeded the tap water RSL of 0.0002 mg/L at HQ of 0.1 and 0.002 mg/kg at HQ of 1.

5.7 SUMMARY OF CONTAMINANT NATURE AND EXTENT

Data from the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and 2010 PBA08 RI have effectively characterized the nature and extent of the contamination at the AOC. Media of concern at this AOC are surface and subsurface soil. Surface water at the AOC only occurs intermittently. Sections 5.5 and 5.6 summarize the intermittent ponded water (and corresponding sediment) previously sampled and the sample results collected from the unnamed tributary to Sand Creek.

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 the Buildings F-15 and F-16 AOC.

5.7.1 Building F-15 Aggregate

No explosives were detected at the Building F-15 aggregate in surface or subsurface soil samples. One propellant (nitrocellulose) was detected in one ISM surface soil sample (F15ss-006M) at a concentration below the SL. No propellants were detected in the subsurface soil samples. Arsenic and cobalt were the only two inorganic chemicals to exceed their background concentrations and FWCUGs of HQ of 0.1 or TR of 1E-06 in surface soil. No propellants were detected in subsurface soil samples. Arsenic exceeded the background concentration of 15.4 mg/kg in two of the 2004 Characterization of 14 AOCs ISM surface samples collected to evaluate the ditch to the southwest (F15ss-005M) and former buildings T-3002 and T-3003 (F15ss-011M) and was not detected above background in subsurface soil samples.

One location (F15ss-036M at 0.48 mg/kg) slightly exceeded the benzo(a)pyrene Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1 (0.221 mg/kg). Sample location F15ss-036M was collected as an ISM surface soil sample during the PBA08 RI from a ditch along Slagle Road northwest of Building F-15. PAHs were not detected in any subsurface soil samples. PAH concentrations detected across the entire AOC were generally higher in samples taken from low-lying areas and ditches bordering Slagle Road and parking areas. PAHs were identified as potential contaminants from previous site use at Buildings U-17 that were formerly used as a coal-powered boiler house; however, concentrations in surface soil at this former building location were less than SLs.

As presented in Table 2-1, historical records indicated three transformers serviced all buildings at the AOC. PCBs were not detected in surface or subsurface soil. Furthermore, VOCs and pesticides were not detected in surface or subsurface soil, which is consistent with the historical record that shows they were not previously used at the AOC.

5.7.2 Building F-16 Aggregate

No explosives were detected at the Building F-16 aggregate in ISM surface or discrete subsurface soil samples. One explosive, 2,6-DNT, was detected below its SL in the discrete surface soil sample taken at F16sb-021. Two propellants (nitrocellulose and nitroglycerin) were detected in two ISM surface soil samples (F16ss-026M and F16ss-005M) collected from ditches located at the northern end of the Building F-16 aggregate at concentrations below their respective SLs; therefore, nitrocellulose and nitroglycerin were not considered COPCs. No propellants were detected in subsurface soil samples.

Arsenic, cobalt, manganese, and thallium were the only four inorganic chemicals to exceed their background concentration and FWCUGs of HQ of 0.1 or TR of 1E-06 in surface soil. Cobalt and thallium did not exceed the FWCUGs of HQ of 1 or TR of 1E-05 and were not detected in subsurface soil samples. Arsenic exceeded the background concentration of 15.4 mg/kg in the 2004 Characterization of 14 AOCs ISM surface sample F16ss-004M (18 mg/kg) collected to evaluate the ditch located to the north of former Building F-15 and in PBA08 RI sample location F16sb-021 (31.3 mg/kg) collected from a discrete boring installed in the ditch to the west of former Building F-16. Arsenic exceeded the background concentration of 19.8 mg/kg in subsurface soil at F16sb-021 (24.3J mg/kg from 4–7 ft bgs). Evaluation of the vertical extent at F16sb-021 indicated a potential decreasing concentration profile of 24.3J mg/kg from 4–7 ft bgs and 11.3J mg/kg from 7–13 ft bgs. Manganese was detected above the background concentration (1,450 mg/kg) and FWCUG at a TR of 1E-05, HQ of 1 (2,927 mg/kg) in only one of the two discrete surface soil samples with a concentration of 2,140 mg/kg at PBA08 RI location F16sb-022. All subsurface samples collected at these locations had concentrations of manganese below the SL.

Benzo(a)pyrene and benzo(b)fluoranthene, the only PAHs detected above the SLs were detected below the FWCUG at a TR of 1E-05, HQ of 1 in all surface soil samples at the Building F-16 aggregate. PAHs were not detected in subsurface soil samples. PAHs were identified as potential contaminants from previous site use at Buildings U-18 which was formerly used as a coal-powered boiler house; however, concentrations in surface soil at this former building location were less than SLs.

Although no previous use of VOCs or pesticides were documented at Building F-16, chloroform was detected at PBA08 RI surface sample location F16ss-026M at a concentration of 0.00068J mg/kg. Pesticides (4,4’-DDE and 4,4’-DDT) were also detected in one of two surface samples in the RI data set at 2004 Characterization of 14 AOCs ISM sample F16ss-005M at a concentration of 0.012J and 0.019J mg/kg, respectively. As presented in Table 2-1, historical records indicated three transformers serviced all buildings at the AOC. PCB-1260 was detected in surface soil at F16ss-005M at a concentration of 0.12 mg/kg. No VOCs, PCBs, or pesticides were detected in subsurface soil samples collected at the Building F-16 aggregate. Also, the detected VOC, pesticides and PCB concentrations in surface soil were all below the FWCUGs at a TR of 1E-05, HQ of 1.

Table 5–1. Chromium Speciation Results

Sample Location	Date	Hexavalent Chromium Concentration (mg/kg)	Total Chromium Concentration[a] (mg/kg)	Percent Hexavalent Chromium (%)
F15ss-034	02/24/2010	<1.2U	18.4	NA
F15ss-036	10/19/2010	0.4 J	21.9	1.8
F16ss-024	02/24/2010	2.2	21	10.5
F16ss-025	02/24/2010	0.4J	21.4	1.9
F16ss-026	10/18/2010	<0.95U	16.1	NA
F16ss-027	10/18/2010	<1U	19.1	NA

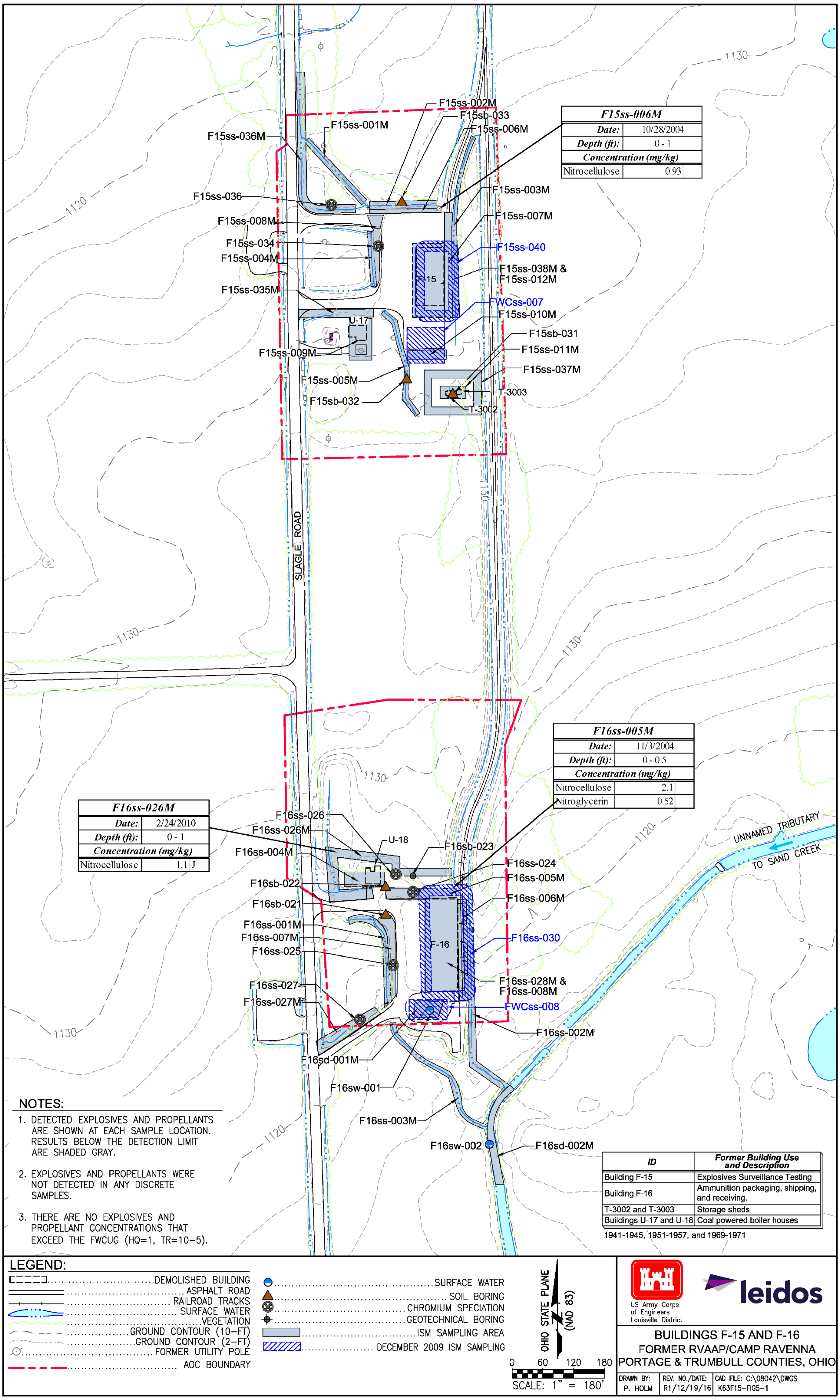
[a] Background concentration for total chromium = 17.4 mg/kg. No background concentration is available for hexavalent chromium.

J = Estimated value less than reporting limits.
mg/kg= Milligrams per kilograms.
NA = Not applicable; hexavalent chromium not detected in sample.
U = Non-detectable concentration.
< = Less than.

Table 5–2. Summary of Geotechnical Parameters

Sample ID: Parameters	F16sb-023-5425-SO	F16sb-023-5426-SO
Depth	4–5 ft bgs	8–8.8 ft bgs
Porosity	36. %	32.5%
Density	1.73 g/cm^3	1.84 g/cm^3
Moisture content	14.3%	14.6%
Total organic carbon	770J mg/kg	1,300 mg/kg
Size fraction analysis	6.4% gravel, 28.4% sand, 44.1% silt, 21.2% clay	5.3% gravel, 20.1% sand, 45.8% silt, 28.9% clay
Permeability (K)	1.5E-07 cm/sec	7.9E-08 cm/sec

J = estimated value less than reporting limits.
bgs = Below ground surface.
cm/sec = Centimeters per second.
ft = Feet.
g/cm^3 = Grams per cubic centimeter.
ID = Identification.
mg/kg = Milligrams per kilogram.



F15ss-006M	
Date:	10/28/2004
Depth (ft):	0 - 1
Concentration (mg/kg)	
Nitrocellulose	0.93

F16ss-005M	
Date:	11/3/2004
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
Nitrocellulose	2.1
Nitroglycerin	0.52

F16ss-026M	
Date:	2/24/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Nitrocellulose	1.1 J

NOTES:

1. DETECTED EXPLOSIVES AND PROPELLANTS ARE SHOWN AT EACH SAMPLE LOCATION. RESULTS BELOW THE DETECTION LIMIT ARE SHADED GRAY.
2. EXPLOSIVES AND PROPELLANTS WERE NOT DETECTED IN ANY DISCRETE SAMPLES.
3. THERE ARE NO EXPLOSIVES AND PROPELLANT CONCENTRATIONS THAT EXCEED THE FWCUG (HQ=1, TR=10-5).

ID	***Former Building Use and Description***
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

LEGEND:

⌐- - -⌐	DEMOLISHED BUILDING
═	ASPHALT ROAD
┼─┼	RAILROAD TRACKS
▭	SURFACE WATER
∿	VEGETATION
— —	GROUND CONTOUR (10-FT)
- - -	GROUND CONTOUR (2-FT)
⊙	FORMER UTILITY POLE
▬ ▬	AOC BOUNDARY
◒	SURFACE WATER
▲	SOIL BORING
⊗	CHROMIUM SPECIATION
⌖	GEOTECHNICAL BORING
▭	ISM SAMPLING AREA
▨	DECEMBER 2009 ISM SAMPLING

BUILDINGS F-15 AND F-16
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

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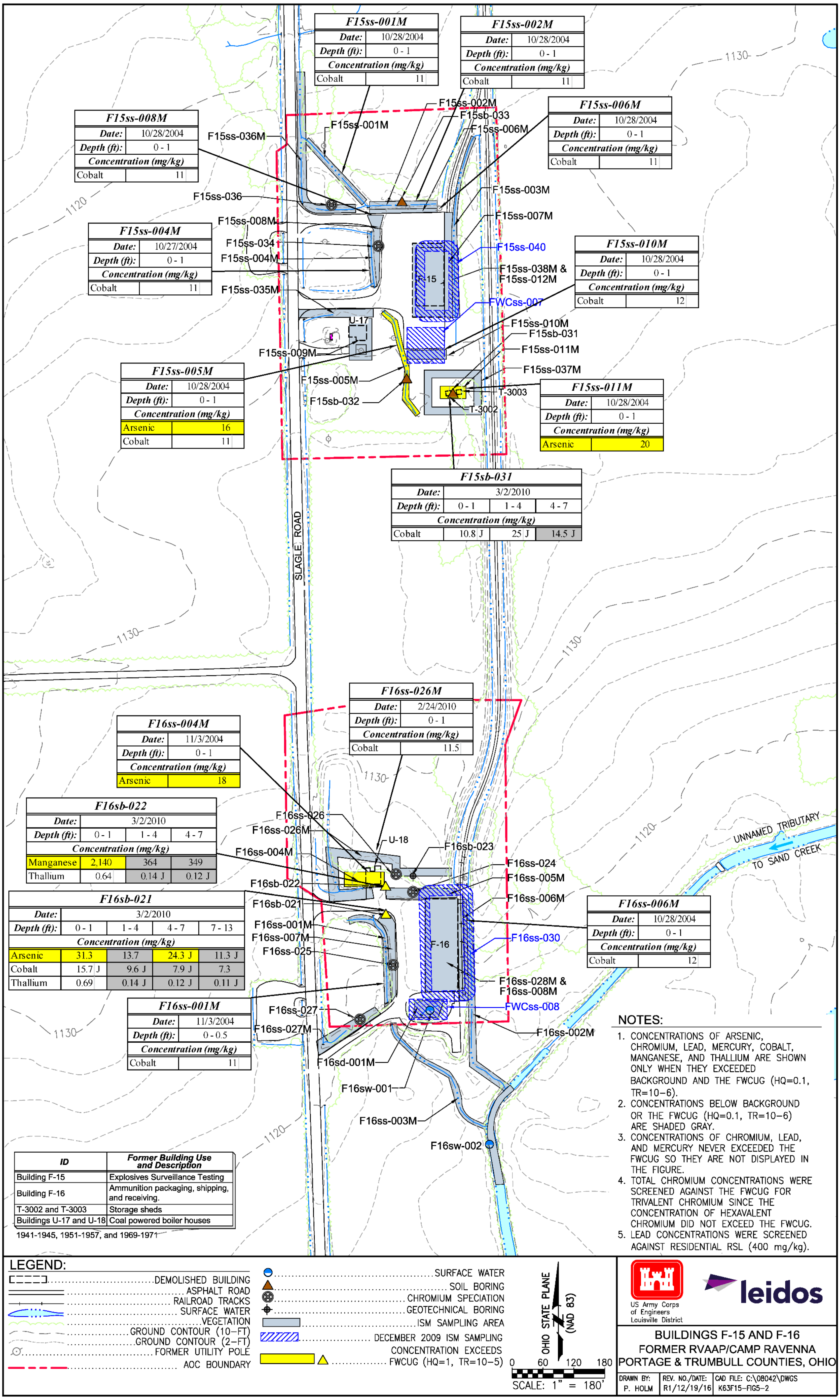
P. HOLM	R1/12/19/16	K63F15–FIG5–1

Figure 5–1. Detected Concentrations of Explosives and Propellants in Soil at the Buildings F-15 and F-16 Aggregates



ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

NOTES:

1. CONCENTRATIONS OF ARSENIC, CHROMIUM, LEAD, MERCURY, COBALT, MANGANESE, AND THALLIUM ARE SHOWN ONLY WHEN THEY EXCEED 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, LEAD, AND MERCURY NEVER EXCEEDED THE FWCUG SO THEY ARE 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).

LEGEND:

- DEMOLISHED BUILDING
- ASPHALT ROAD
- RAILROAD TRACKS
- SURFACE WATER
- VEGETATION
- GROUND CONTOUR (10–FT)
- GROUND CONTOUR (2–FT)
- FORMER UTILITY POLE
- AOC BOUNDARY
- SURFACE WATER
- SOIL BORING
- CHROMIUM SPECIATION
- GEOTECHNICAL BORING
- ISM SAMPLING AREA
- DECEMBER 2009 ISM SAMPLING
- CONCENTRATION EXCEEDS FWCUG (HQ=1, TR=10−5)

BUILDINGS F-15 AND F-16
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

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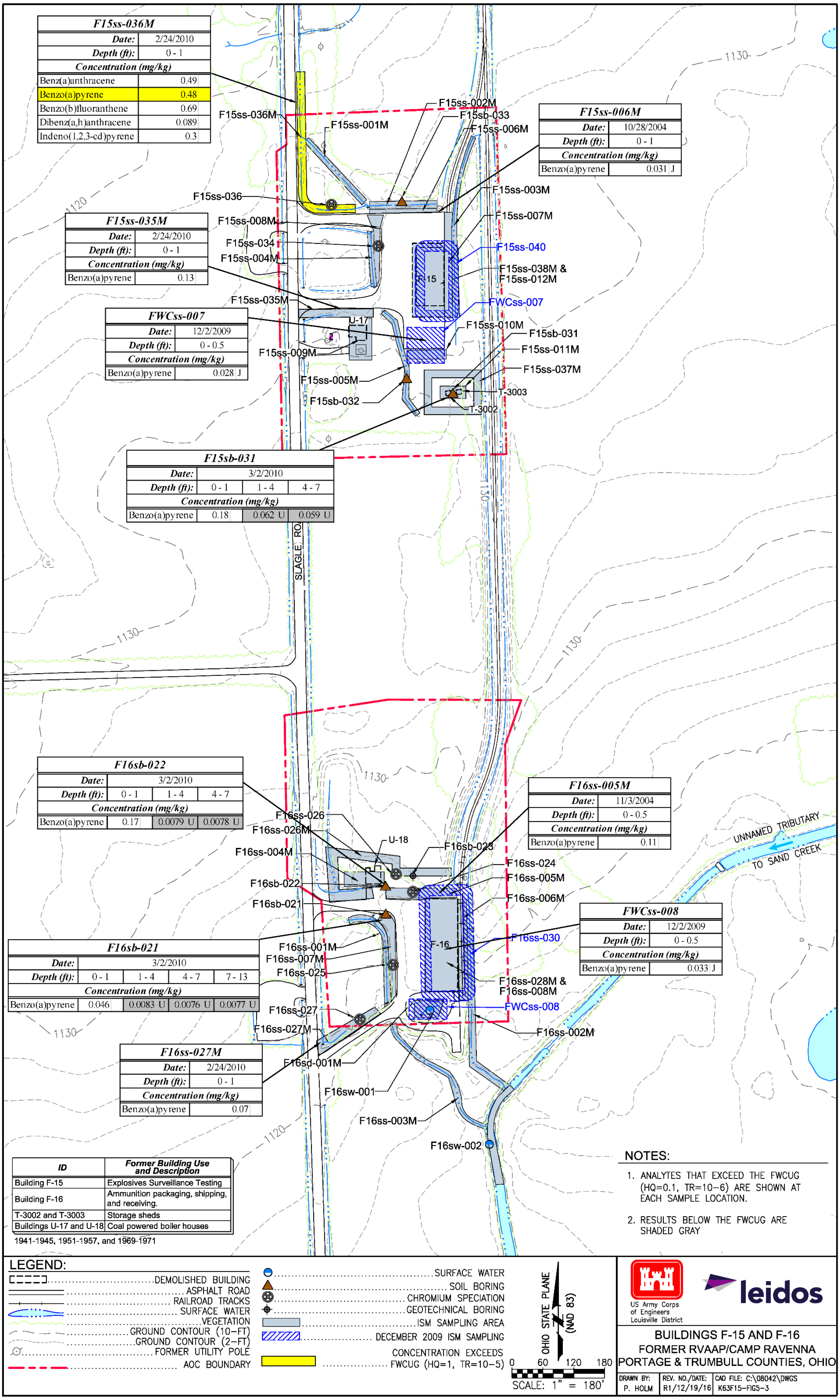
P. HOLM	R1/12/19/16	K63F15–FIG5–2

Figure 5–2. Exceedances of FWCUG (HQ of 0.1, TR of 1E-06) for Arsenic, Chromium, Lead, Mercury, Cobalt, Manganese and Thallium in Soil at the Buildings F-15 and F-16 Aggregates



F15ss-036M	
Date:	2/24/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benz(a)anthracene	0.49
Benzo(a)pyrene	0.48
Benzo(b)fluoranthene	0.69
Dibenz(a,h)anthracene	0.089
Indeno(1,2,3-cd)pyrene	0.3

F15ss-006M	
Date:	10/28/2004
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benzo(a)pyrene	0.031 J

F15ss-035M	
Date:	2/24/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benzo(a)pyrene	0.13

FWCss-007	
Date:	12/2/2009
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
Benzo(a)pyrene	0.028 J

F15sb-031			
Date:	3/2/2010		
Depth (ft):	0 - 1	1 - 4	4 - 7
Concentration (mg/kg)			
Benzo(a)pyrene	0.18	0.062 U	0.059 U

F16sb-022			
Date:	3/2/2010		
Depth (ft):	0 - 1	1 - 4	4 - 7
Concentration (mg/kg)			
Benzo(a)pyrene	0.17	0.0079 U	0.0078 U

F16ss-005M	
Date:	11/3/2004
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
Benzo(a)pyrene	0.11

FWCss-008	
Date:	12/2/2009
Depth (ft):	0 - 0.5
Concentration (mg/kg)	
Benzo(a)pyrene	0.033 J

F16sb-021				
Date:	3/2/2010			
Depth (ft):	0 - 1	1 - 4	4 - 7	7 - 13
Concentration (mg/kg)				
Benzo(a)pyrene	0.046	0.0083 U	0.0076 U	0.0077 U

F16ss-027M	
Date:	2/24/2010
Depth (ft):	0 - 1
Concentration (mg/kg)	
Benzo(a)pyrene	0.07

ID	***Former Building Use and Description***
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

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

BUILDINGS F-15 AND F-16
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

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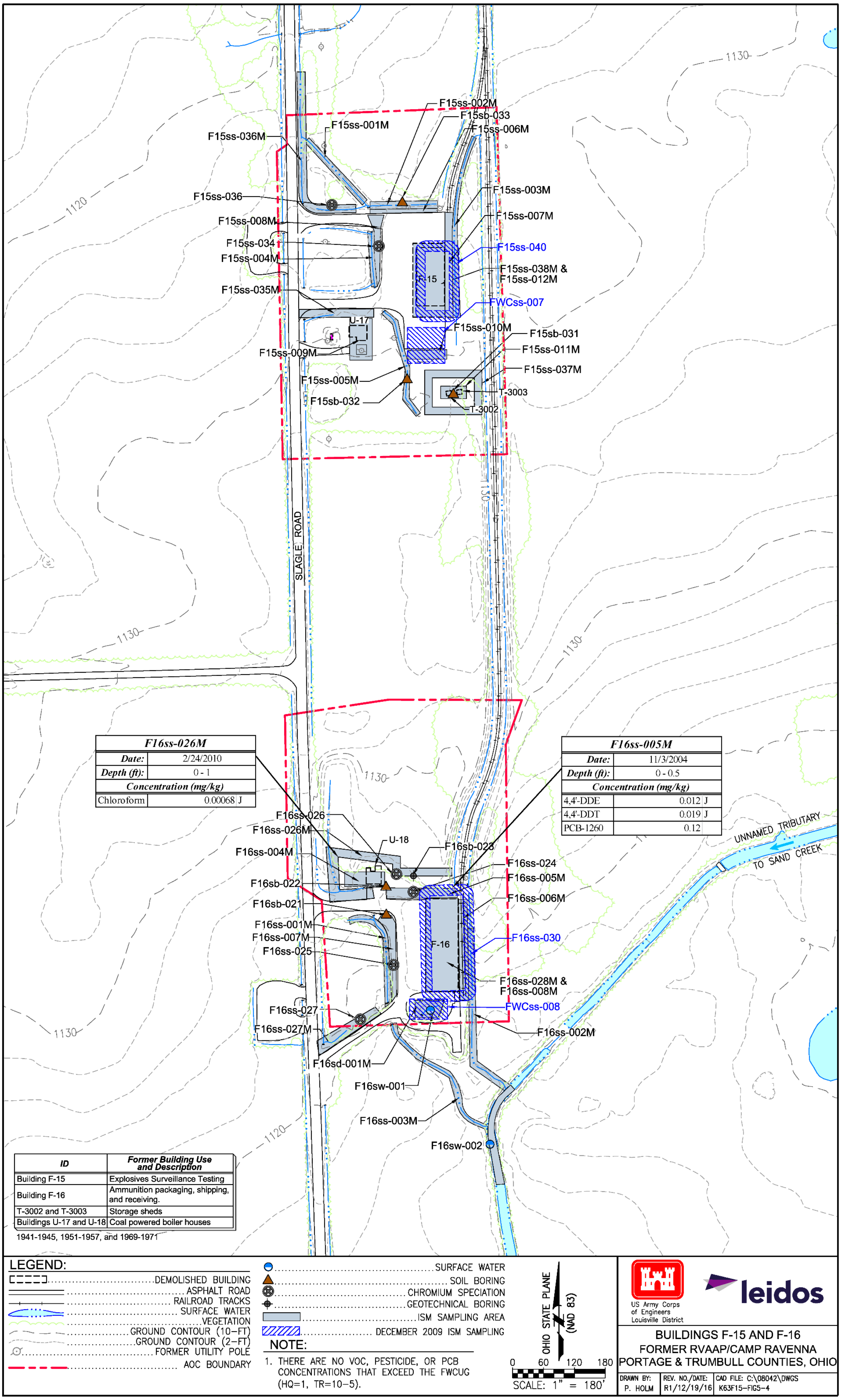
P. HOLM	R1/12/19/16	K63F15–FIG5–3

Figure 5–3. PAH Exceedances of FWCUG (HQ of 0.1, TR of 1E-06) in Soil at the Buildings F-15 and F-16 Aggregates



F16ss-026M		
Date:	2/24/2010	
Depth (ft):	0 - 1	
Concentration (mg/kg)		
Chloroform	0.00068	J

F16ss-005M		
Date:	11/3/2004	
Depth (ft):	0 - 0.5	
Concentration (mg/kg)		
4,4'-DDE	0.012	J
4,4'-DDT	0.019	J
PCB-1260	0.12	

ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

NOTE:

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

Figure 5-4. Detected Concentrations of VOCs, Pesticides, and PCBs in Soil at the Buildings F-15 and F-16 Aggregates

6.0 CONTAMINANT FATE AND TRANSPORT

Contaminant fate and transport modeling assesses the potential for SRCs to leach from surface and subsurface soil sources at the Buildings F-15 and F-16 AOC 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. 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 a soil screening analysis to identify SRCs with the potential to migrate from soil to groundwater as initial CMCOPCs. Section 6.4 describes fate and transport modeling of final CMCOPCs and presents CMCOCs. Section 6.5 provides a list of the remaining final CMCOPCs and a qualitative assessment of the results and considerations of the limitations and assumptions. Section 6.6 presents a 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, sulfates, nitrates, lead styphnate, and lead azide. Additional site-specific contaminants include mercury fulminate, tetryl; HMX, nitroglycerine, nitrocellulose, nitroguanidine, and heavy metals (lead, chromium, mercury, and arsenic) from testing munitions. PAHs from coal storage and use in the two boiler houses (Buildings U-17 and U-18) and PCBs from the on-site transformers at Building F-15 are also considered site-specific contaminants.

This evaluation of contaminant fate and transport evaluates not only those chemicals identified as potential contaminants from previous use but also includes an evaluation of chemicals that were evaluated as part of the overall RI. The comprehensive list of surface and subsurface soil SRCs (including 15 inorganic chemicals and 26 organic chemicals) were detailed in Section 4.0 and are summarized below:

- Inorganic SRCs in surface and subsurface soil include antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc.
- Organic SRCs in surface and subsurface soil include 2-methylnaphthalene; 4,4’-DDE; 4,4’-DDT; acenaphthene; acenaphthylene; anthracene; benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(ghi)perylene; benzo(k)fluoranthene; bis(2-ethylhexyl)phthalate; carbazole; chloroform; chrysene; dibenz(a,h)anthracene; dibenzofuran; fluoranthene; fluorene; indeno(1,2,3-cd)pyrene; naphthalene, nitrocellulose; nitroglycerin; PCB-1260; phenanthrene; and pyrene.

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 Appendix E, Tables E-1 and E-2. 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 are summarized in Sections 6.1.1 through 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 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 (e.g., 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

Nitroglycerin and nitrocellulose were explosive compounds detected in soil at the AOC. Nitroglycerin and nitrocellulose are aliphatic nitrate esters that will gelatinize 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. Nitroglycerin is a liquid under normal conditions that is mobile in soil environments. Microbiological and photochemical transformation may affect the fate and transport of explosive compounds in the environment. Nitrocellulose and nitroglycerin can undergo denitrification as a degradation pathway. Degradation of nitrocellulose to non-reactive nitrocellulose has been observed under methanogenic and fungus-mediated reducing conditions. Degradation of nitroglycerin to glycerol has been observed under aerobic and anaerobic microbe-mediated conditions as well as in the presence of fungal cell cultures (USACE 2006). The biodegradation pathway of nitroglycerin begins with nitroglycerin (glycerol nitrate) that degrades to glycerol dinitrates, then to glycerol mononitrates, followed by glycerol (Christodoulatos et al. 1997). Appendix E, Figure E-1 shows the biotransformation pathway for nitroglycerin (Christodoulatos et al. 1997).

6.2 CONCEPTUAL MODEL FOR FATE AND TRANSPORT

The CSM, which defines the framework for fate and transport modeling, describes conditions at the Buildings F-15 and F-16 AOC, including the contaminant sources, surficial and subsurface hydrogeologic conditions, contaminant migration and pathways, and contaminant release mechanisms.

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 were 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 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; 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) 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 the Buildings F-15 and F-16 AOC ranges from approximately 1,120 ft amsl near the southern and northern boundaries of the AOC to 1,130 ft amsl in the center of the AOC. A local topographical high is located between former Building F-15 and Building F-16 and slopes downward to the northwest and southeast. Surface water drainage associated with heavy rainfall events would follow topography (Figure 3-1). Surface runoff from the Building

F-15 aggregate flows overland to the northwest to a tributary to Eagle Creek. Surface runoff from the Building F-16 aggregate flows overland to the southeast to a tributary to Sand Creek.

- Soil beneath the AOC consists mostly of silty loam that exhibit seasonal wetness, rapid runoff, and low permeability (USDA 2010).
- Groundwater monitoring wells are not installed at the AOC. Current AOC-specific information pertaining to the geology and hydrogeology underneath the AOC were not available; therefore, facility-wide parameters were used where necessary. The estimated depth of groundwater at the AOC ranges from 11–14 ft bgs based on facility-wide measurements.
- The general groundwater flow direction across most of the AOC is to the southeast based on the RVAAP facility-wide potentiometric surface map (EQM 2010). The hydraulic gradient from the facility-wide potentiometric surface was 0.00743.

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 for Buildings F-15 and F-16).

The principal migration pathway 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 the AOC. 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 leaching of soil contaminants 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:

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

or

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

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 Generic Soil Screening Level (GSSL) Hydrologic Evaluation of Landfill Performance (HELP) model (USEPA 1994). See Appendix E, Table E-3 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% (27 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% (23.4 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 are described below.

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

The second step of the soil screening process (Figure 6-2) involves comparing maximum concentrations of SRCs with MCL-based 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 level (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), obtained from the USEPA RSL website is 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 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.

One soil SRC, carbazole, was eliminated as an initial CMCOPC because it does not have an associated GSSL or USEPA risk-based SSL. Because this constituent does not have an associated USEPA RSL or MCL, an AOC-specific SSL could not be calculated. Carbazole was detected in one of three soil samples at Building F-16 with a maximum concentration of 0.038 mg/kg and was not detected at Building F-15. Carbazole is an SVOC with a relatively high K_{oc} value (9.16E+03 L/kg); therefore, this compound has the tendency to partition into soil and is not likely to pose a risk to groundwater.

The initial CMCOPC screen, as presented in Appendix E, Table E-4, eliminates 6 inorganic and 14 organic SRCs at the Building F-15 aggregate and 5 inorganic and 16 organic SRCs at the Building F-15 aggregate from further consideration. There were 8 inorganic and 6 organic SRCs at the Building F-15 aggregate and 10 inorganic and 8 organic SRCs at the Building F-16 aggregate 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 level (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

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

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 calculations for the AOC are presented in Appendix E, Table E-5. It should be noted that the purpose of this screen is not to identify 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 an AOC-specific DAF of 2.97 for the Building F-15 aggregate and 2.95 for the Building F-16 aggregate, five SRCs at the Building F-15 aggregate and five SRCs at the Building F-16 aggregate were eliminated from further consideration. The remaining SRCs exceeded their respective SSSLs and were identified as initial CMCOPCs based on leaching to groundwater. The SRCs identified as initial CMCOPCs are presented in Appendix E, Table E-6.

The fourth step of the soil screening process (Figure 6-2) involves eliminating initial CMCOPCs identified in the SSSL evaluation from further consideration that require more than 1,000 years to leach through the unsaturated zone before reaching the water table. 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, as evaluated in Appendix E, Table E-7, which may vary across the AOC based on the varying depths of soil sample concentrations above the facility-wide background concentrations or SSSLs 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. Eight SRCs at the Building F-15 aggregate and eight SRCs at the Building F-16 aggregate were eliminated from further consideration based on their travel times exceeding 1,000 years. Initial CMCOPCs with travel times less than 1,000 years (naphthalene at the Building F-15 aggregate and selenium, nitroglycerin, 2-methylnaphthalene, and naphthalene at the Building F-16 aggregate) were retained for further evaluation (Appendix E, Table E-7) using the SESOIL model. The constituents selected for further evaluation with SESOIL modeling are listed in Table 6-1.

In the fifth step (Figure 6-2), the initial CMCOPCs (presented in Table 6-1) were further evaluated using fate and transport models provided in Section 6.4.

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 contamination already existing within the aquifer.

6.4 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 Analytical Transient 1-, 2-, 3-Dimensional (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 CMCOPC concentrations in groundwater beneath the source were compared to groundwater monitoring results for the AOC (if available) to validate modeling results and provide WOE for identifying or eliminating CMCOCs.

6.4.1 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 unconsolidated zone to downgradient receptor locations are conceptually 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, three ISM areas (one at the Building F-15 and two at the Building F-16) were considered as the source 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 6-3.

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 was 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 remedial actions. 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 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 if CMCOCs and COCs were co-located and may be addressed simultaneously under a potential remedial action.

6.4.2 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.

6.4.2.1 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. 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.

6.4.2.2 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 Appendix E, Table E-8. 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, using the two different weather station data sets did not impact modeling results.

6.4.2.3 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-9. The distribution coefficients (K_ds) for inorganic chemicals and the K_{oc} values for 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.

6.4.2.4 Soil Data

The soil data file of SESOIL contains input parameters describing the physical characteristics of the subsurface soil and is presented in Table 6-2. 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 5-2). There is, however, no measurement method for the soil disconnectedness index or a measured value of the Freundlich exponent. 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 6-2. 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.

6.4.2.5 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.

6.4.2.6 Application Data

Three different layering schemes were developed for the source areas based on soil sample data and depths to groundwater. Details of the model layers utilized in this modeling are presented in Appendix E, Table E-10.

The models of 11- or 13-ft vadose zones were arranged in four layers. Depending on the chemical being modeled, the top three layers varied between contaminant loading layers and leaching layers. The top layer (Layer 1) was 1 ft thick and divided into two sublayers that were each 0.5 ft thick. Layers 2 and 3 varied between 4.5 and 6 ft thick and were leaching layers for all analytes except selenium, which were contaminant loading layers. Layer 4, which was 0.25 ft thick for selenium and 0.5 ft thick for the remaining analytes, was included just above the water table to read output results at the water table/vadose zone interface (i.e., leachate concentration entering groundwater).

6.4.3 SESOIL Modeling Results

SESOIL modeling was performed for initial CMCOPCs (i.e., naphthalene at Building F-15 and selenium, nitroglycerin, 2-methylnaphthalene, and naphthalene at Building F-16) that have the potential to reach the water table within 1,000 years based on the soil screening analysis results (Table 6-1). Table 6-3 presents the predicted peak leachate concentrations beneath the source areas relative to the 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. The predicted leachate concentrations below the source and just above the water table were above their respective screening criteria for all initial CMCOPCs except 2-methylnaphthalene; therefore, they were selected as final CMCOPCs. Appendix E, Figures E-2 through E-6 show the leachate mass flux versus time plots generated by SESOIL that were used by AT123D modeling.

Naphthalene at the Building F-15 aggregate and selenium, nitroglycerin, and naphthalene at the Building F-16 aggregate were identified as final soil CMCOPCs based on SESOIL modeling results for each sample location within the AOC where the leachate concentration exceeded its screening criteria. This leachate concentration does not reflect the groundwater concentration beneath the source. When the leachate reaches the water table, dilution by groundwater further reduces leachate concentrations.

6.4.4 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 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 6-2. 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-11. A discussion of model assumptions and limitations is presented in Section 6.4.6.

Appendix E, Figures E-7 through E-10 show the predicted concentration versus time curves based on AT123D modeling.

6.4.5 AT123D Modeling Results

Results of AT123D modeling for final soil CMCOPCs are shown in Table 6-4. The results show predicted groundwater concentrations for CMCOPCs beneath the source area and at the selected downgradient receptor locations (i.e., tributary to Sand Creek). Groundwater monitoring wells were not installed at the AOC, so observed groundwater concentrations could not be included in Table 6-4 for comparison.

The maximum predicted concentrations of all four final soil CMCOPCs (naphthalene at the Building F-15 aggregate and naphthalene, nitroglycerin, and selenium at the Building F-16 aggregate) were predicted to exceed the screening criteria in groundwater beneath the source area and were modeled to the downgradient receptor (i.e., unnamed tributary to Sand Creek).

Lateral transport modeling showed the maximum predicted concentrations of naphthalene from the Building F-15 aggregate and nitroglycerin and selenium from the Building F-16 aggregate did not exceed the screening criteria at the downgradient receptor location. However, the maximum predicted concentration for naphthalene from the Building F-16 aggregate was slightly above the screening criteria at the downgradient receptor location. Figure 6-4 presents CMCOCs identified based on AT123D modeling.

6.4.6 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-phase 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.
- Since AOC-specific hydraulic parameters (e.g., hydraulic gradient, hydraulic conductivity, etc.) are not available, the values used in this analysis represent facility-wide values and may not be highly representative for this AOC.
- The K_d for inorganic chemicals used in the modeling evaluation assumed a pH of 6.8 [i.e., the middle value in 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 the 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 concentrations 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 cause 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.

6.5 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.

The limitations and assumptions of the overall process are presented in Section 6.4.6. The text below provides a list of the remaining final CMCOPCs and a qualitative assessment of the results and considerations of the limitations and assumptions.

6.5.1 Evaluation of Remaining Soil CMCOPCs

6.5.1.1 Building F-15

Naphthalene - The maximum surface soil concentration for naphthalene at Building F-15 (0.13 mg/kg) was well below the Resident Receptor Adult FWCUG at a TR of 1E-06, HQ of 0.1 (368 mg/kg), and naphthalene and was not considered a COPC in the HHRA at Building F-15. The modeling estimates that naphthalene concentrations in groundwater beneath the source area could potentially exceed its RSL after about 100 years. However, naphthalene is not predicted to migrate to the downgradient receptor location at concentrations exceeding the RSL within 1,000 years (Table 6-4). Therefore, this evaluation concludes that the model-predicted concentrations are conservative, and naphthalene would be expected to be below its RSL based on site-specific attenuation and biodegradation rates.

6.5.1.2 Building F-16

Selenium – Of the 16 surface and subsurface soil samples collected at Building F-16, only one sample (1.7 mg/kg) exceeded its surface and subsurface soil background concentrations (1.4 and 1.5 mg/kg, respectively). The maximum soil concentration was below the soil residential RSL (39 mg/kg), and selenium was not considered a COPC in the HHRA at Building F-16. Using the maximum soil concentration, selenium modeling results indicate it would take about 100 years for a breakthrough in groundwater beneath the source at a concentration above its MCL (0.050 mg/L), and selenium is not predicted to migrate to the downgradient receptor location at concentrations exceeding its MCL within 1,000 years (see Table 6-4).

Nitroglycerin – The single detected soil concentration for nitroglycerin at Building F-16 (0.52 mg/kg) was well below the Resident Receptor Adult FWCUG at a TR of 1E-06, HQ of 0.1 (81.6 mg/kg), and nitroglycerin was not considered a COPC in the HHRA at Building F-16. The modeling estimates that nitroglycerin concentrations in groundwater beneath the source area could potentially exceed its RSL and FWCUG at about 9 years or less with peak concentrations occurring at approximately 12 years or less, falling below SLs within 24–33 years. The maximum predicted nitroglycerin groundwater concentration at the downgradient receptor location is below its RSL and FWCUG (Table 6-4). Based on the AOC period of operations, nitroglycerin concentrations in groundwater beneath the source and at the downgradient location should have already peaked and fallen below SLs. Therefore, this evaluation concludes that the model-predicted concentrations are conservative, and nitroglycerin would be expected to be below its RSL based on site-specific attenuation and biodegradation rates.

Naphthalene – The maximum surface soil concentration for naphthalene at Building F-16 (0.73 mg/kg) was well below the Resident Receptor Adult FWCUG at a TR of 1E-06, HQ of 0.1 (368 mg/kg), and naphthalene was not considered a COPC in the HHRA at Building F-16. The modeling estimates that naphthalene concentrations in groundwater beneath the source area could potentially exceed its RSL after about 100 years, and also the concentration at the downgradient receptor location would be slightly above its RSL (Table 6-4). However it should be noted that if the biodegradation rate of naphthalene was accounted for in the analysis, the concentrations would be reduced to 0 within 100 years. Therefore, this evaluation concludes that the model-predicted concentrations are conservative and naphthalene would be expected to be below its RSL based on site-specific attenuation and biodegradation rates.

This qualitative assessment concludes that the soil 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 at the Buildings F-15 and F-16 AOC, and no further action is required of soil to be protective of groundwater.

6.6 SUMMARY AND CONCLUSIONS

Inorganic and organic SRCs exist in surface and subsurface soil at Buildings F-15 and F-16. 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 may potentially impact groundwater quality and warrant evaluation in an FS.

All SRCs identified in surface and subsurface soil at the AOC were evaluated through the stepwise fate and transport evaluation. Evaluation of modeling results with respect to current AOC groundwater data and model limitations identified the following CMCOPCs.

The CMCOPCs naphthalene at the Building F-15 aggregate and nitroglycerin and selenium at the Building F-16 aggregate were predicted to exceed the screening criteria in groundwater beneath the source area; however, none of these CMCOPCs were predicted to be above their respective groundwater criteria at the downgradient receptor location (i.e., unnamed tributary to Sand Creek).
The CMCOPC naphthalene at Building F-16 was predicted to exceed the screening criteria in groundwater beneath the source area and slightly above the criteria at the downgradient receptor location using conservative assumptions.

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 the Buildings F-15 and F-16 AOC that may potentially impact groundwater at the AOC. This qualitative assessment concluded that CMCOCs are not expected to adversely impact groundwater quality at this site. No further action is required for soil to be protective of groundwater.

Table 6–1. Initial CMCOPCs Evaluated with SESOIL Modeling

Initial CMCOPCs	Maximum Concentrations (mg/kg)	ISM Area	Sample Depth (ft bgs)	Leachate Modeling Required? (Yes/No)
Building F-15 Aggregate				
Semi-volatile Organic Chemicals				
Naphthalene	1.30E-01	F15ss-035M-5428-SO	0–1	Yes
Building F-16 Aggregate				
Inorganic Chemicals				
Selenium	1.70E+00	F16ss-007M-SO	0–0.5	Yes
Explosives				
Nitroglycerin	5.20E-01	F16ss-005M-SO	0–0.5	Yes
Semi-volatile Organic Chemicals				
2-Methylnaphthalene	1.00E+00	F16ss-005M-SO	0–0.5	Yes
Naphthalene	7.30E-01	F16ss-005M-SO	0–0.5	Yes

bgs = Below ground surface.
CMCOPC = Contaminant migration chemical of potential concern.
ft = Feet.
ISM = Incremental sampling method.
mg/kg = Milligrams per kilogram.
SESOIL = Seasonal Soil Compartment model.

Table 6–2. 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	ISM area-specific	ISM area-specific
Intrinsic Permeability	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	1.00E-03	Average from the PBA08 RI Geotechnical Samples F16SB-023-5425-SO and F16SB-023-5425-SO
Bulk Density	ρb	kg/L	1.79	
Moisture Content	w	wt %	14.5	
Water-filled Soil Porosity	θw	unitless	0.260	
Air-filled Soil Porosity	θa	unitless	0.083	
Porosity - total	n_T	unitless	0.343	
Vadose Zone Thickness	Vz	m	3.96 for Building F-15 3.35–3.96 for Building F-16	Based on average ground surface elevation and depth to water table from Facility-wide Groundwater Map (EQM 2010)
Leaching Zone Thickness	Lz	m	3.66 for Building F-15 0.08–3.2 for Building F-16	Based on vadose zone thickness and results for CMCOPCs in soil
AT123D				
Aquifer Thickness	h	m	6	Facility-wide assumption for the unconsolidated aquifer presented the Load Line 1 investigation (USACE 2003b)
Hydraulic Conductivity in Saturated Zone	K_S	cm/s	4.15E-04	Geometric mean from facility-wide range in MKM (2007)
Hydraulic Gradient	i	unitless	7.40E-03	Based on Facility-wide Groundwater Map (EQM 2010)
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	unitless	chemical-specific	Presented in Table E-7 in Appendix E

Environmental Quality Management, Inc. (EQM) 2010. Facility-Wide Groundwater Monitoring Program Report on the January 2010 Sampling Event, Ravenna Army Ammunition Plant, Ravenna, Ohio. July 2010.

MKM Engineers (MKM) 2007. Final Characterization of 14 AOCs at Ravenna Army Ammunition Plant. March 2007.

U.S. Army Corps of Engineers (USACE 2003b). Phase II Remedial Investigation Report for the Load Line 1 at the Ravenna Army Ammunition Plant, Ravenna, Ohio. June 2003.

U.S. Environmental Protection Agency (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.
CMCOPC = Contaminant migration chemical of potential concern.
cm^2 = Square centimeters.
cm/s = Centimeters per second.
ISM = Incremental sampling methodology.
kg/L = Kilograms per liter.
m = Meter.
m/yr = Meters per year.
SESOIL = Seasonal Soil Compartment model.
wt % = Weight by percent.

Table 6–3. Summary of SESOIL Modeling Results

Initial CMCOPC	Maximum Soil Concentration (mg/kg)	ISM Area	Maximum Depth of Contamination (ft bgs)	Depth to Groundwater (ft bgs)	Predicted $C_{leachate, max}$ 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 Unconsolidated Groundwater (mg/L)	Final CMCOPC?[b] (yes/no)
Building F-15 Aggregate										
Organic Chemicals-Semi-Volatile										
Naphthalene	**1.30E-01**	**F15ss-035M-5428-SO**	**1.0**	**13.0**	**1.44E-02**	**67**	**1.70E-04**	**None**	**None**	**Yes**
Building F-16 Aggregate										
Inorganic Chemicals										
Selenium	**1.70E+00**	**F16ss-007M-SO**	**13.0**	**13.0**	**2.90E-01**	**125**	**5.00E-02**	**None**	**0.00E+00**	**Yes**
Organic Chemicals-Explosive										
Nitroglycerin	**5.20E-01**	**F16ss-005M-SO**	**0.5**	**11.0**	**2.90E-01**	**9**	**2.00E-03**	**5.01E-03**	**None**	**Yes**
Organic Chemicals-Semi-Volatile										
2-Methylnaphthalene	1.00E+00	F16ss-005M-SO	0.5	11.0	3.56E-02	91	3.60E-02	None	None	No
Naphthalene	**7.30E-01**	**F16ss-005M-SO**	**0.5**	**11.0**	**4.14E-02**	**58**	**1.70E-04**	**None**	**None**	**Yes**

[a] The Resident Receptor Adult FWCUG is based on a target risk of 10-6 and a hazard quotient of 0.1.

[b] The Final CMCOPC was identified comparing predicted maximum leachate concentration to MCL/RSL, Resident Receptor Adult FWCUGs, and facility-wide background concentrations. A constituent is a CMCOPC if its predicted leachate concentration is higher than its facility-wide background concentration and the lowest risk-based screening value (Resident Receptor Adult FWCUG, MCL, or RSL) within 1,000 years.

bgs = Below ground surface.
CMCOPC = Contaminant migration chemical of potential concern.
ft = Feet.
FWCUG = Facility-wide cleanup goal.
ISM = Incremental sampling method.
MCL = Maximum contaminant level.
mg/kg = Milligram per kilogram.
mg/L = Milligram per liter.
RSL = Regional screening level.
SESOIL = Seasonal soil compartment model.
Bold = CMCOPCs exceeding MCL/RSL, Resident Receptor Adult FWCUGs, and facility-wide background concentrations.

Table 6–4. Summary of AT123D Modeling Results

Final CMCOPC	Maximum Leachate Concentration[a] ($C_{leachate, max}$) (mg/L)	Predicted Maximum Groundwater Concentration[b] Beneath the Source (mg/L)	Predicted Maximum Groundwater Concentration[b] Downgradient Receptor (mg/L)	Distance to Downgradient Receptor (ft)	MCL/RSL (mg/L)	Resident Receptor Adult FWCUG[c] (mg/L)	Facility-wide Background Unconsolidated Groundwater (mg/L)	CMCOC for Further WOE Evaluation?[d] (Yes/No)
Building F-15 Aggregate								
Semi-Volatile Organic Chemicals								
Naphthalene	1.44E-02	2.38E-03	1.11E-05	1500	1.70E-04	None	None	Yes
Building F-16 Aggregate								
Inorganic Chemicals								
Selenium	2.90E-01	8.23E-02	2.78E-03	350	5.00E-02	None	0.00E+00	Yes
Explosives								
Nitroglycerin	2.90E-01	3.16E-02	1.67E-03	340	2.00E-03	5.01E-03	None	Yes
Semi-Volatile Organic Chemicals								
Naphthalene	4.14E-02	5.49E-03	2.35E-04	340	1.70E-04	None	None	Yes

[a] Represents Seasonal Soil Compartment (SESOIL) model-predicted maximum leachate concentration just above the water table.

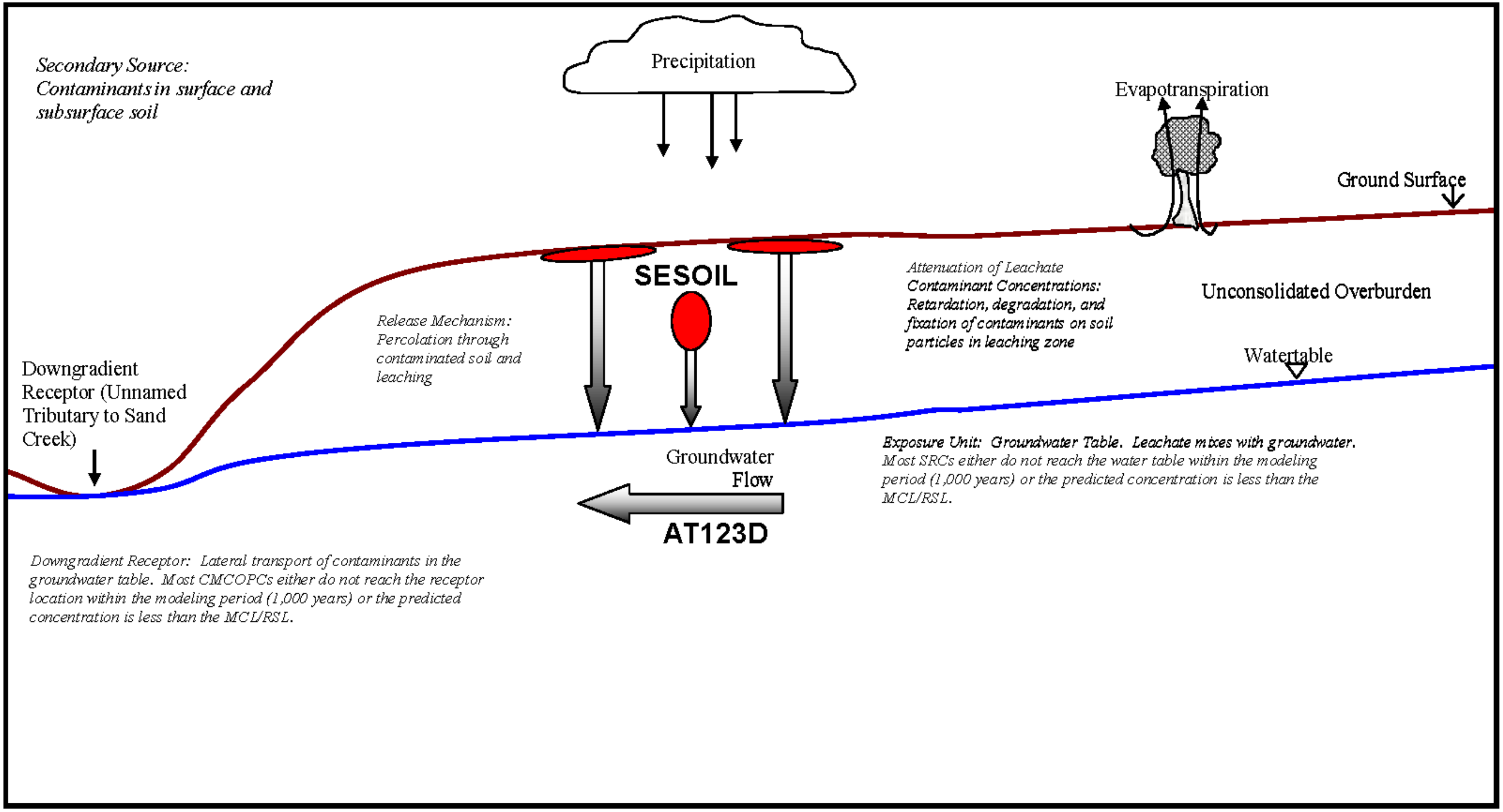
[b] The receptor concentration was estimated using the results from SESOIL and applying the AT123D) model.

[c] The Resident Receptor Adult FWCUG is based on a target risk of 1E-06 and a Hazard quotient of 0.1.

[d] The CMCOC was identified comparing predicted concentration in groundwater to MCL/RSL, Resident Receptor Adult FWCUGs, and facility-wide background concentrations. A constituent is a CMCOC if its predicted concentration in groundwater was higher than its facility-wide background concentration, and the lowest risk-based screening value (Resident Receptor Adult FWCUG, MCL, or RSL) within 1,000 years.

AT123D = Analytical Transient 1-, 2-, 3- Dimensional Model.
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.
RSL = Regional screening level.
WOE = Weight-of-evidence.

Not to scale



Secondary Source: Contaminants in surface and subsurface soil

Release Mechanism: Percolation through contaminated soil and leaching

Attenuation of Leachate ***Contaminant Concentrations: Retardation, degradation, and fixation of contaminants on soil particles in leaching zone***

Exposure Unit: Groundwater Table. Leachate mixes with groundwater. *Most SRCs either do not reach the water table within the modeling period (1,000 years) or the predicted concentration is less than the MCL/RSL.*

Downgradient Receptor: Lateral transport of contaminants in the groundwater table. Most CMCOPCs either do not reach the receptor location within the modeling period (1,000 years) or the predicted concentration is less than the MCL/RSL.

Figure 6–1. Contaminant Migration Conceptual Model

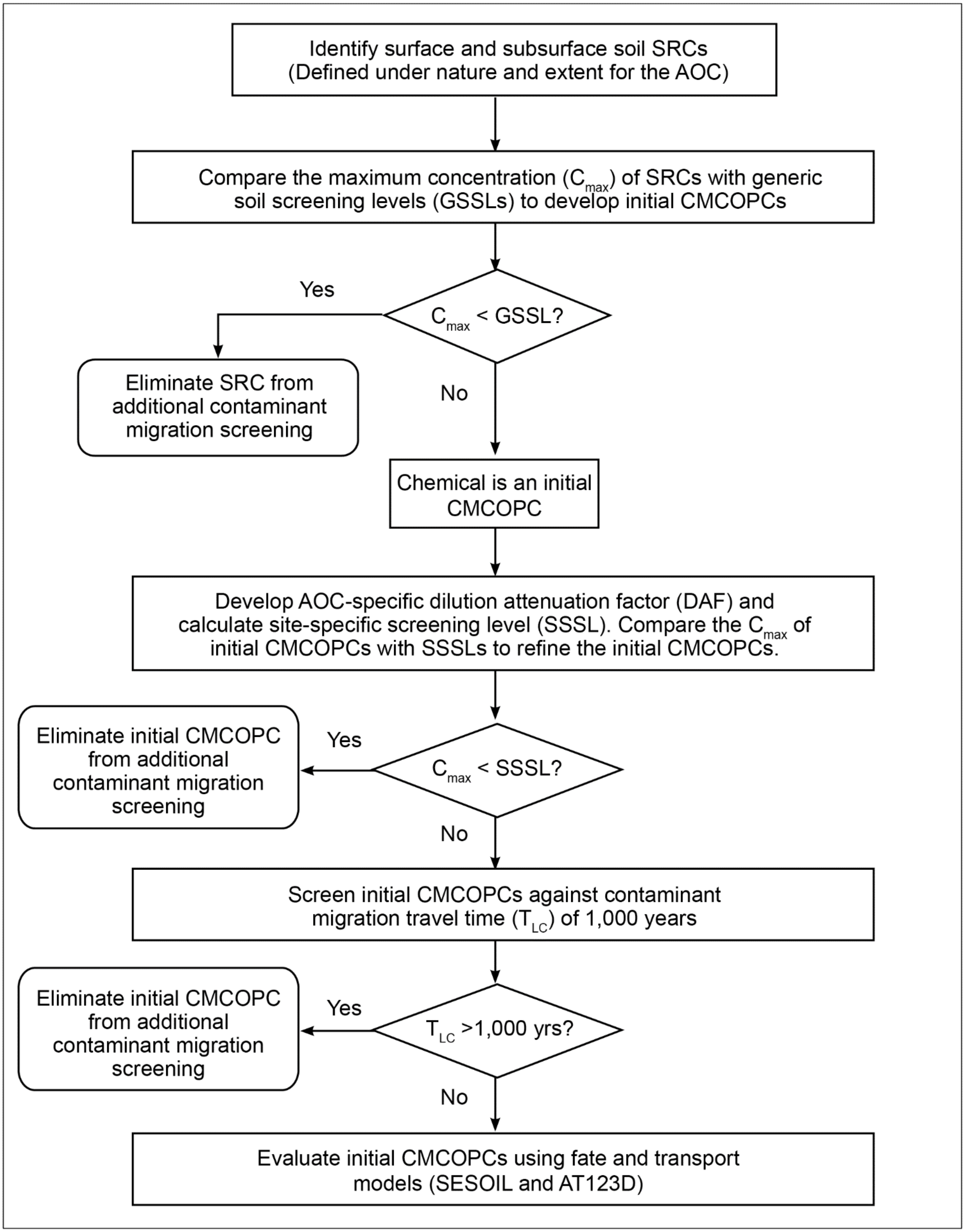


Figure 6–2. AOC Fate and Transport Modeling Approach - Soil

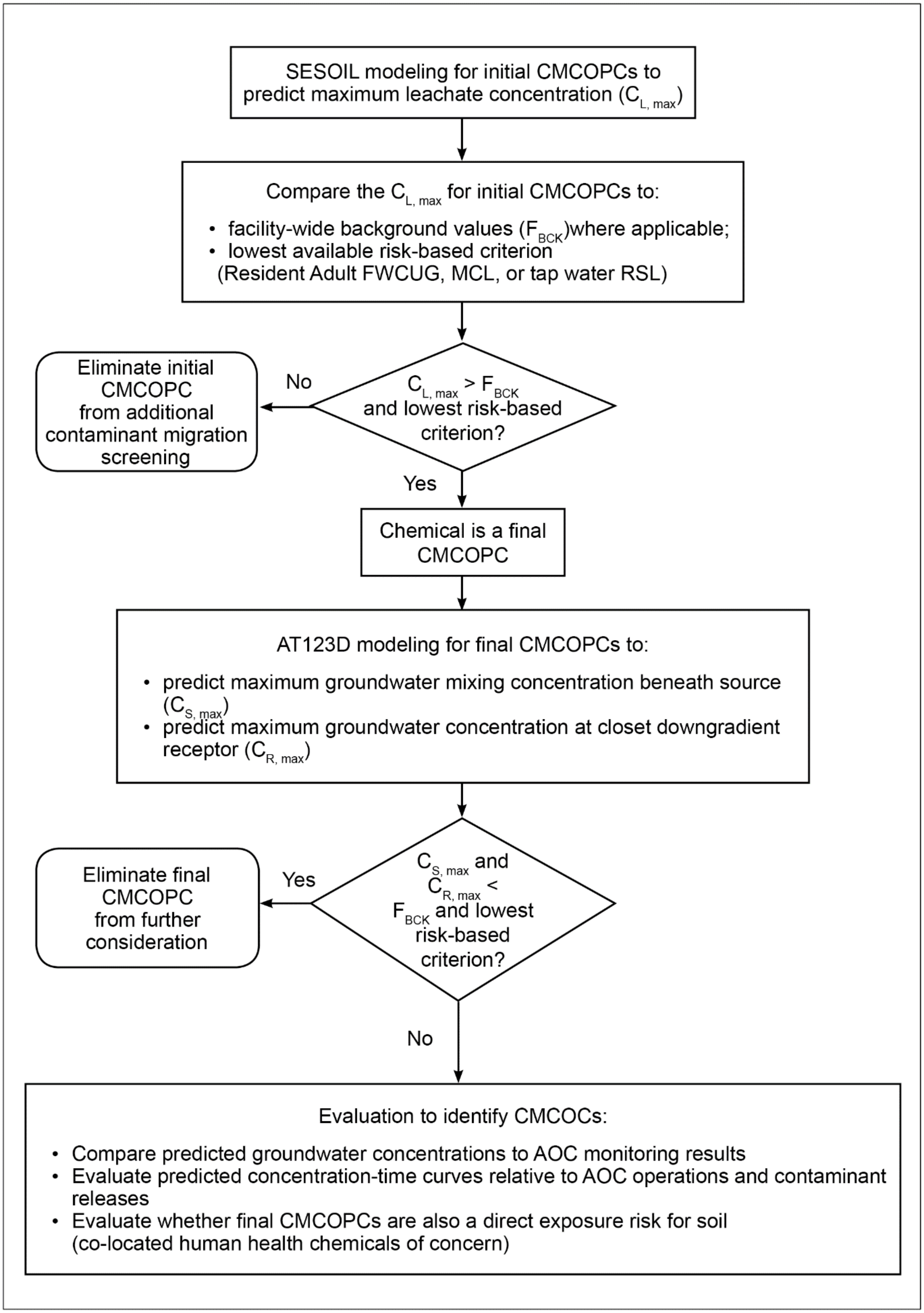


Figure 6–2. AOC Fate and Transport Modeling Approach – Soil (continued)

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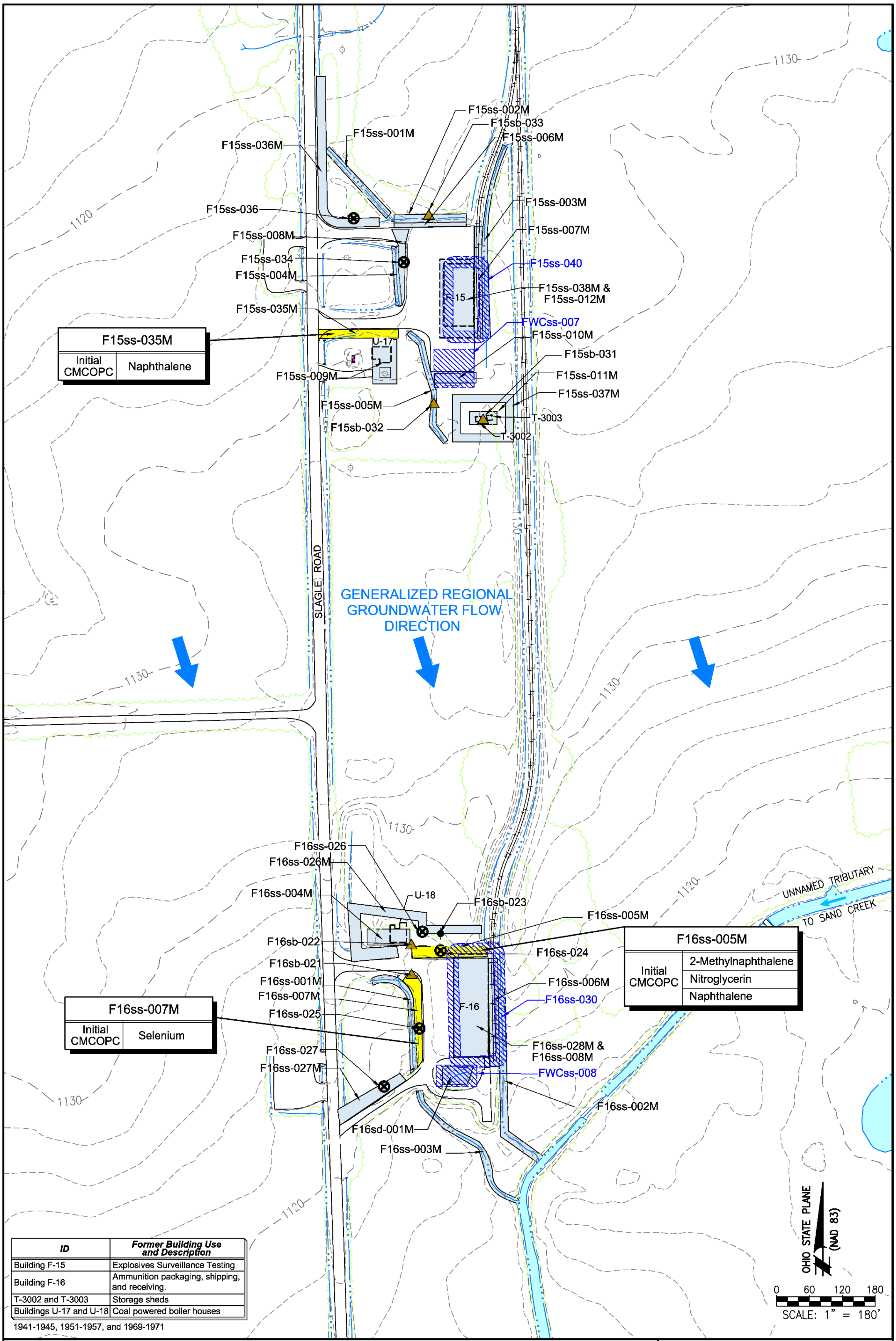


F15ss-035M	
Initial CMCOPC	Naphthalene

F16ss-005M	
Initial CMCOPC	2-Methylnaphthalene
	Nitroglycerin
	Naphthalene

F16ss-007M	
Initial CMCOPC	Selenium

ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

LEGEND:

▭	EXISTING BUILDING
⬚	DEMOLISHED BUILDING
═	ASPHALT ROAD
┼	RAILROAD TRACKS
≈	SURFACE WATER
	VEGETATION
	GROUND CONTOUR (10–FT)
	GROUND CONTOUR (2–FT)
○	FORMER UTILITY POLE
⬅	GROUNDWATER FLOW DIRECTION
▭	ISM SAMPLING AREA
▨	DECEMBER 2009 ISM SAMPLING SAMPLE LOCATIONS
🟨	EXCEEDING SOIL SCREENING
●	GEOTECHNICAL BORING
▲	SOIL BORING
⊗	CHROMIUM SPECIATION SAMPLE

NOTE:

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.

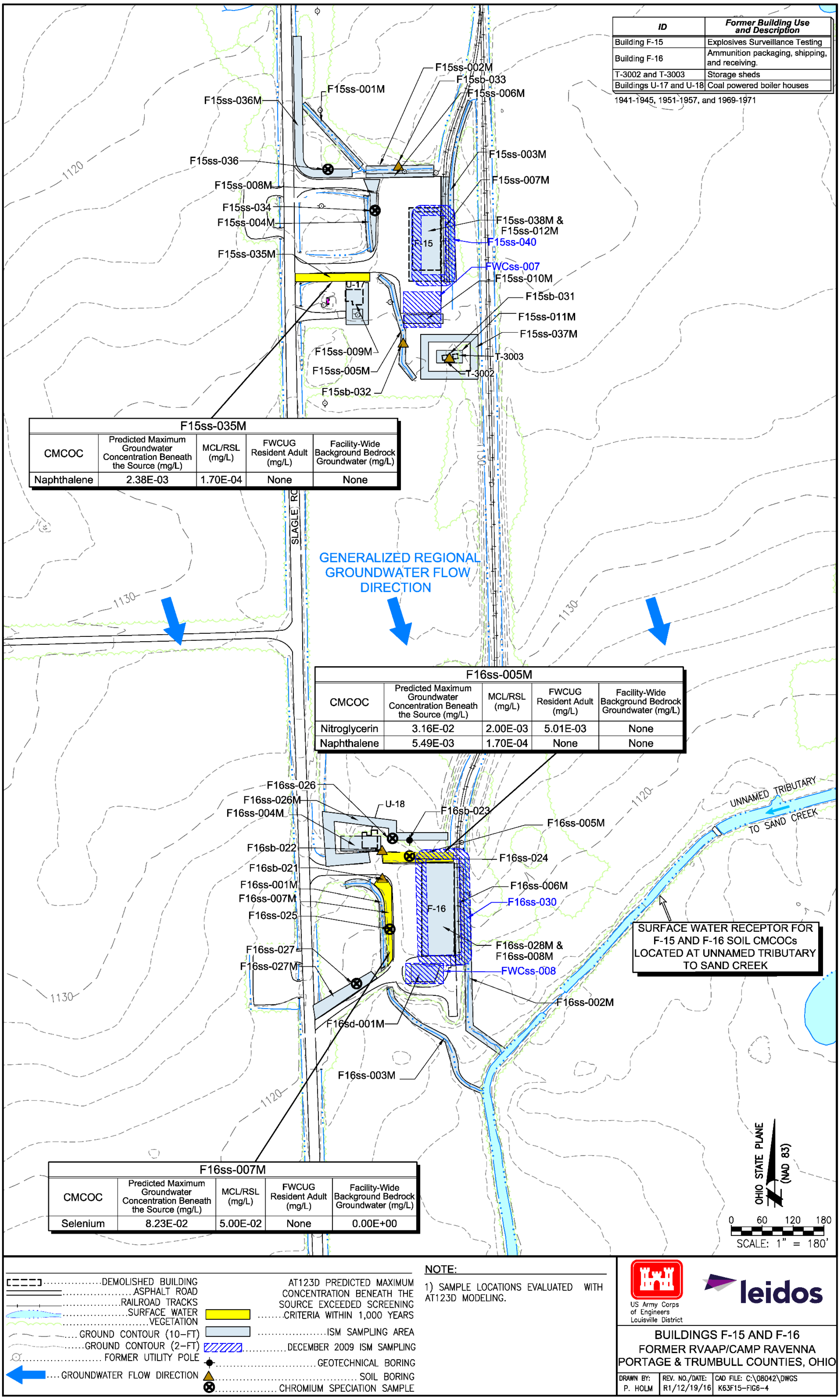
US Army Corps
of Engineers
Louisville District

leidos

BUILDINGS F-15 AND F-16
FORMER RVAAP/CAMP RAVENNA
PORTAGE & TRUMBULL COUNTIES, OHIO

DRAWN BY:	REV. NO./DATE:	CAD FILE: C:\08042\DWGS
P. HOLM	R1/12/19/16	K63F15–FIG6–3

Figure 6–3. Initial CMCOPCs Identified in Soil Screening Analysis for SESOIL Evaluation



ID	Former Building Use and Description
Building F-15	Explosives Surveillance Testing
Building F-16	Ammunition packaging, shipping, and receiving.
T-3002 and T-3003	Storage sheds
Buildings U-17 and U-18	Coal powered boiler houses

1941-1945, 1951-1957, and 1969-1971

F15ss-035M

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	2.38E-03	1.70E-04	None	None

F16ss-005M

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)
Nitroglycerin	3.16E-02	2.00E-03	5.01E-03	None
Naphthalene	5.49E-03	1.70E-04	None	None

F16ss-007M

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)
Selenium	8.23E-02	5.00E-02	None	0.00E+00

NOTE:

1) SAMPLE LOCATIONS EVALUATED WITH AT123D MODELING.

Figure 6–4. CMCOCs Identified for Further Weight-of-Evidence 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 to use for the HHRA and ERA. Data were evaluated to establish data aggregates and identify a list of SRCs.

7.1.1 Data Aggregates

This section provides a description of the data aggregates for the media for which human and ecological receptors are potentially exposed, followed by a summary of SRCs in Section 7.1.2. Section 4.0 includes a summary of available data. Data collected at the Buildings F-15 and F-16 AOC were aggregated by environmental medium and exposure depth (e.g., surface soil), EU, and sample type (i.e., discrete or ISM).

7.1.1.1 <u>Soil Data</u>

EUs were established at the Buildings F-15 and F-16 AOC 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 extent of potential contamination within a given area. In establishing EUs at Buildings F-15 and F-16, since the two buildings were located approximately 1,080 ft apart on opposite sides of a hill, the two areas were evaluated as two separate EUs. The two EUs are shown in Figure 7-1. The Building F-15 EU encompasses approximately 2.9 acres, and the Building F-16 EU encompasses approximately 2.5 acres.

The AOC is located west of Block D and east of Slagle Road (see Figure 1-2). Building F-15 was approximately 5,245 ft^2 and Building F-16 was approximately 3,200 ft^2. The buildings were used during World War II, the Korean War, and the Vietnam War to test miscellaneous explosives and propellants. The number of tests conducted, quantities of material tested, and when testing ceased are unknown. The floor slabs and all associated foundation walls were removed to grade in May 2009. Following slab removal, confirmatory sampling was conducted in November 2009 (USACE 2010c).

Soil data within each EU 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) and for potential risk to ecological receptors, as this layer is the most active biological zone (USACE 2003a). Tables 7-1 and 7-2 list the samples included in the risk assessment data set for surface soil (0–1 ft bgs) data. For this risk assessment, 18 surface soil (0–1 ft bgs) ISM samples collected during the October and November 2004 Characterization of 14 AOCs (MKM 2007), 2 surface soil ISM samples collected during the November 2009 Investigation of Soils Below Floor Slabs (USACE 2010c), 4 surface soil ISM samples collected in December 2009 during the USACE ISM Surface Soil Sampling, and 10 surface soil ISM samples collected in February 2010 for the PBA08 RI were used to characterize surface soil for the AOC. The ISM surface soil samples are associated with the Building F-15 EU or the Building F-16 EU; however, each ISM sampling area was evaluated individually. Discrete surface soil samples collected in 2010 were not used for risk assessment screening purposes since all discrete samples were collected from within the area of small ISM sampled areas, and ISM and discrete data should not be combined into a single statistical analysis. For surface soil ISM samples, each sample result was evaluated as an individual decision unit. Discrete data were used to supplement the evaluation of ISM results and are included in the uncertainty assessment.

- Subsurface soil with an exposure depth of 1–13 ft bgs was evaluated for the Resident Receptor (Adult and Child). Twelve discrete soil samples collected in March 2010 for the PBA08 RI with starting depths within this interval were used to evaluate subsurface soil. Tables 7-3 and 7-4 list the samples for subsurface soil (1–13 ft bgs).

7.1.1.2 Sediment and Surface Water Data

Surface water at the AOC is limited to intermittent storm water runoff. Historical investigations of the AOC included surface water and sediment samples; however, the areas sampled were not permanent water features. Surface water and sediment were not evaluated in the risk assessments because they are not currently present at this AOC. However, Sections 5.5 and 5.6 provide a summary of the sediment and surface water samples collected as part of previous investigations at the site.

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 to be TNT, composition B, sulfates, nitrates, lead styphnate, and lead azide. PAHs from coal storage and used in the two boiler houses (Buildings U-17 and U-18) and PCBs from the on-site transformers at Building F-15 are also considered site-specific contaminants. The evaluation of historical chemical contamination is not limited to these chemicals; rather, this evaluation is expanded to include all eligible chemical data that are available.

The SRC screen was not limited to only contaminants that may have been a product 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 (USACE 2010a). Inorganic chemicals 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 so long as they are present at low concentrations (i.e., only slightly elevated above naturally occurring levels) and toxic at 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 Position Paper for Human Health CUGs (USACE 2012a), analytes detected in less than 5% of the samples are screened out from further consideration, with the exception of explosives and propellants. However, for this AOC, no frequency of detection screening was performed because fewer than 20 discrete samples were available for the data sets used. Frequency of detection screening was not used for ISM samples.

Details of the SRC screening for each exposure medium are provided in Appendix G, Tables G-1 through G-4. The SRCs identified at the Building F-15 EU are summarized in Table 7-5 and the SRCs identified at the Building F-16 EU 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 the Buildings F-15 and F-16 AOC. The HHRA was conducted as part of the PBA08 RI and is based on the methods from the following guidance documents:

- FWHHRAM (USACE 2005a),
- FWCUG Report (USACE 2010a),
- Position Paper for Human Health CUGs (USACE 2012a), 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 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 through the application of the CERCLA process at the former RVAAP.

Most of the agreed upon risk assessment methodology has been documented in the FWHHRAM (USACE 2005a) and follows standard USEPA-approved risk assessment guidance. This includes the process to identify RVAAP COPCs (Figure 4-7); a TR of 1E-06, HQ of 0.1 to identify COPCs; and a TR of 1E-05, 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 2012a). 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 are presented in Section 4.0.
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 2012a), perform data analysis and mapping to identify SRCs and COPCs, establish EUs, and calculate exposure point concentrations (EPCs) for each COPC. The results of the mapping and data analysis to identify SRCs are presented in Sections 4.0 and 5.0 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: 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 are surface and subsurface soil, as defined in Section 7.1.1. Surface water and sediment are not present at this AOC. Groundwater is present at this AOC and will be evaluated (including a risk assessment) in a separate document, as explained 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 MDCs of all SRCs were screened against the most stringent chemical-specific FWCUG of all RVAAP receptors at a cancer TR 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 existed 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 three of six discrete surface soil samples collected at the AOC 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 Appendix G, Tables G-1 (Building F-15 EU surface soil), G-2 (Building F-16 EU surface soil), G-3 (Building F-15 EU subsurface soil), and G-4 (Building F-16 EU subsurface soil). The COPCs identified for the media of concern are presented in Tables 7-7 and 7-8 and are summarized below.

7.2.2.1 COPCs in Surface Soil

Building F-15 EU

A total of 42 chemicals were detected in surface soil (0–1 ft bgs) ISM samples; 33 of these chemicals (14 inorganic chemicals, 1 explosive, and 18 SVOCs) were identified as SRCs. Risk-based screening identified arsenic, chromium, cobalt, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene as COPCs in surface soil.

Building F-16 EU

A total of 45 chemicals were detected in surface soil (0–1 ft bgs) ISM samples; 37 of these chemicals (15 inorganic chemicals, 2 explosives, 16 SVOCs, 2 pesticides, 1 PCB, and 1 VOC) were identified as SRCs. Risk-based screening identified arsenic, chromium, cobalt, and benzo(a)pyrene as COPCs in surface soil.

7.2.2.2 COPCs in Subsurface Soil

Building F-15 EU

A total of 24 chemicals were detected in discrete subsurface soil samples collected from the 1–13 ft bgs exposure depth. Of these, five chemicals (four inorganic chemicals and one SVOC) were identified as SRCs. Risk-based screening identified cobalt as a COPC for subsurface soil (1–13 ft bgs).

Building F-16 EU

A total of 28 chemicals were detected in discrete subsurface soil samples collected from the 1–13 ft bgs exposure depth. Of these, nine chemicals (three inorganic chemicals and six SVOCs) were identified as SRCs. Risk-based screening identified arsenic as a COPC for subsurface soil (1–13 ft bgs).

7.2.3 Land Use and Representative Receptors

Camp Ravenna is a controlled-access facility. The Buildings F-15 and F-16 AOC is located in the west-central portion of RVAAP and is currently inactive. Three Land Uses for the RVAAP restoration program were 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 (ARNG 2014), 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 the Commercial/Industrial Land Use as an Alternative if it achieves no further action for Unrestricted (Residential) Land Use.

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 2012a) and Technical Memorandum (ARNG 2014).

The COC determination process is as follows:

- Report all carcinogenic- and non-carcinogenic-based FWCUGs corresponding to a TR of 1E-05, target HQ of 1 using the most stringent of the Resident Receptor (Adult and Child) FWCUGs to evaluate Unrestricted (Residential) Land Use for each COPC. If no FWCUG is available for a COPC, the Residential RSL, adjusted to represent a TR of 1E-05 or target HQ of 1, is used.
- Report critical effect and target organ for each non-carcinogenic-based FWCUG.
- Compare the selected FWCUG to the EPC, including an SOR.
    - For non-carcinogens, compare the EPC to the target HQ FWCUG. Sum the ratios of the EPC/FWCUG for COPCs that affect similar target organs or do not have an identified target organ.

    - For carcinogens, compare the EPC to the TR FWCUG. Sum the ratios of EPCs/FWCUGs for all carcinogens.
- Identify the COPC as a COC for a given receptor if:
    - The EPC exceeds the most stringent of the Resident Receptor (Adult and Child) FWCUGs for either the cancer TR of 1E-05 or the target HQ of 1; or
    - The SOR for all carcinogens or all non-carcinogens that may affect the same organ is greater than one. Chemicals contributing at least 10% to the SOR are also considered COCs. In accordance with the Position Paper for Human Health CUGs (USACE 2012a), 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 rearranges cancer risk or non-cancer hazard equations in order 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 risks (ILCRs) are 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 risks 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 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 the 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 FWCUG 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 if adjusted for exposure to multiple COPCs), and a ratio less than or equal to one represents acceptable cumulative exposure (i.e., below FWCUGs if adjusted for exposure to multiple COPCs). The FWCUGs for some chemical/receptor combinations are less than the background concentration. In these instances, 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 are further evaluated in an uncertainty analysis to identify COCs requiring evaluation in the FS.

Selecting FWCUGs, calculating EPCs for comparison to FWCUGs, and the resulting risk-based COCs are detailed in the following sections.

7.2.4.1 Selection of Appropriate FWCUGs

As specified in the Technical Memorandum (ARNG 2014), EPCs for each AOC should initially be evaluated using the most stringent Resident Receptor (Adult and Child) FWCUGs to determine if no further action is necessary at an AOC to attain Unrestricted (Residential) Land Use. If this assessment indicates COCs exist that prevent Unrestricted (Residential) Land Use, an FS must be completed to evaluate cleanup options for all three Land Uses [i.e., Unrestricted (Residential) Land Use, Military Training Land Use, and Commercial/Industrial Land Use].

Unrestricted (Residential) Land Use is evaluated using FWCUGs for the Resident Receptor (Adult and Child). These FWCUGs, provided in Table 7-9, are the lower of the Resident Receptor (Adult and Child) values for each COPC and endpoint (non-cancer and cancer). The critical effect or target organ associated with the toxicity values used to calculate the FWCUGs are also provided in this table.

The SLs provided in Table 7-9 for the Resident Receptor (Adult and Child) are the FWCUGs corresponding to a TR of 1E-05, target HQ of 1. If no FWCUG is available for a COPC, the residential RSLs, adjusted to represent a TR of 1E-05 or target HQ of 1, are used for the Resident Receptor.

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 2012b, USACE 2012c), indicate chromium exists predominantly in the trivalent state rather than the more toxic hexavalent state.

Implementing the chromium speciation process per the PBA08 SAP is discussed below.

- **Hexavalent and total chromium sample collection and results** – To determine whether FWCUGs for trivalent or hexavalent chromium are most applicable to the Buildings F-15 and F-16 AOC and to support risk management decisions, six discrete surface soil samples were collected and analyzed for hexavalent and total chromium. Three samples were collected in February 2010 per the PBA08 SAP. Two samples were collected from areas previously identified as having elevated total chromium concentrations and one sample was collected from an area identified as having chromium concentrations near facility-wide background concentrations for surface soil. Three additional samples were collected in October 2010 to correspond to some of the highest detected total chromium results from the February 2010 PBA08 RI ISM samples. Two of the six chromium speciation samples were collected from the Building F-15 EU and four samples were collected from the Building F-16 EU. Hexavalent chromium was not detected in three samples, but was detected in the remaining three samples at concentrations of 0.4, 0.4, and 2.2 mg/kg. Total and hexavalent chromium results for these six samples are summarized in Table 7-10.
- **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.” No hexavalent chromium was detected in three of the six chromium speciation samples collected at the Buildings F-15 and F-16 AOC. Hexavalent chromium was detected in the three remaining speciation samples at 0.4, 0.4, and 2.2 mg/kg, which is 1.8%, 1.9%, and 10.5% of the total chromium measured in these samples. The total chromium concentrations in samples F15ss-024 (21.9 mg/kg), F16ss-025 (21.4 mg/kg), and F16ss-024 (21 mg/kg) are below the facility-wide background concentrations of 27.3 mg/kg in subsurface soil. The FWCUG for hexavalent chromium is based on a cancer unit risk factor (URF) calculated using a chromium mixture containing 14% hexavalent chromium and 86% trivalent chromium. The 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.
- **Comparing the concentration of hexavalent chromium detected in the chromium speciation samples to the residential RSL for hexavalent chromium** – The FWCUG for hexavalent chromium is more appropriately applied to total chromium because it was calculated from a cancer URF based on a chromium mixture containing 1/7 (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 concentrations of hexavalent chromium in the chromium speciation samples (0.4–2.2 mg/kg) are less than 3 mg/kg, indicating hexavalent chromium is not present above the residential RSL.
- **Comparing 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 of hexavalent chromium is less than 14%. Therefore, hexavalent chromium is not of concern, and the reported concentrations of

total chromium were compared to the FWCUGs for trivalent chromium for identifying COCs at this AOC.

7.2.4.2 Exposure Point Concentrations for Comparison to FWCUGs

Surface Soil

Surface soil (0–1 ft bgs) was characterized using ISM sampling. The ISM analytical result can provide a more reliable estimate of the average concentration for a decision unit but cannot be combined with analytical results from discrete samples (USACE 2009b). As noted in the *Technical and Regulatory Guidance for Incremental Sampling Methodology* (ITRC 2012), different objectives require different spatial scales for ISM sample areas.

A total of 34 ISM samples were collected to evaluate potential contamination at former Buildings F-15 and F-16 and the footprint of the former coal storage piles. The ISM samples ranged from 0.002–0.024 acres and were focused on the areas with the highest potential for contamination (e.g., the former buildings and their perimeters, shed areas, drainage channels, and the footprints of the former coal storage piles).

EPCs are intended to provide representative concentrations that a receptor might contact during the period of exposure. Exposure to surface soil was based on ISM samples. The ISM was used to determine an average concentration representative of the soil contained within a defined area (i.e., the “decision unit”). Therefore, individual ISM results were compared directly to the surface soil FWCUGs for the AOC receptors.

Subsurface Soil

EPCs were calculated for the 1–13 ft bgs subsurface soil exposure depth using analytical results from the discrete samples presented in Tables 7-3 (for the Building F-15 EU) and 7-4 (for the Building F-16 EU). 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.

7.2.4.3 Identification of COCs for Unrestricted (Residential) Land Use

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) at the Building F-15 EU

The COC screening for surface soil for the Resident Receptor (Adult and Child) is detailed in Appendix G, Tables G-5 and G-6. Benzo(a)pyrene was identified as a COC in the surface soil for the Resident Receptor (Adult and Child), as explained below:

<u>COPCs with Concentrations Lower than the Resident Receptor (Adult and Child) FWCUG:</u> All chromium, cobalt, benz(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene concentrations were lower than the Resident Receptor (Adult and Child) FWCUG.

<u>COPCs with Concentrations Exceeding the Resident Receptor (Adult and Child) FWCUG</u>: Concentrations of arsenic and benzo(a)pyrene exceeded the FWCUGs for the Resident Receptor (Adult and Child) at one or more sample locations.

The MDC of arsenic (20 mg/kg at F15ss-011M collected in 2004) exceeds the FWCUG of 4.25 mg/kg as well as the surface soil facility-wide background concentration of 15.4 mg/kg. Building removal operations conducted at this AOC resulted in significant soil disturbance. Therefore, it is appropriate to compare surface soil results to the subsurface soil background concentration. The facility-wide background concentration for subsurface soil is 19.8 mg/kg. Since the MDC for arsenic in surface soil is essentially equal to the subsurface background concentration for arsenic, it was not identified as a surface soil COC for the Resident Receptor (Adult and Child) at the Building F-15 EU.

Benzo(a)pyrene was identified as a COC at ISM sample location F15ss-036M because the detected concentration (0.48 mg/kg) exceeds the FWCUG of 0.221 mg/kg. Sample F15ss-036M was collected from an area along Slagle Road and an unnamed access road. Benzo(a)pyrene was not identified as a COC in the remaining surface soil samples because the detected concentrations (0.014–0.13 mg/kg) are less than the FWCUG (0.221 mg/kg).

SOR analysis*:* Three additional PAHs were identified as COCs based on the SOR analysis summarized below:

- Three COPCs (arsenic, chromium, and cobalt) identified in surface soil have FWCUGs for non-cancer endpoints. Arsenic, chromium, and cobalt were detected below facility-wide background concentrations at most ISM sample locations. There are no ISM samples having more than one of these metals present above surface or subsurface background concentrations. Therefore, an SOR for non-cancer endpoints was not calculated.
- Seven COPCs [arsenic, cobalt, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] identified in surface soil have FWCUGs for the cancer endpoint (as previously discussed, chromium was evaluated for non-carcinogenic effects as trivalent chromium). The FWCUG for arsenic is less than the background concentration; therefore, the arsenic concentrations were compared to the facility-wide background concentrations for identification of COCs. Since the background concentrations are not risk-based, arsenic was not included in the SOR calculations. An SOR was calculated for the six COPCs for each ISM sample (Table G-6). Cobalt was not included in the SOR for samples where the detected concentration is less than the facility-wide background concentrations for surface soil. The SOR for sample location F15ss-036M is greater than one due largely to benzo(a)pyrene, as noted below and in Appendix G, Table G-6.
    - The SOR for sample location F15ss-036M was three due primarily to benzo(a)pyrene, which was detected above the FWCUG. Additional COPCs contributing at least 5% to this

    SOR are benz(a)anthracene, benzo(b)fluoranthene, and dibenz(a,h)anthracene (Appendix G, Table G-7). These PAHs were identified as COCs at this location.

  - The calculated SORs for all other ISM sample locations are less than or equal to one.

COCs in Subsurface Soil (1–13 ft bgs) at the Building F-15 EU

The COC screening for the subsurface soil exposure depth (1–13 ft bgs) for the Resident Receptor (Adult and Child) is detailed in Appendix G, Table G-8. No COCs were identified in the subsurface soil for the Resident Receptor (Adult and Child), as explained below:

<u>COPCs with EPCs Lower than the Resident Receptor (Adult and Child) FWCUG</u>: The EPC for cobalt is lower than the FWCUG for the Resident Receptor (Adult and Child).

<u>COPCs with EPCs Exceeding the Resident Receptor (Adult and Child) FWCUG</u>: There were no COPCs with EPCs exceeding the FWCUG for the Resident Receptor (Adult and Child); therefore, no COCs were identified.

SOR Analysis*:* Because only one COPC (cobalt) was identified in the subsurface soil interval, an SOR analysis was not conducted.

COCs for Surface Soil (0–1 ft bgs) at the Building F-16 EU

The COC screening for surface soil for the Resident Receptor (Adult and Child) is detailed in Appendix G, Tables G-9 and G-10. No COCs were identified in the surface soil for the Resident Receptor (Adult and Child), as explained below:

<u>COPCs with Concentrations Lower than the Resident Receptor (Adult and Child) FWCUG:</u> All chromium, cobalt, and benzo(a)pyrene concentrations were lower than the Resident Receptor (Adult and Child) FWCUG.

<u>COPCs with Concentrations Exceeding the Resident Receptor (Adult and Child) FWCUG</u>: The concentration of arsenic in one sample (18 mg/kg at F16ss-004M) exceeds the FWCUG of 4.25 mg/kg and the surface soil facility-wide background concentration of 15.4 mg/kg, but is less than the subsurface soil facility-wide background concentration of 19.8 mg/kg. Building removal operations conducted at this AOC resulted in significant soil disturbance. Therefore, it is appropriate to compare surface soil results to the subsurface soil background concentration. Since the MDC for arsenic in surface soil is less than subsurface background concentration, it was not identified as a surface soil COC for the Resident Receptor (Adult and Child) at the Building F-16 EU.

***SOR analysis**:* No COCs were identified by the SOR analysis. The SOR analysis is summarized below:

- Three COPCs (arsenic, chromium, and cobalt) identified in surface soil have FWCUGs for non-cancer endpoints. There are no ISM samples having more than one of these metals present above surface or subsurface background concentrations. Therefore, an SOR for non-cancer endpoints was not calculated.
- Three COPCs [arsenic, cobalt, and benzo(a)pyrene] identified in surface soil have FWCUGs for the cancer endpoint (as previously discussed, chromium was evaluated for non-carcinogenic effects as trivalent chromium). The FWCUG for arsenic is less than the background concentration; therefore, the arsenic concentrations are compared to the facility-wide background concentrations for identifying COCs. Since the background concentrations are not risk-based, arsenic was not included in the SOR calculations. An SOR was calculated for the two COPCs for each ISM sample (Appendix G, Table G-10). Cobalt was not included in the SOR for samples where the detected concentration is less than the facility-wide background concentrations for surface soil. All SORs are less than one.

COCs in Subsurface Soil (1–13 ft bgs) at the Building F-16 EU

The COC screening for the subsurface soil exposure depth (1–13 ft bgs) for the Resident Receptor (Adult and Child) is detailed in Appendix G, Table G-11. Arsenic was the only COPC identified for subsurface soil. Arsenic was identified as a COC in subsurface soil for the Resident Receptor (Adult and Child) because the EPC for arsenic (23.1 mg/kg) exceeded the FWCUG of 4.25 mg/kg and the subsurface soil facility-wide background concentration of 19.8 mg/kg for the Resident Receptor (Adult and Child). The EPC for arsenic is strongly influenced by the MDC of 24.3 mg/kg in the 4–7 ft bgs interval of soil boring F16sb-021. Reported concentrations in the other four subsurface samples range from 11.3–17.1 mg/kg. Reported concentrations in F16sb-021 above (1–4 ft bgs) and below (7–13 ft bgs) the MDC were 13.7 and 11.3 mg/kg, respectively.

***SOR Analysis**:* Because only one COPC (arsenic) was identified in the subsurface soil interval, an SOR analysis was not conducted for the subsurface soil.

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, comparing these limitations with background concentrations to identify SRCs, and estimating 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. In accordance with the PBA08 SAP, small targeted ISM samples (0.002–0.024 acres) were collected from areas biased toward areas anticipated to have the highest level of potential contamination (i.e., around former buildings, coal storage pile areas, or dry ditches) to delineate potential sources. The results of surface soil sampling were used to efficiently guide selection of locations for discrete subsurface soil sampling with a bias toward the areas of highest potential contamination.

In addition to the ISM samples, a limited number of discrete samples (three within the Building F-15 area and two within the Building F-16 area) are available from the 0–1 ft bgs interval of the PBA08 RI soil borings used to evaluate subsurface soil. The results of these discrete samples were considered in the context of the ISM samples in which they were located to identify the potential for hotspots not identified by the ISM samples. The results of the ISM and discrete sample evaluation are included in Tables 7-11 and 7-12. The discrete sample results parallel the conclusions of the ISM samples as summarized by EU below.

Building F-15 EU

- Bis(2-ethylhexyl)phthalate was detected in one discrete surface soil sample and was not detected in the ISM samples. The concentration of this chemical was below the FWCUG in the discrete sample. Therefore; conclusions drawn from the ISM samples regarding bis(2-ethylhexyl)phthalate would not be changed by the discrete sample.
- MDCs of three inorganics (barium, iron, and selenium) and three SVOCs (2-methylnaphthalene, dibenzofuran, and naphthalene) in the discrete samples were higher than the MDCs in ISM samples. The MDCs of these chemicals were below facility-wide background criteria and/or FWCUGs in both ISM and discrete samples. Therefore, conclusions drawn from the ISM samples regarding these analytes would not be changed by the discrete samples.

Building F-16 EU

- Three chemicals (2,6-DNT; acenaphthene; and fluorene) were detected in the discrete surface soil samples and were not detected in the ISM samples. All of the concentrations of these chemicals were below FWCUGs in the discrete samples. Therefore; conclusions drawn from the ISM samples regarding these three analytes would not be changed by the discrete samples.
- MDCs of 11 inorganic chemicals (arsenic, calcium, cobalt, iron, magnesium, manganese, mercury, selenium, silver, thallium, and vanadium) and 9 SVOCs [anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)pyrene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-cd)pyrene, and phenanthrene] in discrete samples were higher than the MDCs in ISM samples. With the exception of arsenic, the MDCs of these chemicals were below facility-wide surface and/or subsurface background criteria and/or FWCUGs in both ISM and discrete samples. Therefore, conclusions drawn from the ISM samples regarding these analytes would not be changed by the discrete samples.

  - ***Arsenic*** – The concentrations of arsenic in the discrete surface soil samples at the Building F-16 EU were 31.3 and 14.6 mg/kg. Although the concentration of arsenic in F16sb-021 exceeded the FWCUG (4.25 mg/kg) and the subsurface facility-wide soil background concentration (19.8 mg/kg), native soil concentrations of arsenic in Ohio have been reported as ranging from 0.5–56 mg/kg (Ohio EPA 1996), and the U.S. Geological Survey's Certificate of Analysis of the Devonian Ohio Shale estimates arsenic concentrations of 68.5 mg/kg are naturally present in bedrock shale (USGS 2004). Discrete sample F16sb-021 was collected from an area adjacent to a drainage ditch and within ISM sample location F16ss-007M. The concentration of arsenic in the 0.006-acre ISM sample (10 mg/kg) was below facility-wide surface and subsurface soil background concentrations. The concentration in the discrete sample is likely to be a naturally occurring variation and conclusions drawn from the ISM samples regarding arsenic would not be changed by the discrete sample results.

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, which 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 maximum detection limit (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.

Identifying SRCs – Part of determining SRCs is to identify chemicals detected above established RVAAP background concentrations. This screen does not account for potential sources of chemicals, and background concentrations are only available for inorganic chemicals.

Uncertainty associated with screening against background concentrations results from statistical limitations and natural variation in background concentrations. Because of these variations, inorganic chemical concentrations below the background concentration are likely representative of background conditions. Inorganic chemical concentrations above the background concentration may be above background conditions or may reflect natural variation. This is especially true for measured concentrations close to the background concentration.

At the Building F-15 EU, 6 of 14 inorganic chemicals identified as SRCs (antimony, arsenic, barium, beryllium, cobalt, and zinc) had MDCs in surface soil that were above but close to (i.e., less than two times) the background concentration. At the Building F-16 EU, 6 of 15 inorganic chemicals identified as SRCs (antimony, arsenic, cobalt, mercury, nickel, and selenium) had MDCs in surface soil that were above but close to (i.e., less than two times) the background concentration. Cadmium, silver, and thallium had no background concentrations for comparison. The consequences of carrying most of these inorganic chemicals forward as SRCs, even if they are representative of background, is negligible because they are not toxic at near-background concentrations. By contrast, naturally occurring (background) arsenic in soil exceeds risk-based CUGs. Therefore, the consequence of identifying arsenic as an SRC if it is, in fact, representative of background can have a significant impact on the conclusions of the risk assessment.

The MDCs of arsenic in surface and subsurface soil at the Building F-15 EU were 20 and 12.2 mg/kg, respectively and at the Building F-16 EU they were 18 and 24.3 mg/kg. The RVAAP background concentration for arsenic in surface soil is 15.4 mg/kg and 19.8 mg/kg in subsurface soil. Because building demolition activities disturbed the soil, including removing surface soil and exposing subsurface soil at the surface, it is appropriate to compare surface soil sample results to the subsurface background concentrations. Although the MDCs of arsenic were slightly above the subsurface soil background concentration in surface soil at the Building F-15 EU and in subsurface soil at the Building F-16 EU, 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). Also, Vosnakis and Perry (2009) published the results of arsenic concentration studies that included 313 samples of Ohio soil. Naturally occurring arsenic in these samples ranged from 1.6–71.3 mg/kg with 95th percentiles of 21.7 mg/kg in surface soil, 25.5 mg/kg in subsurface soil, and upper tolerance limits of 22.8 mg/kg for surface soil and 29.6 mg/kg for subsurface soil. In other studies, native soil concentrations of arsenic in Ohio have been reported as ranging from 0.5–56 mg/kg (Ohio EPA 1996), and the U.S. Geological Survey's Certificate of Analysis of the Devonian Ohio Shale estimates arsenic concentrations of 68.5 mg/kg are naturally present in bedrock shale (USGS 2004). Based on this information, arsenic appears to be present at the AOC at naturally occurring concentrations.

Organic chemicals were 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 the AOC, PAHs were detected across the entire AOC; as one or more PAHs were detected in 10 of 11 surface soil ISM samples analyzed for PAHs. PAH concentrations were less than the Resident Receptor (Adult and Child) FWCUGs in all but one sample location (F15ss-036M) where the concentration (0.48 mg/kg) was approximately twice the FWCUG of 0.221 mg/kg for benzo(a)pyrene. Sample location F15ss-036M is located within a ditch line northwest of the former Building F-15 and immediately adjacent to Slagle Road. The ditch where F15ss-036M was collected would have received runoff from the adjacent road, as well as the asphalt parking lots surrounding the former Building F-15. A total of 15 of the 17 PAH SRCs were detected at their maximum concentration at location F15ss-036M and at concentration levels an order of magnitude higher, on average, than in the other Building F-15 EU ISM samples. No PAHs were detected at PBA08 RI sample F15ss-038M collected in the footprint of former Building F-15 after slab removal was conducted. The result of sample F15ss-036M is not indicative of an operation-related point source of PAHs and may represent background concentrations for PAHs.

Although no background concentrations for PAHs were established for RVAAP, the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b), which established the 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 the 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 the 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 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; 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 7-13.

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 7-14. 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 7.2.7).

Exposure Point Concentrations – Surface soil was characterized using ISM sampling techniques. ISM samples provide a physical average concentration across an exposure area. Using ISM sampling reduces the uncertainty associated with estimating a statistical average exposure.

EPCs were calculated for the 1–13 ft bgs sample interval using analytical results from the discrete samples listed in Tables 7-3 and 7-4. Soil borings for discrete samples were located in areas of highest potential contamination based on site history and site geography, resulting in calculated EPCs that conservatively estimate exposure concentrations across the EU. 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 the Building F-15 and the Building F-16 EUs 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 subsurface soil, individual discrete sample results above FWCUGs were evaluated to identify whether potential hotspots are present as a result of specific source areas (Appendix G, Tables G-8 and G-11). Both the MDC and the EPC of the only subsurface soil COPC (cobalt) are less than the FWCUG for the Resident Receptor (Adult and Child) at the Building F-15 EU. Therefore, cobalt does not represent a hotspot and is not identified as a COC. Both the MDC (24.3 mg/kg) and EPC (23.1 mg/kg) of the only subsurface soil COPC (arsenic) exceed the FWCUG for the Resident Receptor (Adult and Child) and facility-wide subsurface soil background concentration (19.8 mg/kg) at the Building F-16 EU. The remaining concentrations of arsenic in the subsurface soil samples (11.3–17.1 mg/kg) were below the facility-wide subsurface soil background concentration. Arsenic was identified as a COC and is discussed further in Section 7.2.6.

There is some evidence that using stainless steel grinding blades when processing ISM samples could contribute chromium to the ISM soil samples. Three ISM areas located in the Building F-15 EU were re-sampled for total chromium because potential laboratory contamination from the grinding process was suspected after reviewing preliminary data. The grinder used for ISM processing at this AOC in February 2010 was a standard kitchen quality coffee grinder. The coffee grinder blades chipped, bent, and were no longer able to grind soil samples, so the laboratory switched to an agricultural-grade grinder for processing the remainder of the PBA08 RI ISM samples. Metal chips from low-grade stainless steel blades could have contributed to the elevated chromium results observed in the Building F-15 EU ISM samples. The corrosion resistance of stainless steel is due to a thin layer of trivalent chromium. Potential contamination due to sample grinding would increase trivalent and total chromium concentrations, but not necessarily affect the percent of hexavalent chromium. The issue of elevated total chromium in ISM samples due to the grinding process was addressed by re-sampling the ISM areas with elevated total chromium (F15ss-035M, F15ss-036M, and F15ss-037M). New ISM samples were collected in October 2010 at these three areas using the same sample equipment and techniques for total chromium used in February 2010; however, the samples collected in October 2010 were processed using a mortar and pestle instead of metal blade grinder, resulting in substantially lower concentrations of total chromium. Total chromium results from both sampling events are presented and discussed further in Section 4.2.4.6. Total chromium results for other ISM samples processed with the coffee grinder and not re-sampled could be elevated due to sample grinding. However, chromium was not identified as a COC; therefore, the impact of the potential contribution from grinding is minimal.

7.2.5.2 Uncertainty in Use of FWCUGs

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.

Selection of Representative Receptors – The Buildings F-15 and F-16 AOC 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 required by CERCLA and the Army. As stated in Paragraph 6.d of the Technical Memorandum (ARNG 2014), 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, 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 a pathway, the resulting risk can be in excess of the 99^{th} percentile and, therefore, outside of the range that may be reasonably expected. Thus, the consistent selection of 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 FWCUGs were the most recent values available at the time (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 is dependent on the chemical species present. Two important examples are arsenic and chromium. The toxicity values used in developing the FWCUGs are for inorganic arsenic, and 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 chromium 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). The 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 1/7 of the total chromium in air to which the workers were exposed. As noted in IRIS, the assumption that the ratio of hexavalent to trivalent chromium was 1:6 in this study may lead to a seven-fold 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. No hexavalent chromium was detected in three of the six speciation samples. The detected concentrations of hexavalent chromium in the remaining three chromium speciation samples are less than the residential RSL for hexavalent chromium, and supports using the trivalent chromium FWCUGs for evaluating total chromium results. Using speciation samples to identify the appropriate FWCUG minimizes the associated uncertainty.

FWCUGs 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 are risk-based values. In some cases, natural or anthropogenic background concentrations, unrelated to process operations, exceed the risk-based FWCUGs. 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 baseline 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 (e.g., 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 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 the 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 a FWCUG for a given receptor or any COPC contributing significantly to an SOR greater than one. For inorganic chemicals with FWCUGs below background concentrations, the background concentration was used as the point of comparison. The TR for the FWCUGs 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 and are discussed by EU below.

Building F-15 EU COCs for Potential Remediation: Surface Soil (0–1 ft bgs)

Four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] were identified as COCs for the Resident Receptor (Adult and Child). Benzo(a)pyrene (0.48 mg/kg) is present in one sample (F15ss-036M) above the FWCUG (0.221 mg/kg) for the Resident Receptor (Adult and Child) and benz(a)anthracene, benzo(b)fluoranthene, and dibenz(a,h)anthracene contribute to an SOR greater than one in the same sample. The F15ss-036M ISM area is approximately 0.012 acres and was located within a ditch northwest of the former Building F-15 and immediately adjacent to Slagle Road and an unnamed access road. The ditch where F15ss-036M was collected would have received runoff from the adjacent roads, as well as the asphalt parking lots surrounding the former Building F-15. No PAHs were detected at the PBA08 RI sample F15ss-038M collected in the footprint of former Building F-15 after slab removal was conducted. The benzo(a)pyrene concentration (0.48 mg/kg) is only slightly above the Resident Receptor (Adult and Child) FWCUG of 0.221 mg/kg. The result of sample F15ss-036M is not indicative of an operation-related point source of PAHs and may represent background concentrations for PAHs. Due to the low concentrations of PAHs reported in F15ss-036M collected from an area with no identified source of PAHs other than roads and traffic, PAHs were not identified as COCs for potential remediation.

Building F-15 EU COCs for Potential Remediation: Subsurface Soil (1-13 ft bgs)

No COCs were identified for the Resident Receptor (Adult and Child) in subsurface soil.

Building F-16 EU COCs for Potential Remediation: Surface Soil (0–1 ft bgs)

No COCs were identified for the Resident Receptor (Adult and Child) in surface soil.

Building F-16 EU COCs for Potential Remediation: Subsurface Soil (1-13 ft bgs)

Arsenic was the only COC identified for subsurface soil at the Building F-16 EU. The EPC for arsenic in subsurface soil was 23.1 mg/kg, which exceeds the FWCUG for the Resident Receptor Adult (4.25 mg/kg) and the background screening concentration of 19.8 mg/kg. The EPC for arsenic is strongly influenced by the MDC of 24.3 mg/kg in the 4–7 ft bgs interval of soil boring F16sb-021. Reported concentrations in the other four subsurface samples range from 11.3–17.1 mg/kg. Reported concentrations in F16sb-021 above (1–4 ft bgs) and below (7–13 ft bgs) the MDC were 13.7 and 11.3 mg/kg, respectively. Arsenic is a common element in Ohio soil and values exceeding 20 mg/kg are not uncommon (ODNR 2010). Naturally occurring arsenic in a study of 313 samples of Ohio soil ranged from 1.6–71.3 mg/kg with 95th percentiles of 25.5 mg/kg in subsurface soil (Vosnakis and Perry 2009). There is no known operational source for arsenic associated with this AOC. Based on the low magnitude of exceedance of the facility-wide subsurface soil background concentration, regional Ohio background concentrations, and absence of an operational source, arsenic is not identified as a COC for potential remediation for the Resident (Adult and Child) in the Building F-16 EU.

7.2.7 Summary of HHRA

This HHRA documents COCs that may pose potential health risks to human receptors resulting from exposure to contamination at the Buildings F-15 and F-16 AOC. 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 CUGs (USACE 2012a), and Technical Memorandum (ARNG 2014). The components of the risk assessment (receptors, exposure media, EPCs, and results) are summarized below.

Receptors – Camp Ravenna is a controlled-access facility. The Buildings F-15 and F-16 AOC is located in the west/central portion of the facility and is currently inactive. 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).

Exposure Media – Media of concern are surface and subsurface soil.

Exposure Point Concentration – For surface soil (0–1 ft bgs), the EPC is the detected concentration in each ISM sample collected. For the subsurface soil (1–13 ft bgs) depth interval, EPCs were calculated using analytical results from discrete soil boring samples listed in Tables 7-3 and 7-4. The EPC was either the 95% UCL of the mean or the MDC, whichever value is lowest. If the 95% UCL could not be determined, the EPC is the MDC.

Results of Human Health Risk Assessment – No COCs were identified for potential remediation at the Buildings F-15 and F-16 AOC.

7.3 ECOLOGICAL RISK ASSESSMENT

7.3.1 Introduction

The ERA presented in this RI 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 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

The Buildings F-15 and F-16 AOC contains habitat that supports ecological receptors. This habitat has known chemical contamination (MKM 2007). Habitat types and an assessment of the ecological resources found at the AOC are presented in subsequent subsections. Additionally, the results of a historical ERA (an ERS performed as part of the Characterization of 14 AOCs) 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

The Buildings F-15 and F-16 AOC habitat area is approximately 5.4 acres. The northern Building F-15 EU is approximately 2.9 acres, and the southern Building F-16 EU is approximately 2.5 acres. The habitat at the Building F-15 EU is dominated by forest, while the habitat at the Building F-16 EU is mostly shrubland. Both habitats are large enough to support cover and food for small birds and mammals that typically require approximately 1 acre of habitat (USEPA 1993). The habitat area at the AOC represents approximately 0.03% of the 21,683 acres at Camp Ravenna.

Future use at the Buildings F-15 and F-16 AOC is anticipated to be within the Military Training or 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, sulfates, nitrates, lead styphnate, and lead azide. PAHs from coal storage and used in the two boiler houses (Buildings U-17 and U-18) and PCBs from the on-site transformers at Building F-15 are also considered site-specific contaminants. Additional site-specific contaminants at the Buildings F-15 and F-16 AOC include explosives and propellants, PAHs, and heavy metals. The evaluation of historical chemical contamination is not limited to these chemicals; rather, this evaluation is expanded to include all eligible chemical data that are available.

The goal of the historical ERA (MKM 2007) was to identify COPECs in soil, sediment, and surface water for the Buildings F-15 and F-16 AOC. The historical ERA followed instructions presented in the *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2003) and consisted of the first two of six steps listed in Figure III of the FWERWP (USACE 2003a). These two steps identified the 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. 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. The estimated depth of groundwater at the AOC ranges from 11–14 ft bgs, based on facility-wide measurements.

The historical ERA tables for soil, sediment, and surface water are included in Appendix H, Tables H-1, H-2, and H-3 and contain the following:

- Frequency of detection,
- Average concentration,
- MDC,
- Background concentrations for each medium (surface soil, sediment, and surface water),
- Comparison of MDC to background concentrations (SRC determination),
- Sediment reference value (sediment only),
- Comparison of MDC to sediment reference value (sediment only),
- Screening values (ESVs),
- Comparison of MDC to ESVs,
- PBT compound identification,
- COPEC determination, and
- COPEC rationale.

Historical COPECs for Soil – The historical ERA conducted as part of the Characterization of 14 AOCs considered this AOC as a single EU and reported 42 chemicals in surface soil (0–1 ft bgs) (MKM 2007). Of the 42 chemicals detected, 4 (calcium, magnesium, potassium, and sodium) were essential nutrients and were excluded from the COPEC screen. Thirty-eight chemicals were determined to be SRCs because they either exceeded background concentrations or did not have an associated background concentration for comparison. Eight of the inorganic chemicals (arsenic, chromium, copper, iron, lead, mercury, selenium, and zinc) and three organic chemicals (4,4’-DDT; PCB-1260; and naphthalene) were identified as COPECs because detected concentrations were above ESVs. Four other chemicals (carbazole, dibenzofuran, nitrocellulose, and nitroglycerin) were also identified as COPECs due to a lack of ESV. In total, 15 chemicals were identified as COPECs in surface soil (Table 7-15). Appendix H, Table H-1 presents the ecological screening for soil.

Historical COPECs for Sediment – The historical ERA conducted as part of the Characterization of 14 AOCs reported 19 SRCs in sediment (MKM 2007). Of the 19 chemicals detected, only 1 inorganic chemical (beryllium) was selected as a sediment COPEC because it did not have an ESV (Table 7-15). Appendix H, Table H-2 presents the ecological screening for sediment.

Historical COPECs for Surface Water – The historical ERA conducted as part of the Characterization of 14 AOCs reported 21 chemicals in surface water (MKM 2007). All of these chemicals were determined to be SRCs because they either exceeded background concentrations or did not have an associated background concentration for comparison. Of the 21 chemicals, 2 inorganic chemicals (iron and manganese) and 1 organic chemical (acetone) were identified as COPECs due to a lack of ESVs (Table 7-15). Appendix H, Table H-3 presents the ecological screening for surface water.

Summary of Historical ERA – As explained previously, a historical ERA was performed to determine COPECs at the AOC in surface soil, sediment, and surface water. The historical COPECs are summarized in Table 7-15. Based on the identified COPECs, ecological risk in all three media was predicted in the historical investigation, and an additional investigation was recommended for the AOC (MKM 2007).

7.3.2.3 Ecological Significance

Sources of data and information about the ecological resources at the AOC include the *Integrated Natural Resources Management Plan* (INRMP) (OHARNG 2014), previous characterization work (e.g., Characterization of 14 AOCs), and visits to the Buildings F-15 and F-16 AOC 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 the AOC. 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 or near an AOC that is subject to contaminant exposure.

The underlying basis for this distinction can be found in *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 H, 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 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 the AOC with each of the important places and resources listed in Appendix H, Table H-4.

Ecological significance is defined as an important resource found at or near an AOC that is subject to contaminant exposure. Thus, any important places and resources listed in Appendix H, 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 that the ecological place or resource is either 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 the Buildings F-15 and F-16 AOC through the natural resource management goals expressed in the INRMP (OHARNG 2014). 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 resources management goals of OHARNG (listed in Appendix H, Table H-5) benefit the AOC. For example, Goal 1 states 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 by utilizing native species mixes for revegetation after ground disturbance activities. These management goals help detect degradation (whether from training activities or historical contamination). While the applicability of the remaining 10 management goals to the AOC varies, all of the management goals are intended to monitor, maintain, or enhance the Camp Ravenna natural resources and ecosystem. While these goals are for managing all types of resources at and near the AOC, they do not affect the decisions concerning the presence or absence of important or significant ecological places or resources at the AOC.

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 rare species. An important resource becomes significant when found on an AOC and there is contaminant exposure.

As noted in Appendix H, Table H-4, a small portion (0.06 acres) of a wetland is within the AOC. The wetland is an important ecological resource at the AOC (Appendix H, Table H-4). This wetland is discussed in greater detail later in this section.

Terrestrial Resources – The AOC is dominated by terrestrial resources, as described below.

Habitat Descriptions and Species**.** The INRMP and AOC visits by SAIC biologists in 2008 and 2010 indicate the AOC consists of two predominant vegetation types (Figure 7-2): the Building F-15 EU is dominated by red maple (*Acer rubrum)* successional forest, and the Building F-16 EU (about 800 ft south of Building F-15) consists of dry, late-successional, cold-deciduous shrubland. 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 2014).

SAIC biologists confirmed these two main habitat types were still present during field surveys conducted at the AOC in November 2008 (Photographs 7-1 and 7-2). A small amount of dry, early-successional herbaceous field habitat is mapped in the northeastern corner of the Building F-15 EU, and a small amount of mixed cold-deciduous successional forest is mapped in the southwestern corner of the Building F-16 EU. Herbaceous field habitat and cold-deciduous, successional forest were limited in extent within the AOC boundaries. The addition of dry, early-successional herbaceous field habitat is a result of an expansion of the Building F-15 EU AOC boundary rather than changes in the habitat observed from 1999–2010.

The shrubland habitat within the Building F-16 EU is in the early stages of replacing herbaceous habitat. In the absence of mowing and other disturbances, the shrub community is likely to continue expanding. SAIC biologists judged the habitats at the AOC to be healthy and functioning, based on the October 2008 observations. 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. The AOC has not been previously surveyed for rare, threatened, or endangered species; however, there have been no documented sightings of rare, threatened, or endangered species at the AOC (OHARNG 2014).

Other Terrestrial Resources**.** While there are no known important terrestrial places and resources (Appendix H, Table H-4), there are other resources at or near the AOC (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 animals at the AOC beyond those summarized in the INRMP (OHARNG 2014).

Aquatic Resources – The AOC has few aquatic resources. There are no streams or ponds at the AOC and surface water or sediment at the AOC is currently limited to the wetland along the eastern edge of the Building F-15 EU, as described below. While two historical surface water and sediment samples exist, one was collected from an ephemeral "puddle" of surface water that has since dried, and the other sample was off-AOC in the nearby surface water conveyance south of the Building F-16 EU that drains the area north of the AOC.

Photograph 7-1. Habitat of Herbaceous Field in Foreground and Forest in Background at the Building F-15 Exposure Unit (October 19, 2010)

Photograph 7-2. Habitat of Herbaceous and Shrubland Vegetation near a Patch of Forest at the Building F-16 Exposure Unit (October 18, 2010)

Habitat Descriptions and Species. As noted, there is only one type of aquatic resource at the Buildings F-15 and F-16 AOC. The topography at the AOC is relatively flat; however, a small portion of the eastern edge of the Building F-15 EU drains east between the railroad spurs. 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. This is a sufficient amount of precipitation to create and maintain aquatic habitat at the Buildings F-15 and F-16 AOC, as evidenced by the presence of a small wetland in the southeast corner of the Building F-15 EU.

Wetlands. Wetlands are important habitats with water-saturated soil or sediment whose plant life can survive saturation. Wetlands are home to many different species and are also chemical sinks that can serve as detoxifiers and natural water purifiers. Although only a small portion (0.06 acres) of a wetland (0.69 acres in total) is within the AOC boundary (Figure 7-2), it is expected the wetland at the AOC vicinity can perform these and other related functions.

The wetland is associated with two wet weather ditches in a low area between the old railroad beds for the former Building F-15 and F-16 railroad spurs. The wetland likely receives some runoff from the eastern side of the former building site and the F-15 railroad spur; the F-16 railroad bed to the east probably acts to impede the natural drainage from the AOC. The wetland consists of emergent and scrub-shrub habitat in approximately equal proportions.

There are other wetlands near the AOC. For example, a small wetland (0.5 acres) is located south of former Building F-15, and a larger wetland (7.6+ acres) is located to the east. Also, there is a wetland (9.5+ acres) located south of former Building F-16. All are planning level survey wetlands [i.e., based on desktop surveys conducted for OHARNG of wetlands data and resources (e.g., NWI maps and aerials)]. No jurisdictional wetlands determination has been conducted at this AOC. A jurisdictional determination by USACE would be required to determine the regulatory status of any wetland at the AOC potentially affected by remedial activities.

An SAIC Professional Wetland Scientist used the Ohio Rapid Assessment Method (ORAM) (Ohio EPA 2001) in November 2011 to assess the condition of the wetland within and along the eastern edge of the habitat area for the Building F-15 EU and to determine the potential ecological importance of the wetland (Appendix H, Figure H-1). Using the ORAM, wetlands are classified into three categories:

- Category 1 wetlands are described as “limited quality waters.” They are considered to be a resource that has been degraded, has limited potential for restoration, or is of such low functionality that lower standards for avoidance, minimization, and mitigation can be applied. Scores range from 1–29.
- Category 2 includes wetlands of moderate quality and wetlands that are degraded but exhibit reasonable potential for restoration. Scores range from 30–59.
- Category 3 includes wetlands of very high quality and wetlands of concern regionally and/or statewide, such as wetlands that provide habitat for species listed as threatened or endangered. Scores range from 60–100.

The field sheet detailing the ORAM is presented in Appendix H, Figure H-1. Figure 7-2 shows the location of the evaluated wetland and planning level survey wetlands within the vicinity. Based on the ORAM, the wetland is classified as Category 1 (with a final score of 21), indicating a low wetland quality, with some degradation of wetland functions and conditions (Appendix H, Figure H-1).

Because there is contamination within the Building F-15 EU (discussed in Sections 7.3.2.2 and 7.3.2.5), further contaminant trend analysis was conducted to determine if the contamination was at a level of concern to ecological receptors in the wetland and could be contributing to its Category 1 score.

Eleven integrated COPECs (based on PBA08 RI and historical data), including eight inorganic chemicals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) and three organic chemicals (nitrocellulose, dibenzofuran, and naphthalene) were identified at the Building F-15 EU (see Section 7.3.2.5 for a more thorough discussion on integrated COPECs). Maximum concentrations of these COPECs were scattered throughout the Building F-15 EU. To determine if the integrated COPECs were impacting the wetland in the southeast corner of the EU, the concentrations of COPECs in the three soil sampling locations (F15ss-037M, F15ss-011M, and F15sb-031) located in and adjacent to the wetland in the southeast corner of the EU were reviewed (Table 7-16). These locations included two ISM and one discrete soil boring.
The results are discussed below:

- Chromium and copper were detected in these three samples below their respective ESVs, which indicates these inorganic chemicals are not impacting the wetland.
- Although the maximum concentrations of arsenic (20 mg/kg), cadmium (0.41 mg/kg), and nickel (54.4 mg/kg) exceeded their ESVs (18 mg/kg, 0.36 mg/kg, and 38 mg/kg, respectively) in one of the three samples collected in or around the wetland, these concentrations were just slightly above their respective ESV. For each of these chemicals, the concentrations in the other two wetland samples were well below the ESV. In addition, the average concentrations of arsenic (13.9 mg/kg), cadmium (0.25 mg/kg), and nickel (30.2 mg/kg) are below their respective ESVs. As a result, these inorganic chemicals are not present at concentrations of concern for ecological receptors.
- Although concentrations exceeded their ESVs in one of three samples (for lead and zinc) or three of three samples (for mercury) samples collected in or around the wetland, the ESVs were all below the Camp Ravenna background concentrations. Therefore, these ESVs are judged to be conservative. In comparing the average concentrations of lead (36.8 mg/kg), mercury (0.05 mg/kg), and zinc (71.3 mg/kg) from the three wetland samples to the Camp Ravenna background concentrations (26.1, 0.036, and 61.8 mg/kg, respectively), the average concentrations of these samples are very similar to their background concentrations. This suggests these inorganic chemicals are not present at concentrations of concern for ecological receptors.
- While nitrocellulose was identified as an integrated COPEC in soil at the Building F-15 EU, the three soil samples collected at or near the wetland were not analyzed for nitrocellulose. However, nitrocellulose is essentially non-toxic to wildlife and is not a concern for ecological receptors.

- Dibenzofuran was analyzed for in only one wetland sample. Although it was detected at a concentration of 0.098 mg/kg, no soil ESV was available for comparison to this concentration. The detected concentration in soil was below the USEPA Region 5 sediment ESV (0.449 mg/kg); therefore, dibenzofuran is not likely a concern for ecological receptors.
- Naphthalene was detected in one of two wetland samples (F15sb-031) above the soil ESV. PAHs are found throughout the environment in air, soil, water, and sediment and enter the environment from both natural (e.g., forest fires) and anthropogenic (e.g., combustion of oil or presence in coal tar) sources. Although the maximum concentration (0.33 mg/kg) exceeded the ESV (0.094 mg/kg) in one of two samples collected in or around the wetland, the ESV is judged to be conservative. Although ecological soil screening levels (EcoSSLs) for individual PAHs are not available, EcoSSLs have been derived by USEPA for low and high molecular weight classes to address physical/chemical properties of individual PAHs that influence toxicity and environmental fate (USEPA 2007). The most conservative low molecular weight PAH EcoSSL was 29 mg/kg, while the most conservative high molecular weight PAH EcoSSL was 1.1 mg/kg (USEPA 2007). Fluoranthene and phenanthrene are also low molecular weight PAHs detected at maximum concentrations (0.093 and 0.18 mg/kg, respectively) in F15sb-031. The total concentration of low molecular weight PAHs (fluoranthene, naphthalene, and phenanthrene) detected in F15sb-031 is 0.603 mg/kg, which is below the lowest USEPA EcoSSL for low molecular weight PAHs (29 mg/kg) (USEPA 2007); this suggests PAHs are not present at concentrations of concern for ecological receptors.

In summary, although contamination is present at the Building F-15 EU, review of the data suggests that migration of contamination to the wetland along the eastern boundary and within the southeastern corner of the EU has not resulted in concentrations of concern to ecological receptors. It also does not appear likely that these concentrations have contributed to the Category 1 score of this small portion (0.06 acres) of a larger wetland. As a result, although the wetland is an important place, it is not ecologically significant with respect to the contamination at the Building F-15 EU.

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. The AOC has not been previously surveyed for rare, threatened, or endangered species; however, there have been no documented sightings of rare, threatened, or endangered species at the AOC (OHARNG 2014).

Other Aquatic Resources. There are no other known important aquatic places and resources at the AOC (Appendix H, Table H-4). There are no other reported surveys of habitats and animals at the AOC beyond those summarized in the INRMP (OHARNG 2014).

Ecosystem and Landscape Roles and Relationships – There are four spatial areas that were evaluated to assess the ecosystem and landscape roles and relationships at Buildings F-15 and F-16: the actual AOC, the vicinity of the AOC, the entire Camp Ravenna, and the ecoregion of northeastern Ohio. Information about the first spatial area (the AOC) was provided in the section above on terrestrial and aquatic resources.

Vicinity of the AOC. Five vegetation communities border the AOC (Figure 7-2) and include various 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. For example, red maple successional forest extends west 200 ft south of the boundaries of the Building F-15 EU. The dry, late-successional, cold-deciduous shrubland extends several hundred feet to the north and northeast beyond the Building F-16 EU boundary. The types and qualities of habitat are not unique to the AOC and can be found at many other areas at Camp Ravenna.

Figure 7-2 shows the wetland that is within the AOC and extends to the east. Other planning level survey wetlands within the vicinity are also shown on Figure 7-2. Water that drains from the Building F-16 EU travels along ditches leading to a wetland and tributary of Sank Creek. There are no additional known connections between the AOC and the off-site wetlands.

The closest recorded rare species [Bobcat (*Felis rufus*)] occurs approximately 900 ft west of the AOC (Table 7-17); it is a state threatened species. The next closest rare species [Bobolink (*Dolichonyx oryzivorus*)] was observed approximately 1,300 ft west of the AOC; it is a state species of concern. The Canada warbler (*Wilsonia canadensis*), purple finch (*Carpodacus purpureus*), and winter wren (*Troglodytes troglodytes*) were sighted about 1,800 ft west of the AOC; these are state species of special interest.

Table 7-17 summarizes the geographical relationships of various ecological resources near AOC. No beaver dams, 100-year floodplains, or biological/water quality sampling locations are in or near the AOC. Wetlands are found within and near the AOC. Although there are no streams or ponds within the AOC, a small unnamed tributary that flows south toward Sand Creek is approximately 120 ft southwest of the AOC. With the exception of the wetlands and tributary, the remainder of the nearest ecological resources are 900 ft or more from the AOC.

The Entire Camp Ravenna. The Buildings F-15 and F-16 AOC is approximately 5.4 acres, which represents 0.025% of the entire area of Camp Ravenna (21,683 acres). Five types of habitat types [FU4 (red maple successional forest), FU5 (mixed cold-deciduous forest), HU1 (herbaceous field), SU2 (dry, late-successional, cold deciduous shrubland), and wetland] are present at the AOC. The AOC contains only a small percentage (0.06%) of these types of habitat (9,842 acres) at Camp Ravenna. There are approximately 5,160 acres of forest types FU4 and FU5 [red maple successional forest and mixed cold-deciduous successional forest (e.g., wild black cherry, red maple, and black locust)] at Camp Ravenna. Based on the INRMP map (OHARNG 2014), this represents 23.8% of the habitat at Camp Ravenna. There are approximately 2,050 acres of herbaceous field (HU1) and 662 acres of dry, late-successional, cold deciduous shrubland (SU2) (OHARNG 2014) at Camp Ravenna, representing 9.5% and 3.1%, respectively, of the habitat at Camp Ravenna. There are approximately 1,970 acres of wetlands (jurisdictional and planning level survey) as defined in the INRMP (OHARNG 2014), representing 9.1% of the habitat at Camp Ravenna. These types of resources are not unique to the AOC and Camp Ravenna.

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 (USGS 1998) is located in northeastern Ohio and contains the communities of forest alliance [e.g., green ash (*Fraxinum pennsylvanica*), American elm (*Ulmus Americana*), and hackberry (*Celtis occidentalis*)]; successional forest [e.g., red maple (*A. rubrum*) and elm (*Ulmus spp.*)]; and dry, mid-successional, cold-deciduous shrubland [e.g., gray dogwood (*Swida racemosa*) and hawthorn (*Crataegus spp.*)]. The Erie/Ontario Drift and Lake Plain ecoregion exhibits rolling to level terrain formed by lacustrine and low lime drift and deposits. Lakes, wetlands, and swampy streams occur where stream networks converge or where the land is flat and clayey (USGS 1998). The U.S. Forest Service (USFS) has a Forest Inventory Data Online tool that was queried for the forest alliance in the surrounding counties in or near Camp Ravenna (USFS 2011). In 2009, approximately 371,580 acres of forest types FU4 and FU5 (138,840 acres of red maple successional forest and 232,740 acres of cold-deciduous forest) and approximately 171,380 acres of dry, late-successional, cold deciduous shrubland type SU2 [e.g., red maple and wild cherry (*Prunus serotina*)] were found throughout Ohio and also in the Cuyahoga, Geauga, Mahoning, Portage, Stark, Summit, and Trumbull counties that surround Camp Ravenna. The herbaceous field HU1 [e.g., goldenrod (*Solidago spp.*)] 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 fields are common across the ecoregion. Wetlands across the ecoregion make up 207,800 acres (USEPA 1999). Thus, the vegetation communities and wetlands at the AOC are also found in the surrounding counties in the ecoregion of northeastern Ohio.

In summary, the current vegetation types of red maple successional forest; mixed, cold-deciduous successional forest [e.g., wild black cherry, maple, and black locust (*Robinia pseudoacacia*)]; early-successional herbaceous field; dry, late-successional, cold deciduous shrubland; and a wetland are present at the AOC. The two forest types, herbaceous field, shrubland, and wetlands are in abundance at Camp Ravenna and the larger surrounding local ecoregion. There is no known unique resource at the AOC 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

At the Buildings F-15 and F-16 AOC, there were 18 COPECs identified in the historical ERA as part of the Characterization of 14 AOCs: arsenic; beryllium; chromium; copper; iron; lead; manganese; mercury; selenium; zinc; 4,4'-DDT; PCB-1260; acetone; carbazole; dibenzofuran; naphthalene; nitroglycerin; and nitrocellulose (Section 7.3.2.2). Section 7.3.2.3 provides information about presence of important ecological resources and the lack of significant ecological resources at the AOC. There is one wetland at the eastern boundary of the AOC. The entire extent of the wetland is 0.69 acres; however, only 0.06 acres of the wetland lies within the AOC boundary. Although the wetland is an important resource, this wetland is not a significant resource, as soil sampling results in and around the wetland (discussed in Section 7.3.2.3) do not indicate exposure to elevated concentrations of contaminants would occur within the wetland. As a result, there are no significant ecological resources. Section 7.3.2.6 summarizes the chemicals and resources demonstrating there is contamination but no important/significant ecological resources at the AOC.

7.3.2.5 Evaluation of Current Chemical Contamination

This section provides information about methods and results of the analysis of current and historical chemical contamination.

The screening level approach to evaluate sample results from the PBA08 RI followed a similar approach as used in the historical ERA. Section 5.0 details chemical concentration data. The PBA08 RI evaluation uses ISM soil data collected during the PBA08 RI and ISM soil data used in the historical ERA. The PBA08 RI included collecting surface soil (0–1 ft bgs) samples at locations different from the historical soil sample locations (Figures 4-1, 4-2, and 4-3). Surface soil was evaluated in two EUs: Building F-15 EU and Building F-16 EU. This ERA uses ESVs that follow the revised *Ecological Risk Assessment Guidance* (Ohio EPA 2008), as provided in Appendix H, Table H-6.

The MDC of each chemical is compared to its respective facility-wide background concentration. Chemicals are not considered site-related if the MDC is below the background concentration. 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 the ESV, if the chemical exceeds its background concentration 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.

Integrated COPECs in Surface Soil (0–1 ft bgs) at the Building F-15 EU – Five chemicals (calcium, iron, magnesium, potassium, and sodium) were essential nutrients and were excluded as SRCs at the Building F-15 EU. A total of 14 detected inorganic chemicals and 19 organic chemicals were determined to be SRCs because they either exceeded background concentrations or did not have an associated background concentration for comparison. Of the 33 SRCs, 9 inorganic chemicals and 1 organic chemical (naphthalene) exceeded their ESVs and were identified as integrated COPECs (Table 7-18). In addition, two organic chemicals (nitrocellulose and dibenzofuran) were selected as COPECs because they do not have an ESV. One of the 12 soil COPECs (mercury) was also a PBT compound. The calculated ratio of MDC to ESV is shown in Table 7-18 for each integrated COPEC. Appendix H, Table H-7 presents the details of the ESV comparisons for surface soil at the Building F-15 EU.

Most of the COPECs reported in the historical ERA (Table 7-15) are also identified in the current ERA. The Characterization of 14 AOCs identified six COPECs that are not integrated COPECs. Iron was considered an essential nutrient and selenium was detected below background concentrations in the PBA08 RI samples. Organic chemicals 4,4’-DDT and PCB-1260 were only analyzed at the Building F-16 EU, and carbazole and nitroglycerin were not detected in the PBA08 RI at the Building F-15 EU. Three new COPECs (antimony, cadmium, and nickel) are identified in the PBA08 RI. Cadmium was added due to an updated, more conservative ESV. Antimony and nickel were detected during the PBA08 RI at a higher concentration that is greater than the ESV.

Integrated COPECs in Surface Soil (0–1 ft bgs) at the Building F-16 EU – Five chemicals (calcium, iron, magnesium, potassium, and sodium) were essential nutrients and were excluded as SRCs at the Building F-16 EU. A total of 15 detected inorganic chemicals and 22 organic chemicals were determined to be SRCs because they either exceeded background concentrations or did not have an associated background concentration for comparison. Of the 37 SRCs, 9 inorganic chemicals and 1 organic chemical (naphthalene) exceeded their ESVs and were identified as integrated COPECs (Table 7-19). In addition, five organic chemicals (nitrocellulose, nitroglycerin, carbazole, dibenzofuran, and PCB-1260) were selected as COPECs because they do not have an ESV. A total of 3 of the 17 soil COPECs (4,4'-DDE; 4,4'-DDT; and PCB-1260) were also PBT compounds. The calculated ratio of MDC to ESV is shown in Table 7-19 for each integrated COPEC. Appendix H, Table H-8 presents the details of the ESV comparisons for surface soil at the Building F-16 EU.

Most of the COPECs reported in the historical ERA (Table 7-15) are also identified in the current ERA. The Characterization of 14 AOCs identified two COPECs (arsenic and iron) that are not integrated COPECs. Iron was considered an essential nutrient, and the arsenic MDC samples were equal to the ESV in the PBA08 RI. Four new COPECs (antimony; cadmium; nickel; and 4,4'-DDE) are identified in the PBA08 RI. Cadmium was added due to an updated, more conservative ESV. Antimony; nickel; and 4,4'-DDE were detected at a higher concentration during the PBA08 RI that is greater than the ESV.

Integrated COPECs in Sediment at the Buildings F-15 and F-16 AOC – No sediment samples were included in the PBA08 RI because this medium is not present within the AOC. Therefore, sediment is not considered a permanent medium at this AOC, and no sediment integrated COPECs were present. There were only two historical sediment samples taken at or near the former Building F-16 during the Characterization of 14 AOCs. One sample was from an ephemeral "puddle" of surface water that has since dried, and the other sample was off-AOC in the nearby surface water conveyance that drains the area north of the AOC. One historical sediment COPEC (beryllium) was identified in the Characterization of 14 AOCs. Beryllium was detected in all 25 surface soil samples collected at the AOC; however, the MDC (2.9 mg/kg) was well below the ESV of 21 mg/kg.

Integrated COPECs in Surface Water at the Buildings F-15 and F-16 AOC – No surface water samples were included in the PBA08 RI because this medium is not present within the AOC. Therefore, surface water is not considered a permanent medium at this AOC, and no surface water integrated COPECs were present. There were only two historical surface water samples taken at or within the vicinity of former Building F-16 during the Characterization of 14 AOCs. One sample was from an ephemeral "puddle" of surface water that has since dried, and the other sample was off-AOC in the nearby surface water conveyance that drains the area north of the AOC. Three historical surface water COPECs (iron, manganese, and acetone) were identified in the Characterization of 14 AOCs. Iron was considered an essential nutrient and was eliminated from the integrated COPECs. Manganese was detected in all 25 surface soil samples collected at the AOC; however, the MDC (1,200 mg/kg) was below the facility-wide background concentration of 1,450 mg/kg. Acetone was not detected in any historical or PBA08 RI soil samples.

Summary of ERA Findings – There were 12 integrated COPECs identified in soil at the Building F-15 EU and 17 integrated COPECs identified in soil at the Building F-16 EU. There were 18 integrated COPECs identified in soil at the Buildings F-15 and F-16 AOC: antimony; arsenic; cadmium; chromium; copper; lead; mercury; nickel; selenium; zinc; nitrocellulose; nitroglycerin; carbazole; dibenzofuran; naphthalene; 4,4'-DDE; 4,4'-DDT; and PCB-1260. There were no integrated COPECs identified in sediment or surface water at the AOC due to the lack of these media at the AOC.

7.3.2.6 Summary and Recommendations of Scoping Level Ecological Risk Assessment

Based on information from the Characterization of 14 AOCs and PBA08 RI, there are 18 integrated soil COPECs at the Buildings F-15 and F-16 AOC. These COPECs consist of inorganic chemicals, explosives, PCBs, pesticides, and SVOCs. Thus, there is contamination present at the AOC.

The information in Section 7.3.2.3 regarding ecological resources at the AOC was compared to the list of important ecological places and resources (Appendix H, Table H-4). One of the 39 important places (wetlands) was present. Although the wetland is an important resource, this wetland is not a significant resource, as soil sampling results in and around the wetland (discussed in Section 7.3.2.5) do not indicate chemicals are present at concentrations of concern for ecological receptors. As a result, there are no important and significant ecological resources. Environmental management goals and objectives of OHARNG are applicable to the AOC, as presented in Appendix H, Table H-5. Some of the management goals benefit the AOC, including Goal 1 requiring management of natural resources to be compatible with military mission and Goal 5 requiring the Army to sustain usable training lands and natural resources.

The Buildings F-15 and F-16 AOC is approximately 5.3 acres and is vegetated with dry, early-successional, herbaceous field; dry, late-successional, cold-deciduous shrubland; *Acer rubrum* successional forest; mixed, cold-deciduous, successional forest; and a wetland. These same types of habitats are found adjacent to the AOC and elsewhere at Camp Ravenna (OHARNG 2014). The habitats are also found in the larger, local ecoregion that surrounds Camp Ravenna (USFS 2011). Thus, there is no known unique resource at the AOC.

Accordingly, although there is contamination at the AOC and an important ecological resource is present, the AOC has no known significant ecological places or resources. Consequently, the ERA for the Buildings F-15 and F-16 AOC can conclude with a Level I Scoping Level Risk Assessment, with the recommendation that no further action is required to be protective of important ecological resources.

7.3.3 Conclusions

There is chemical contamination present at Buildings F-15 and F-16 AOC. There are 18 integrated soil COPECs at the AOC. Although a small wetland is present (an important ecological resource), the soil sampling results in and around the wetland do not indicate that chemicals are present at concentrations of concern for ecological receptors. Thus, there are no significant ecological resources at the AOC. Further, the vegetation types are found elsewhere near the AOC, at Camp Ravenna, and in the ecoregion. Per guidance from the Ohio EPA, there is sufficient justification to recommend that no further action is required to be protective of important ecological resources at the Buildings F-15 and F-16 AOC.

Table 7–1. Risk Assessment Data Set for Building F-15 EU Surface Soil (0–1 ft bgs): ISM Samples

Station	Sample ID	Date	Depth (ft bgs)
F15ss-001M	F15ss-001M-SO	10/28/2004	0–1
F15ss-002M	F15ss-002M-SO	10/28/2004	0–1
F15ss-003M	F15ss-003M-SO	10/28/2004	0–1
F15ss-004M	F15ss-004M-SO	10/27/2004	0–1
F15ss-005M	F15ss-005M-SO	10/28/2004	0–1
F15ss-006M	F15ss-006M-SO	10/28/2004	0–1
F15ss-006D	F15ss-006D-SO[a]	10/28/2004	0–1
F15ss-007M	F15ss-007M-SO	10/28/2004	0–1
F15ss-008M	F15ss-008M-SO	10/28/2004	0–1
F15ss-009M	F15ss-009M-SO	10/28/2004	0–0.5
F15ss-010M	F15ss-010M-SO	10/28/2004	0–1
F15ss-011M	F15ss-011M-SO	10/28/2004	0–1
F15ss-012M	F15ss-012M-0500-SO	11/4/2009	0–1
F15ss-034	F15ss-034-5436-SO[b]	2/24/2010	0–1
F15ss-036	F15ss-036-5814-SO[b]	10/19/2010	0–1
F15ss-035M	F15ss-035M-5428-SO[c]	2/24/2010	0–1
F15ss-035M	F15ss-035M-5812-SO[d]	10/19/2010	0–1
F15ss-036M	F15ss-036M-5427-SO[c]	2/24/2010	0–1
F15ss-036M	F15ss-036M-5813-SO[d]	10/19/2010	0–1
F15ss-037M	F15ss-037M-5429-SO[c]	2/24/2010	0–1
F15ss-037M	F15ss-037M-5815-SO[d]	10/19/2010	0–1
F15ss-038M	F15ss-038M-5430-SO	2/24/2010	0 – 1
F15ss-040	F15ss-040-0001-SO	12/02/09	0.0–0.5
FWCss-007	FWCss-007-0001-SO	12/02/09	0.0–0.5

[a] Discrete sample taken in ISM area for determining volatile organic compounds in ISM area.

[b] Chromium speciation samples used to evaluate the presence of hexavalent chromium. F15ss-034 collected at ISM area F15ss-008M; F15ss-036 collected at ISM area F15ss-036M.

[c] Sample used for all analytes except for total chromium, which was re-sampled as described in Section 4.2.4.6.

[d] Sample analyzed for chromium only.

bgs = Below ground surface.
EU = Exposure unit.
ft = Feet.
ID = Identification.
ISM = Incremental sampling methodology.

Table 7–2. Risk Assessment Data Set for Building F-16 EU Surface Soil (0-1 ft bgs): ISM Samples

Station	Sample ID	Date	Depth (ft bgs)
F16ss-001M	F16ss-001M-SO	11/3/2004	0–0.5
F16ss-002M	F16ss-002M-SO	11/3/2004	0–0.5
F16ss-003M	F16ss-003M-SO	11/3/2004	0–0.5
F16ss-004M	F16ss-004M-SO	11/3/2004	0–1
F16ss-005D	F16ss-005D-SO[a]	11/3/2004	0–0.5
F16ss-005M	F16ss-005M-SO	11/3/2004	0–0.5
F16ss-006M	F16ss-006M-SO	10/28/2004	0–1
F16ss-007M	F16ss-007M-SO	11/3/2004	0–0.5
F16ss-008M	F16ss-008M-0504-SO	11/4/2009	0–1
F16ss-024	F16ss-024-5434-SO[b]	2/24/2010	0–1
F16ss-025	F16ss-025-5435-SO[b]	2/24/2010	0–1
F16ss-026	F16ss-026-5816-SO[b]	10/18/2010	0 – 1
F16ss-026M	F16ss-026M-5431-SO	2/24/2010	0–1
F16ss-027	F16ss-027-5817-SO[b]	10/18/2010	0–1
F16ss-027M	F16ss-027M-5432-SO	2/24/2010	0–1
F16ss-028M	F16ss-028M-5433-SO	2/24/2010	0 – 1
F16ss-030	F16ss-030-0001-SO	12/02/09	0.0–0.5
FWCss-008	FWCss-008-0001-SO	12/02/09	0.0–0.5

[a] Discrete sample taken for determination of volatile organic compounds in ISM area.

[b] Chromium speciation samples used to evaluate the presence of hexavalent chromium. F16ss-024 collected at ISM area F16ss-005M; F16ss-025 collected at ISM area F16ss-007M; F16ss-026 collected at ISM area F15ss-026M; F16ss-027 collected at ISM area F15ss-027M.

bgs = Below ground surface.
EU = Exposure unit.
ft = Feet.
ID = Identification.
ISM = Incremental sampling methodology.

Table 7–3. Risk Assessment Data Set for Building F-15 EU Subsurface Soil (1–13 ft bgs): Discrete Samples

Station	Sample ID	Date	Depth (ft bgs)
F15sb-031	F15sb-031-5406-SO	3/2/2010	1–4
F15sb-032	F15sb-032-5410-SO	3/2/2010	1–4
F15sb-033	F15sb-033-5414-SO	3/2/2010	1 – 4
F15sb-031	F15sb-031-5407-SO	3/2/2010	4–7
F15sb-032	F15sb-032-5411-SO	3/2/2010	4–7
F15sb-033	F15sb-033-5415-SO	3/2/2010	4–7
F15sb-033	F15sb-033-5416-SO	3/2/2010	7–13

Subsurface soil is defined as 1–13 ft bgs for Resident (Adult and Child).
bgs = Below ground surface.
EU = Exposure unit.
ft = Feet.
ID = Identification.

Table 7–4. Risk Assessment Data Set for Building F-16 EU Subsurface Soil (1–13 ft bgs): Discrete Samples

Station	Sample ID	Date	Depth (ft bgs)
F16sb-021	F16sb-021-6123-SO	3/2/2010	1–4
F16sb-022	F16sb-022-5422-SO	3/2/2010	1–4
F16sb-021	F16sb-021-5419-SO	3/2/2010	4–7
F16sb-022	F16sb-022-5423-SO	3/2/2010	4–7
F16sb-021	F16sb-021-5420-SO	3/2/2010	7–13

Subsurface soil is defined as 1-13 ft bgs for Resident (Adult and Child).
bgs = Below ground surface.
EU = Exposure unit.
ft = Feet.
ID = Identification.

Table 7–5. Summary of SRCs: Building F-15 EU

SRC	Surface Soil[a] (0–1 ft bgs)	Subsurface Soil[b] (1–13 ft bgs)
Inorganic Chemicals		
Arsenic	X	--
Barium	X	--
Beryllium	X	--
Cadmium	X	X
Chromium	X	--
Cobalt	X	X
Copper	X	--
Lead	X	--
Mercury	X	X
Nickel	X	--
Silver	X	X
Thallium	X	--
Zinc	X	--
Explosives		
Nitrocellulose	X	--
Semi-volatile Organic Compounds		
2-Methylnaphthalene	X	--
Acenaphthene	X	--
Acenaphthylene	X	--
Anthracene	X	--
Benz(a)anthracene	X	--
Benzo(a)pyrene	X	--
Benzo(b)fluoranthene	X	--
Benzo(ghi)perylene	X	--
Benzo(k)fluoranthene	X	--
Bis(2-ethylhexyl)phthalate	--	X
Chrysene	X	--
Dibenz(a,h)anthracene	X	--
Dibenzofuran	X	--
Fluoranthene	X	--
Fluorene	X	--
Indeno(1,2,3-cd-pyrene)	X	--

Table 7–5. Summary of SRCs: Building F-15 EU (continued)

SRC	Surface Soil[a] (0–1 ft bgs)	Subsurface Soil[b] (1–13 ft bgs)
Naphthalene	X	--
Phenanthrene	X	--
Pyrene	X	--

[a]Surface soil characterized using incremental sampling methodology sampling.
[b]Subsurface soil characterized using discrete sampling.
bgs = Below ground surface.
EU = Exposure unit.
ft = Feet.
SRC = Site-related contaminant.
X = Chemical is an SRC in this medium.
-- = Chemical is not an SRC in this medium.

1 ## Table 7–6. Summary of SRCs: Building F-16 EU

SRC	Surface Soil[a] (0–1 ft bgs)	Subsurface Soil[b] (1–13 ft bgs)
Inorganic Chemicals		
Antimony	X	--
Arsenic	X	X
Barium	X	--
Beryllium	X	--
Cadmium	X	X
Chromium	X	--
Cobalt	X	--
Copper	X	--
Lead	X	--
Mercury	X	X
Nickel	X	--
Selenium	X	--
Silver	X	--
Thallium	X	--
Zinc	X	--
Explosives		
Nitrocellulose	X	--
Nitroglycerin	X	--
Semi-volatile Organic Compounds		
2-Methylnaphthalene	X	--
Acenaphthene		X
Anthracene	X	--
Benz(a)anthracene	X	--
Benzo(a)pyrene	X	--
Benzo(b)fluoranthene	X	--
Benzo(ghi)perylene	X	X
Benzo(k)fluoranthene	X	--
Bis(2-ethylhexyl)phthalate	X	--
Carbazole	X	--
Chrysene	X	--
Dibenzofuran	X	--
Fluorene		X
Fluoranthene	X	--

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Table 7–6. Summary of SRCs: Building F-16 EU (continued)

SRC	Surface Soil[a] (0–1 ft bgs)	Subsurface Soil[b] (1–13 ft bgs)
Indeno(1,2,3-cd)pyrene	X	--
Naphthalene	X	X
Phenanthrene	X	X
Pyrene	X	X
Chloroform	X	--
4,4’-DDE	X	--
4,4’-DDT	X	--
PCB-1260	X	--

[a]Surface soil characterized using incremental sampling methodology sampling.
[b]Subsurface soil characterized using discrete sampling.
bgs = Below ground surface.
DDE = Dichlorodiphenyldichloroethylene.
DDT = Dichlorodiphenyltrichloroethane.
EU = Exposure unit.
ft = Feet.
PCB = Polychlorinated biphenyl.
SRC = Site-related contaminant.
X = Chemical is an SRC in this medium.
-- = Chemical is not an SRC in this medium.

Table 7–7. Summary of COPCs: Building F-15 EU

COPC	Surface Soil (0–1 ft bgs)[a]	Subsurface Soil (1–13 ft bgs)[b]
Inorganic Chemicals		
Arsenic	X	--
Chromium	X	--
Cobalt	X	X
Semi-volatile Organic Compounds		
Benz(a)anthracene	X	--
Benzo(a)pyrene	X	--
Benzo(b)fluoranthene	X	--
Dibenz(a,h)anthracene	X	--
Indeno(1,2,3-cd)pyrene	X	--

[a]Surface soil characterized using incremental sampling methodology sampling.
[b]Subsurface soil characterized using discrete sampling.
bgs = Below ground surface.
COPC = Chemical of potential concern.
EU = Exposure unit.
ft = Feet.
X = Chemical is an SRC in this medium.
-- = Chemical is not an SRC in this medium.

Table 7–8. Summary of COPCs: Building F-16 EU

COPC	Surface Soil (0–1 ft bgs)[a]	Subsurface Soil (1–13 ft bgs)[b]
Inorganic Chemicals		
Arsenic	X	X
Chromium	X	--
Cobalt	X	--
Semi-volatile Organic Compounds		
Benzo(a)pyrene	X	--

[a] Surface soil characterized using incremental sampling methodology sampling.

[b] Subsurface soil characterized using discrete sampling.

bgs = Below ground surface.
COPC = Chemical of potential concern.
EU = Exposure unit.
ft = Feet.
X = Chemical is an SRC in this medium.
-- = Chemical is not an SRC in this medium.

Table 7–9. FWCUGs Corresponding to an HQ of 1 and TR of 1E-05 for COPCs in Soil

COPC	Critical Effect or Target Organ	FWCUG (mg/kg) Resident (Adult and Child) HQ=1	FWCUG (mg/kg) Resident (Adult and Child) TR=1E-05
Arsenic	skin	20.2	4.25[c]
Chromium, hexavalent[b]	Stomach, liver/kidney	199	1,874
Chromium, trivalent	NOAEL	81,473	--
Cobalt	NS	1,313	8,030
Benz(a)anthracene	NA	--	2.21
Benzo(a)pyrene	NA	--	0.221
Benzo(b)fluoranthene	NA	--	2.21
Dibenz(a,h)anthracene	NA	--	0.221
Indeno(1,2,3-cd)pyrene	NA	--	2.21

[a] Resident FWCUGs are the smaller of the Adult or Child values for each COPC and endpoint (non-cancer and cancer).

[b] FWCUG for hexavalent chromium was calculated using a cancer unit risk factor developed for a chromate mixture consisting of 1/7 hexavalent chromium and 6/7 trivalent chromium.

[c] FWCUG value is less than the background screening values for arsenic in surface soil (15.4 mg/kg) and subsurface soil (19.8 mg/kg).

COPC = Chemical of potential concern.
FWCUG = Facility-wide cleanup goal.
HQ = Hazard quotient.
mg/kg = Milligrams per kilogram.
NA = Not applicable.
NOAEL = No observable adverse effect level.
NS = Not specified.
TR = Target risk.
-- = No FWCUG available.

Table 7–10. Total and Hexavalent Chromium Soil Sample Results

ISM Sample Results		Discrete Chromium Speciation Sample Results			
ISM Sample Location	**Total Chromium (mg/kg)**	**Discrete Sample Location[a]**	**Total Chromium (mg/kg)**	**Hexavalent Chromium (mg/kg)**	**Percent Hexavalent Chromium (%)**
F15ss-008M	19	F15ss-034	18.4	<1.2U	NA
F15ss-036M	16.5	F15ss-036	21.9	0.4J	1.8
F16ss-005M	38	F16ss-024	21	2.2	10.5
F16ss-007M	55	F16ss-025	21.4	0.4J	1.9
F16ss-026M	58.5	F16ss-026	16.1	<0.95U	NA
F16ss-027M	65.3	F16ss-027	19.1	<1U	NA

[a] Discrete sample location is located within the corresponding ISM sample location.
ISM = Incremental sampling methodology.
mg/kg = milligrams per kilogram
J = estimated concentration.
U = non-detectable concentration.
NA = Not applicable; hexavalent chromium not detected in sample.
< = Less than.

Table 7–11. Comparison of Surface Soil (0–1 ft bgs) Results for ISM and Discrete Samples at the Building F-15 EU

		ISM Sample Results		Discrete Sample Results		
Analyte (mg/kg)	**CAS Number**	**Freq. of Detect**	**Maximum Detect**	**Freq. of Detect**	**Maximum Detect**	**Maximum Detected Concentration in ISM or Discrete Sample**
Inorganic Chemicals						
Aluminum	7429-90-5	16/16	16000	3/3	15300	ISM
Antimony	7440-36-0	6/15	1.4	3/3	0.31	ISM
Arsenic	**7440-38-2**	**16/16**	**20**	**3/3**	**11.7**	**ISM**
Barium	7440-39-3	16/16	100	3/3	117	Discrete
Beryllium	7440-41-7	16/16	1.4	3/3	0.85	ISM
Cadmium	7440-43-9	6/16	1.03	3/3	0.23	ISM
Calcium	7440-70-2	16/16	29000	3/3	5970	ISM
Chromium	**7440-47-3**	**16/16**	**58.4**	**3/3**	**19.5**	**ISM**
Cobalt	**7440-48-4**	**16/16**	**12**	**3/3**	**10.8**	**ISM**
Copper	7440-50-8	16/16	38.4	3/3	18.6	ISM
Iron	7439-89-6	16/16	27900	3/3	28400	Discrete
Lead	7439-92-1	16/16	58	3/3	28.5	ISM
Magnesium	7439-95-4	16/16	6600	3/3	3430	ISM
Manganese	7439-96-5	16/16	870	3/3	804	ISM
Mercury	7439-97-6	16/16	0.072	3/3	0.048	ISM
Nickel	7440-02-0	16/16	55	3/3	21.6	ISM
Potassium	7440-09-7	16/16	2000	3/3	1070	ISM
Selenium	7782-49-2	8/16	1.3	3/3	1.4	Discrete
Silver	7440-22-4	3/15	0.043	1/3	0.035	ISM
Sodium	7440-23-5	16/16	430	3/3	65.5	ISM
Thallium	7440-28-0	7/16	0.59	3/3	0.19	ISM
Vanadium	7440-62-2	16/16	29	3/3	26.5	ISM
Zinc	7440-66-6	16/16	110	3/3	58.7	ISM

Table 7–11. Comparison of Surface Soil (0–1 ft bgs) Results for ISM and Discrete Samples at the Building F-15 EU (continued)

Analyte (mg/kg)	CAS Number	ISM Sample Results		Discrete Sample Results		Maximum Detected Concentration in ISM or Discrete Sample
		Freq. of Detect	Maximum Detect	Freq. of Detect	Maximum Detect	
Semi-Volatile Organic Compounds						
2-Methylnaphthalene	91-57-6	2/2	0.098	1/1	0.63	Discrete
Anthracene	120-12-7	3/6	0.13	1/3	0.02	ISM
Benz(a)anthracene	**56-55-3**	**5/6**	**0.49**	**2/3**	**0.066**	**ISM**
Benzo(a)pyrene	**50-32-8**	**5/6**	**0.48**	**2/3**	**0.18**	**ISM**
Benzo(b)fluoranthene	**205-99-2**	**4/6**	**0.69**	**2/3**	**0.088**	**ISM**
Benzo(ghi)perylene	191-24-2	4/6	0.33	1/3	0.016	ISM
Benzo(k)fluoranthene	207-08-9	4/6	0.26	2/3	0.13	ISM
Bis(2-ethylhexyl)phthalate	117-81-7	ND	ND	1/1	0.029	Discrete
Chrysene	218-01-9	5/6	0.54	2/3	0.092	ISM
Dibenzofuran	132-64-9	1/2	0.017	1/1	0.098	Discrete
Fluoranthene	206-44-0	5/6	1.2	2/3	0.093	ISM
Naphthalene	91-20-3	5/6	0.13	2/3	0.33	Discrete
Phenanthrene	85-01-8	5/6	0.71	2/3	0.18	ISM
Pyrene	129-00-0	5/6	0.85	2/3	0.11	ISM

bgs = Below ground surface
mg/kg = Milligrams per kilogram.
CAS = Chemical Abstract Service.
Freq. = Frequency.
ft = Feet.
ISM = Incremental sampling methodology.
ND = Not detected.
Bold = Chemical is a chemical of potential concern in either the discrete data set or the ISM data set.

Table 7–12. Comparison of Surface Soil (0–1 ft bgs) Results for ISM and Discrete Samples at the Building F-16 EU

Analyte (mg/kg)	CAS Number	ISM Sample Results		Discrete Sample Results		Maximum Detected Concentration in ISM or Discrete Sample
		Freq. of Detect	Maximum Detect	Freq. of Detect	Maximum Detect	
Inorganic Chemicals						
Aluminum	7429-90-5	11/11	16000	2/2	15800	ISM
Antimony	7440-36-0	6/11	1.5	2/2	0.53	ISM
Arsenic	**7440-38-2**	**11/11**	**18**	**2/2**	**31.3**	**Discrete**
Barium	7440-39-3	11/11	200	2/2	192	ISM
Beryllium	7440-41-7	11/11	2.9	2/2	2.6	ISM
Cadmium	7440-43-9	6/11	2.5	2/2	0.32	ISM
Calcium	7440-70-2	11/11	25000	2/2	58500	Discrete
Chromium	**7440-47-3**	**11/11**	**65.3**	**2/2**	**23.7**	**ISM**
Cobalt	**7440-48-4**	**11/11**	**12**	**2/2**	**15.7**	**Discrete**
Copper	7440-50-8	11/11	200	2/2	28.3	ISM
Iron	7439-89-6	11/11	29300	2/2	31900	Discrete
Lead	7439-92-1	11/11	120	2/2	40.8	ISM

Table 7–12. Comparison of Surface Soil (0–1 ft bgs) Results for ISM and Discrete Samples at the Building F-16 EU (continued)

Analyte (mg/kg)	CAS Number	ISM Sample Results		Discrete Sample Results		Maximum Detected Concentration in ISM or Discrete Sample
		Freq. of Detect	Maximum Detect	Freq. of Detect	Maximum Detect	
Inorganic Chemicals						
Magnesium	7439-95-4	11/11	4600	2/2	8940	Discrete
Manganese	**7439-96-5**	**11/11**	**1200**	**2/2**	**2140**	**Discrete**
Mercury	7439-97-6	10/11	0.05	2/2	0.081	Discrete
Nickel	7440-02-0	11/11	39.6	2/2	37	ISM
Potassium	7440-09-7	11/11	2100	2/2	1360	ISM
Selenium	7782-49-2	5/11	1.7	2/2	2.9	Discrete
Silver	7440-22-4	2/10	0.048	2/2	0.065	Discrete
Sodium	7440-23-5	11/11	710	2/2	390	ISM
Thallium	**7440-28-0**	**5/11**	**0.33**	**2/2**	**0.69**	**Discrete**
Vanadium	7440-62-2	11/11	26	2/2	26.3	Discrete
Zinc	7440-66-6	11/11	130	2/2	76.9	ISM
Explosives						
2,6-Dinitrotoluene	606-20-2	ND	ND	1/2	0.017	Discrete
Semi-Volatile Organic Compounds						
Acenaphthene	83-32-9	ND	ND	1/2	0.014	Discrete
Anthracene	120-12-7	2/4	0.053	2/2	0.057	Discrete
Benz(a)anthracene	56-55-3	4/5	0.14	2/2	0.16	Discrete
Benzo(a)pyrene	**50-32-8**	**4/5**	**0.11**	**2/2**	**0.17**	**Discrete**
Benzo(b)fluoranthene	**205-99-2**	**5/5**	**0.13**	**2/2**	**0.39**	**Discrete**
Benzo(ghi)perylene	191-24-2	3/4	0.095	2/2	0.16	Discrete
Benzo(k)fluoranthene	207-08-9	3/4	0.1	2/2	0.17	Discrete
Chrysene	218-01-9	5/5	0.2	2/2	0.29	Discrete
Fluoranthene	206-44-0	5/5	0.26	2/2	0.25	ISM
Fluorene	86-73-7	ND	ND	1/2	0.012	Discrete
Indeno(1,2,3-cd)pyrene	193-39-5	3/4	0.073	2/2	0.12	Discrete
Naphthalene	91-20-3	4/4	0.73	2/2	0.5	ISM
Phenanthrene	85-01-8	4/4	0.52	2/2	0.62	Discrete
Pyrene	129-00-0	5/5	0.3	2/2	0.24	ISM

bgs = Below ground surface
mg/kg = Milligrams per kilogram.
CAS = Chemical Abstract Service.
Freq. = Frequency.
ft = Feet.
ISM = Incremental sampling methodology.
ND = Not detected.
Bold = Chemical is a chemical of potential concern in either the discrete data set or the ISM data set.

Table 7–13. 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.
PAH = Polycyclic aromatic hydrocarbon.
RVAAP = Ravenna Army Ammunition Plant.

Table 7–14. Concentrations of Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, and Dibenz(a,h)anthracene in Soil from Various Environmental Studies

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

Table 7–14. Concentrations of Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, and Dibenz(a,h)anthracene in Soil from Various Environmental Studies (continued)

Study	Number of Samples	Geometric Mean or Median	Minimum	95th Percentile[a]	Maximum
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
NYSDEC Rural Distant Roads[f]	118	--	ND	--	0.23
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
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	--	0.23

[a] Lognormal 95th percentile value for all studies except New England value is 95% upper confidence limit and NYSDEC values are distribution-free 95th percentile.

[b] Data reported by Massachusetts Department of Environmental Protection (MADEP 2002) are from the following data sets:

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 data submitted by its members in 2001.

Water Town and Worcester Site-specific samples.

[c] Data from three New England locations from Bradley et al. 1994.

[d] Concentrations of polycyclic aromatic hydrocarbons (PAHs) in Illinois metropolitan statistical areas (urban) and non-metropolitan statistical areas (rural) as reported by Illinois Environmental Protection Agency (IEPA 2005).

[e] Data published by the Agency for Toxic Substances and Disease Registry (ATSDR) 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.

NYSDEC = New York State Department of Environmental Conservation.

-- = No value reported for this source.

Table 7–15. Summary of Historical COPECs per the Characterization of 14 AOCs

Group	COPEC	Shallow Soil	Sediment	Surface Water
Inorganic Chemicals	Arsenic	X	--	--
	Beryllium	--	Q	--
	Chromium	X	--	--
	Copper	X	--	--
	Iron	X	--	Q
	Lead	X	--	--
	Manganese	--	--	Q
	Mercury	X	--	--
	Selenium	X	--	--
	Zinc	X	--	--
Pesticides and PCBs	4,4’-DDT	X	--	--
	PCB-1260	X	--	--
VOCs	Acetone	--	--	Q
SVOCs	Carbazole	Q	--	--
	Dibenzofuran	Q	--	--
	Naphthalene	X	--	--
Explosives and Propellants	Nitroglycerin	Q	--	--
	Nitrocellulose	Q	--	--

Adapted from Table F-15/F-16-14 from the Characterization of 14 AOCs (MKM 2007).
AOC = Area of concern.
COPEC = Chemical of potential ecological concern.
PBT = Persistent, bioaccumulative, and toxic.
PCB = Polychlorinated biphenyl.
SVOC = Semi-volatile organic compound.
VOC = Volatile organic compound.
-- = Chemical not identified as a COPEC.
Q = Qualitative COPEC; persistent, bioaccumulative, and toxic chemical or no ecological screening value (ESV).
X = Quantitative COPEC, exceeds ESV.

Table 7–16. Summary of Integrated COPEC Concentrations for Surface Soil at and Near the Wetland in the Southeastern Corner of the Building F-15 EU

COPEC	Background Concentration (mg/kg)	ESV (mg/kg)	F15Sss-011M-SO (mg/kg)	F15ss-037M-5429-SO (mg/kg)	F15sb-031-5405-SO (mg/kg)
Arsenic	15.4	18	20	10.1	11.7
Cadmium	0	0.36	0.21	0.41	0.12
Chromium	17.4	26	24	19.4	16.6
Copper	17.7	28	24	14.4	11.7
Lead	26.1	11	58	18	15.5
Mercury	0.036	0.00051	0.05	0.05	0.044
Nickel	21.1	38	19	54.4	17.3
Zinc	61.8	46	100	49	42.6
Nitrocellulose	No BKG	No ESV	NR	NR	NR
Dibenzofuran	No BKG	No ESV	NR	NR	0.098
Naphthalene	No BKG	0.0994	NR	0.043	0.33

Background concentrations are the concentrations for 0–1 ft bgs from final facility-wide background concentrations for Camp Ravenna, published in the Final Phase II Remedial Investigation Report for Winklepeck Burning Grounds at Ravenna Army Ammunition Plant, Ravenna, Ohio (USACE 2001b).
COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
EU = Exposure unit.
mg/kg = Milligrams per kilogram.
NR = Not reported.
No BKG = A background concentration does not exist for the specified chemical.

Table 7–17. Survey of Proximity to the AOC of Various Ecological Resources

Natural Resource	Natural Resources Inside Habitat Area	Proximity Within or Near the AOC	Distances from the AOC to Nearest Resource [a]
Wetlands (Planning Level Survey and Jurisdictional)	A small portion (0.06 acres) of a 0.69-acre low quality wetland (Category 1) along the eastern boundary of the Building F-15 EU	Small wetlands along the eastern border of the Building F-15 EU, south of the Building F-15 EU, and south of the Building F-16 EU. Several wetland complexes located east and north of the AOC	Other wetlands in vicinity (Figure 7-2)
Rare species	No known sightings	None	Nearest occurrence 900 ft west of AOC. Additional rare species occur 1,300 ft and 1,800 ft west of the AOC. See text for species names
Beaver dams	None	None	Nearest beaver dam located about 1,200 ft south
100-year floodplain	None	None	Nearest about 4,400 ft south
Stream sampling[b]	None	None	Nearest stream sampling location is approximately 4,000 ft southwest (downstream) of the AOC
Pond sampling[b]	None	None	Nearest pond station is at Reference Pond No. 2 (RT 80 Trout Pond) about 8,000 ft west-southwest

[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 the biological and surface water study performed by the Ohio Environmental Protection Agency and U.S. Army Corps of Engineers Louisville and presented in the *Facility-wide Biological and Water Quality Study 2003* (USACE 2005b).

AOC = Area of concern.
EU = Exposure unit.
ft = Feet.

Table 7–18. Summary of Integrated COPECs for Surface Soil at the Building F-15 EU

COPEC	Maximum Concentration (mg/kg)	ESV (mg/kg)	Ratio of Maximum to ESV	Comments
Antimony	1.4	0.27	5.2	None
Arsenic	20	18	1.1	None
Cadmium	1.03	0.36	2.9	None
Chromium	58.4	26	2.25	None
Copper	38.4	28	1.4	None
Lead	58	11	5.3	None
Mercury	0.072	0.00051	141.2	PBT compound
Nickel	55	38	1.5	None
Zinc	110	46	2.4	None
Nitrocellulose	0.93	No ESV	--	No ESV
Dibenzofuran	0.017	No ESV	--	No ESV
Naphthalene	0.13	0.0994	1.3	None

Table excludes nutrients.
COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
EU = Exposure unit.
mg/kg = Milligrams per kilogram.
PBT = Persistent, bioaccumulative, and toxic.

Table 7–19. Summary of Integrated COPECs for Surface Soil at the Building F-16 EU

COPEC	Maximum Concentration (mg/kg)	ESV (mg/kg)	Ratio of Maximum to ESV	Comments
Antimony	1.5	0.27	5.6	None
Cadmium	2.5	0.36	6.9	None
Chromium	65.3	26	2.5	None
Copper	200	28	7.1	None
Lead	120	11	10.9	None
Mercury	0.05	0.00051	98.0	PBT compound
Nickel	39.6	38	1.04	None
Selenium	1.7	0.52	3.3	None
Zinc	130	46	2.8	None
Nitrocellulose	2.1	No ESV	--	No ESV
Nitroglycerin	0.52	No ESV	--	No ESV
Carbazole	0.038	No ESV	--	No ESV
Dibenzofuran	0.26	No ESV	--	No ESV
Naphthalene	0.73	0.0994	7.3	None
4,4’-DDE	0.012	0.021	0.57	PBT compound
4,4’-DDT	0.019	0.021	0.90	PBT compound
PCB-1260	0.12	No ESV	--	No ESV, PBT compound

Table excludes nutrients.
COPEC = Chemical of potential ecological concern.
DDE = Dichlorodiphenyldichloroethylene.
DDT = Dichlorodiphenyltrichloroethane.
ESV = Ecological screening value.
EU = Exposure unit.
mg/kg = Milligrams per kilogram.
PCB = Polychlorinated biphenyl.
PBT = Persistent, bioaccumulative, and toxic.

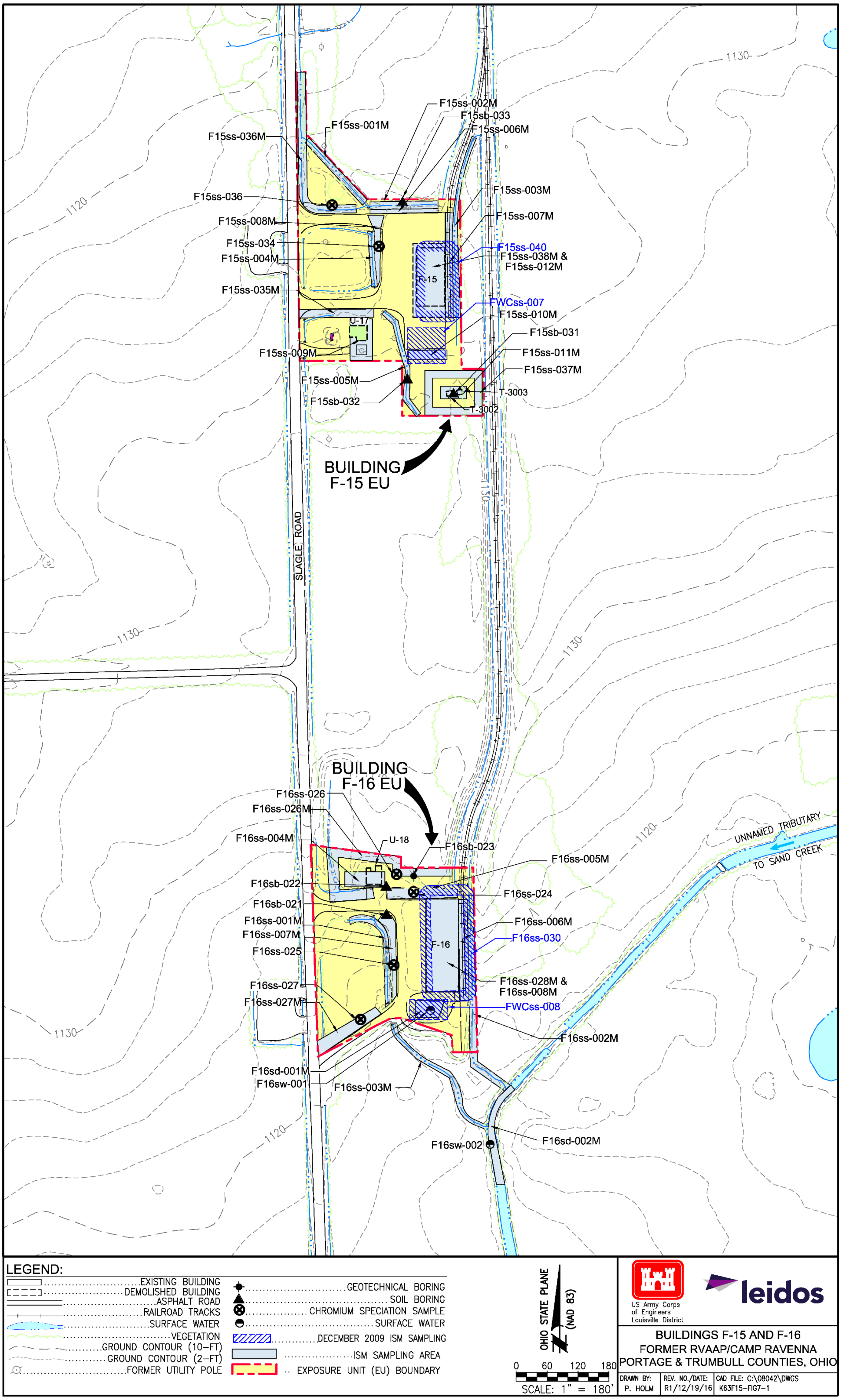

Figure 7–1. Buildings F-15 and F-16 Exposure Units

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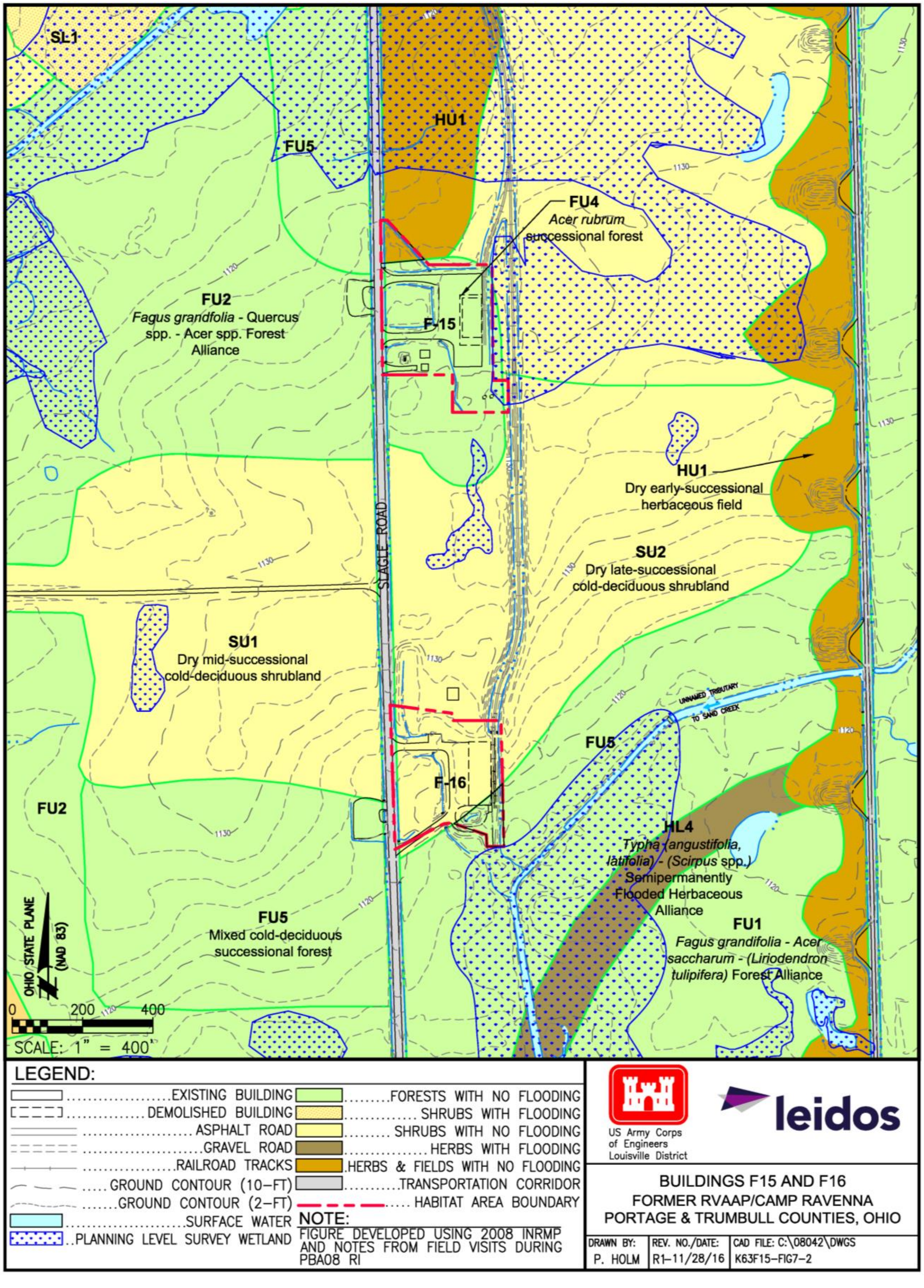

Figure 7–2. Natural Resources Inside the Habitat Area

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8.0 REMEDIAL INVESTIGATION CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

The RI Report for the Buildings F-15 and F-16 AOC 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, contaminant fate and transport modeling, and human health and ecological risk assessments. An updated CSM incorporating all available information is 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 if COCs occur that may require further evaluation in an FS. This section concludes with recommendations with respect to the need for any further characterization under the RI phase of work and, for each of the media evaluated in the RI, whether to proceed to the FS phase of the RI/FS process.

8.2 SUMMARY OF DATA USED IN THE REMEDIAL INVESTIGATION

Available quality-assured data for the Buildings F-15 and F-16 AOC represent conditions of the AOC over a span of approximately seven years and were collected using ISM and discrete sampling methods. PBA08 RI quality-assured sample data were collected for the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, 2009 USACE ISM Surface Soil Sampling, and 2010 PBA08 RIs. Physical conditions at the AOC, particularly around the former buildings, changed during the intervening time between sampling for the 2004 Characterization of 14 AOCs and 2010 PBA08 RI due to building demolition and floor slab/footer removal activities completed in several phases between 2007 and 2009.

A systematic process was used to evaluate data usability for this report based on project DQOs, data age and representativeness with respect to current AOC conditions, and sampling methods. The data usability evaluation included a particular focus on whether samples from the Characterization of 14 AOCs were representative of current conditions due to factors such as soil disturbance or removal during building demolition and re-grading of construction areas following demolition. Section 4.4.4 presents the results of the data usability evaluation for all available samples. All data collected during the above-referenced investigations were deemed usable for this report; however, use of certain samples was limited to the nature and extent evaluation, analysis of temporal trends, and/or fate and transport evaluation, and these samples were not included in quantitative data screening or risk assessment calculations.

Samples from the 2004 Characterization of 14 AOCs, 2009 Under Slab Sampling, and 2009 USACE ISM Surface Soil Sampling data sets were evaluated to determine if conditions had changed substantively between earlier characterization efforts and the 2010 PBA08 RI, as building demolition activities occurred in 2007–2009. The samples collected in 2004 were collected within ditch lines adjacent to former buildings and in areas encompassing, but also extending substantially beyond the footprint of the former buildings. The 2009 Under Slab Sampling was conducted within the footprints of the demolished buildings, following slab removal and exposure of the underlying surface soil.

Therefore, both of these data sets were considered representative of current conditions within and surrounding the footprints of the former buildings. No samples from the 2004 and 2009 data sets were eliminated from the SRC screening process.

Data collected as part of the PBA08 RI focused on delineating the extent of contaminants identified in surface soil (0–1 ft bgs) during prior investigations and characterizing subsurface soil (1–13 ft bgs) (not previously sampled). Since ISM was used for surface soil (0–1 ft bgs) as part of the 2004 Characterization of 14 AOCs, ISM was also used for surface soil sampling during the PBA08 RI. 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 were analyzed for chemicals identified in historical investigations. In addition to analyses of chemicals identified in historical investigations, select samples were analyzed for the "RVAAP full suite" as part of the QA/QC protocol.

8.3 SUMMARY OF NATURE AND EXTENT

Section 5.0 provides a detailed presentation of available investigation data for the AOC, an evaluation of the usability of those data, screening for SRCs, and an evaluation of contaminant nature and extent. The media of concern are surface soil (0–1 ft bgs) and subsurface soil (1–13 ft bgs). Perennial surface water and corresponding sediment are not present at the AOC. However, off-AOC samples in an unnamed tributary to Sand Creek and an intermittent pond south of Building F-16 are included in the nature and extent of contamination evaluation. A summary of the findings is presented in the following sections.

8.3.1 Soil

8.3.1.1 <u>Building F-15 Aggregate</u>

No explosives were detected at Building F-15 in surface or subsurface soil samples. One propellant (nitrocellulose) was detected in one ISM surface soil sample (F15ss-006M) at a concentration below the SL. No propellants were detected in subsurface soil samples at Building F-15. Arsenic and cobalt were the only two inorganic chemicals to exceed their background concentrations and FWCUGs of HQ of 0.1 or TR of 1E-06 in surface soil. No propellants were detected in subsurface soil samples at Building F-15. Arsenic exceeded the background concentration of 15.4 mg/kg in two of the 2004 Characterization of 14 AOCs ISM surface samples collected to evaluate the ditch to the southwest (F15ss-005M) and former buildings T-3002 and T-3003 (F15ss-011M) and was not detected above background in subsurface soil samples.

One location (F15ss-036M at 0.48 mg/kg) slightly exceeded the benzo(a)pyrene Resident Receptor (Adult and Child) FWCUG at a TR of 1E-05, HQ of 1 (0.221 mg/kg). Sample location F15ss-036M was collected as an ISM surface soil sample during the PBA08 RI from a ditch along Slagle Road northwest of Building F-15. PAHs were not detected in any subsurface soil samples at Building F-15. PAH concentrations detected across the entire AOC were generally higher in samples taken from low-lying areas and ditches bordering Slagle Road and parking areas. PAHs were identified as potential contaminants from previous site use at Buildings U-17 that were formerly used as a coal-powered boiler house; however, concentrations in surface soil at this former building location were less than SLs.

Historical records indicated three transformers serviced all buildings at the AOC. PCBs were not detected in surface or subsurface soil at Building F-15. Furthermore, VOCs and pesticides were not detected in surface or subsurface soil at Building F-15, which is consistent with the historical record that shows they were not previously used at the AOC.

8.3.1.2 Building F-16 Aggregate

No explosives were detected at Building F-16 in ISM surface or discrete subsurface soil samples. One explosive, 2,6-DNT, was detected below its SL in the discrete surface soil sample taken at F16sb-021. Two propellants (nitrocellulose and nitroglycerin) were detected in two ISM surface soil samples (F16ss-026M and F16ss-005M) collected from ditches located at the northern end of Building F-16 at concentrations below their respective SLs; therefore, nitrocellulose and nitroglycerin were not considered COPCs. No propellants were detected in subsurface soil samples at Building F-16.

Arsenic, cobalt, manganese, and thallium were the only four inorganic chemicals to exceed their background concentration and FWCUGs of HQ of 0.1 or TR of 1E-06 in surface soil. Cobalt and thallium did not exceed the FWCUGs of HQ of 1 or TR of 1E-05 and were not detected in subsurface soil samples. Arsenic exceeded the background concentration of 15.4 mg/kg in the 2004 Characterization of 14 AOCs ISM surface sample F16ss-004M (18 mg/kg) collected to evaluate the ditch north of former Building F-15 and in PBA08 RI sample location F16sb-021 (31.3 mg/kg) collected from a discrete boring installed in the ditch west of former Building F-16. Arsenic exceeded the background concentration of 19.8 mg/kg in subsurface soil at F16sb-021 (24.3J mg/kg from 4–7 ft bgs). Evaluation of the vertical extent at F16sb-021 indicated a potential decreasing concentration profile of 24.3J mg/kg from 4–7 ft bgs and 11.3J mg/kg from 7–13 ft bgs. Manganese was detected above the background concentration (1,450 mg/kg) and FWCUG at a TR of 1E-05, HQ of 1 (2,927 mg/kg) in only one of the two discrete surface soil samples with a concentration of 2,140 mg/kg at PBA08 RI location F16sb-022. All subsurface samples collected at these locations had concentrations of manganese below the SL.

Benzo(a)pyrene and benzo(b)fluoranthene, the only PAHs detected above their SLs, were detected below the FWCUG at a TR of 1E-05, HQ of 1 in all surface soil samples at Building F-16. PAHs were not detected in subsurface soil samples. PAHs were identified as potential contaminants from previous site use at Building U-18 which was formerly used as a coal-powered boiler house; however, concentrations in surface soil at this former building location were less than SLs.

Although no previous use of VOCs or pesticides were documented at Building F-16, chloroform was detected at PBA08 RI surface sample location F16ss-026M at a concentration of 0.00068J mg/kg. Pesticides (4,4’-DDE and 4,4’-DDT) were also detected in one of two surface samples in the RI data set at 2004 Characterization of 14 AOCs ISM sample F16ss-005M at a concentration of 0.012J and 0.019J mg/kg, respectively. Historical records indicated three transformers serviced all buildings at the AOC. PCB-1260 was detected in surface soil at F16ss-005M at a concentration of 0.12 mg/kg. No

VOCs, PCBs, or pesticides were detected in subsurface soil samples collected at Building F-16. Also, the detected VOC, pesticide, and PCB concentrations in surface soil were all below the FWCUGs at a TR of 1E-05, HQ of 1.

8.3.2 Sediment and Surface Water

Sediment and surface water are not considered media of concern at the Buildings F-15 and F-16 AOC, as surface water is only intermittent at the AOC. However, during the 2004 Characterization of 14 AOCs, two ISM sediment samples (F16sd-001M-SD and F16sd-002M-SD) and two surface water samples (F16sw-001 and F16sw-002) were collected.

Sediment sample F16sd-001M-SD was collected from the former coal storage area immediately south of former Building F-16. Sample FWCss-008-0001-SO was collected by USACE in 2009 in that same area. The more recent sample (FWCss-008-0001-SO) is used in the risk assessment.

The results from the 2004 sample F16sd-001M-SD are summarized below.

- Only explosives and metals analyses were performed.
- No explosives were detected.
- No metal concentrations exceeded the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 1 or TR of 1E-05.

Sediment sample F16sd-002M-SD was collected downstream of the Building F-16 aggregate in the unnamed tributary to Sand Creek. The results of this sample are summarized below.

- Only explosives and metals analyses were performed.
- No explosives were detected.
- Cobalt at a concentration of 11 mg/kg was the only metal that exceeded the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 0.1 (2.3 mg/kg) but not at HQ of 1 (23 mg/kg).

Surface water sample F16sw-002 was collected downstream of the Building F-16 aggregate in the unnamed tributary to Sand Creek. All the concentrations from this sample were below their background concentration or the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 1 or TR of 1E-05.

Surface water sample F16sw-001 was collected from the former coal storage area immediately south of former Building F-16. Effectively, this was a sample from accumulated, ponded water. The metal, SVOC, VOC, PCB, and pesticide concentrations were either non-detectable or had a concentration below the lowest FWCUG for the Resident Receptor (Adult and Child) and National Guard Trainee at a target HQ of 1 or TR of 1E-05. Nitroglycerin at 0.0021 mg/L exceeded the tap water RSL of 0.0002 mg/L at HQ of 0.1 and 0.002 mg/kg at HQ of 1.

8.4 SUMMARY OF CONTAMINANT FATE AND TRANSPORT

All SRCs identified in surface and subsurface soil at the AOC were evaluated through the stepwise contaminant fate and transport evaluation. The evaluation included analyzing leaching and migration from soil to groundwater and determining whether contamination present in soil 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 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.

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

- Naphthalene at the Building F-15 aggregate, and nitroglycerin and selenium at the Building F-16 aggregate were predicted to exceed the screening criteria in groundwater beneath the source area; however, only naphthalene was predicted to be above its groundwater screening criteria at the downgradient receptor location (i.e., unnamed tributary to Sand Creek).

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 at the AOC 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 that may impact the groundwater beneath the source or at the downstream receptor location. No further action is required of soil at Buildings F-15 and F-16 AOC 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 (Adult and Child). Since the risk management analysis determined there were no unacceptable risks to the Resident Receptor (Adult and Child), it can be concluded that there is no unacceptable risk to the National Guard Trainee and Industrial Receptor.

Media of concern at the Buildings F-15 and F-16 AOC are surface and subsurface soil. Perennial surface water and corresponding sediment are not present at the AOC. However, off-AOC samples in an unnamed tributary to Sand Creek and an intermittent pond south of Building F-16 are included in the nature and extent of contamination evaluation. Soil data associated with the AOC were aggregated into surface and subsurface soil. In addition, soil data were aggregated into two EUs (Buildings F-15 EU and Building F-16 EU).

No COCs were identified for the Resident Receptor (Adult and Child) in subsurface soil at the Building F-15 EU and surface soil at Building F-16 EU. PAHs in surface soil at the Building F-15 EU and arsenic in the subsurface soil at the Building F-16 EU were identified as COCs for the Resident Receptor (Adult and Child).

Four PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene] were identified as surface soil COCs for the Resident Receptor (Adult and Child). Benzo(a)pyrene (0.48 mg/kg) is present in one sample (F15ss-036M) above the FWCUG (0.221 mg/kg) and benz(a)anthracene, benzo(b)fluoranthene, and dibenz(a,h)anthracene contribute to an SOR greater than one in the same sample. The F15ss-036M ISM area is approximately 0.012 acres and was located within a ditch northwest of former Building F-15 and immediately adjacent to Slagle Road and an unnamed access road. The ditch where F15ss-036M was collected would have received runoff from the adjacent roads, as well as the asphalt parking lots surrounding the former Building F-15. No PAHs were detected at PBA08 RI ISM sample F15ss-038M collected in the footprint of former Building F-15 after slab removal was conducted. Due to the low concentrations of PAHs reported in F15ss-036M collected from an area with no identified source of PAHs other than roads and traffic, PAHs were not identified as COCs for potential remediation at the Building F-15 EU.

The arsenic EPC (23.1 mg/kg) exceeded the FWCUG (4.25 mg/kg) and subsurface background criteria of 19.8 mg/kg in subsurface soil at the Building F-16 EU. Only the MDC in subsurface soil (24.3 mg/kg in the 4–7 ft bgs interval of soil boring F16sb-021) exceeded the background criteria. Reported concentrations in F16sb-021 above (1–4 ft bgs) and below (7–13 ft bgs) the MDC did not exceed the subsurface background criteria (13.7 and 11.3 mg/kg, respectively). Regional studies indicate arsenic may be naturally occurring in Ohio soils at greater than 20 mg/kg. Arsenic appears to be present at the Building F-16 EU at naturally occurring concentrations and there is no known operational source of arsenic at the Buildings F-15 and F-16 AOC. Based on this evaluation, arsenic was not identified as a COC for potential remediation in subsurface soil.

Based on the risk management analysis, no COCs were identified to be carried forth in an FS for the Resident Receptor (Adult and Child) in any of the media of concern at either the Building F-15 EU or the Building F-16 EU; therefore, no other receptors were evaluated and no further action is recommended from a human health risk perspective.

8.6 SUMMARY AND CONCLUSIONS OF THE ECOLOGICAL RISK ASSESSMENT

The Buildings F-15 and F-16 AOC is approximately 5.3 acres and is vegetated with dry, early-successional, herbaceous field; dry, late-successional, cold-deciduous shrubland; red maple (*Acer rubrum*) successional forest; mixed, cold-deciduous, successional forest; and a wetland. The Level I ERA presents important ecological resources on or near the AOC and evaluates the potential for current contamination to impact ecological resources. There are 18 integrated soil COPECs at the Buildings F-15 and F-16 AOC based on the soil data collected for the historical ERA and for the PBA08 RI. These COPECs consist of inorganic chemicals, explosives, PCBs, pesticides, and SVOCs. Thus, there is contamination present at the AOC.

Ecological resources at the Buildings F-15 and F-16 AOC were compared to the list of important ecological places and resources. Only 1 of the 39 important places (wetlands) was present. Although the wetland is an important resource, it is not a significant resource, as soil sampling results in and around the wetland do not indicate chemicals are present at concentrations of concern for ecological receptors.

The ERA summarizes the chemicals and resources in detail to demonstrate that there is contamination at the Buildings F-15 and F-16 AOC, but no significant ecological resources are present. Consequently, the ERA for the Buildings F-15 and F-16 AOC concludes with a Level I Scoping Level Risk Assessment and a recommendation that no further action is required to be protective of ecological resources.

8.7 UPDATED CONCEPTUAL SITE MODEL

The CSM is presented in this section to incorporate results of this RI. Elements of the CSM include:

- Primary and secondary contaminant sources and release mechanisms,
- Contaminant migration pathways and discharge or exit points,
- Potential receptors of risk, and
- Data gaps and uncertainties.

The following sections describe each of the CSM elements for the Buildings F-15 and F-16 AOC. 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 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. All buildings were demolished from 2007–2009 with the exception of Building U-17. Demolition included removing all slabs and foundations. Although Building U-17 currently exists at the AOC, the building is not considered a primary contaminant source. 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. The highest number of inorganic SRCs above background concentrations at an individual sample location near former Building F-15 occurred at PBA08 RI sample F15ss-035M, located in a ditch line south of an access road connecting Slagle Road to the Building F-15 parking lot. For areas proximate to former Building F-16, the highest number of inorganic SRCs above background concentrations and the greatest number detected at their maximum concentration was observed at historical sample location F16ss-007M, located west of the former Building F-16 and in the ditch line immediately adjacent to the parking lot in front of the building.

Perennial surface water and corresponding sediment are not present at the AOC. However, off-AOC samples in an unnamed tributary to Sand Creek and an intermittent pond south of Building F-16 are included in the nature and extent of contamination evaluation. The historical surface water samples collected did not indicate that contaminant transport beyond the boundaries of the AOC is occurring in sediment or surface water.

The primary mechanisms for release of chemicals from secondary sources at the AOC are:

- Eroding soil matrices with sorbed chemicals and mobilization in overland surface water storm runoff during heavy rainfall conditions;
- Dissolving soluble chemicals and transport in perennial surface water conveyances and intermittent surface water runoff; and
- Contaminant leaching to groundwater.

8.7.2 Contaminant Migration Pathways and Exit Points

8.7.2.1 Surface Water Pathways

Chemicals migrate from soil sources via surface water occurs primarily by particle-bound chemicals moving through surface water runoff and dissolved chemicals being transported in surface water. In the case of particle-bound contaminant migration, chemicals will be mobilized during periods of high flow (e.g., rain events) and upon reaching portions of surface water conveyances where flow velocities decrease, they will settle out as sediment accumulation. Sediment-bound chemicals may become re-suspended and migrate during storm events or may partition to a dissolved phase in surface water. The ditches surrounding the AOC are predominantly dry but may transport water during periods of heavy rain.

In the case of dissolved phase contaminant transport, migration patterns typically reflect a combination of continuous baseflow inputs with superimposed episodic cycles in association with rain events, snow melt, or seasonal precipitation patterns. Such episodic events may temporarily increase dissolved phase contaminant concentrations depending on the source and solubility of SRCs, or they may serve to dilute and decrease contaminant concentrations if a large influx of comparatively non-contaminated water occurs associated with longitudinal concentration trends may vary depending on the amount of partitioning. As noted in Section 3.4.3, intermittent surface water from a majority of the AOC flows along various small drainage ditches and exits the AOC at the unnamed tributary to Sand Creek, south of the AOC.

8.7.2.2 Groundwater Pathways

The estimated direction of groundwater flow at the AOC is to the southeast toward an unnamed tributary to Sand Creek based on RVAAP facility-wide potentiometric data presented in the Facility-wide Groundwater Monitoring Program Report on the January 2010 Sampling Event (EQM 2010). Surface runoff from the Building F-15 aggregate flows overland to the northwest to a tributary to Eagle Creek, whereas surface runoff from the Building F-16 aggregate flows overland to the southeast to an unnamed tributary to Sand Creek. Groundwater discharge to surface water features (e.g., via base flow to streams or springs) occurs near the AOC boundaries. The closest potential groundwater discharge location is an unnamed tributary to Sand Creek located along southeastern AOC boundary.

Although the FWGWMP was initiated in 2005 and involves quarterly sampling of selected wells within the former RVAAP, no monitoring wells were installed at this AOC and therefore no groundwater data is available from this AOC.

Contaminant leaching pathways from soil to the water table are through silty loam unconsolidated soil. Conservative transport modeling indicated naphthalene at the Building F-15 aggregate, and selenium, nitroglycerin, and naphthalene at the Building F-16 aggregate may leach from soil; however, only naphthalene from Building F-16 aggregate is predicted to migrate laterally and reach the nearest surface water receptor (unnamed tributary to Sand Creek located along the southeastern boundary of Building F-16) at a concentration exceeding its RSL. Because there is no groundwater monitoring well at this AOC, it could not be verified whether naphthalene is already in groundwater or not; however the model-predicted concentrations of naphthalene are highly conservative (as they were simulated without using any biodegradation of naphthalene). A qualitative assessment of the predicted results was performed and the limitations and assumptions of the models were considered to identify if any CMCOCs are present in soil that may potentially impact groundwater beneath the source. 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.

8.7.3 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, 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 did not identify Resident Receptor COCs to be carried forward for potential remediation; therefore, Buildings F-15 and F-16 are considered protective for all potential human health 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. 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. Although there are important ecological resources (one wetland) at the AOC, this resource is not a significant ecological resource, as contaminants are not present at levels of ecological concern in the wetland given the surrounding surface soil ISM concentrations and site topography. Thus, there are no significant ecological resources at the Buildings F-15 and F-16 habitat, according to the Army and Ohio EPA lists of important places and resources.

8.7.4 Uncertainties

Uncertainties are inherent in the CSM depending on the density and availability of data. The CSM for the Buildings F-15 and F-16 AOC is overall well defined using existing data, and major data gaps do not remain to be resolved. However, some uncertainties for the CSM include:

- Surface water characterization within the drainage ditches on the AOC is subject to some uncertainty due to the intermittent occurrence of surface water originating within the AOC during precipitation events. Surface water discharge from the AOC is generally via ditches.
- 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.
- No groundwater wells are present at the AOC.
- While this RI addresses soil, sediment, and surface water, additional ongoing investigations are being conducted for the Facility-wide Groundwater AOC.

8.8 RECOMMENDATION OF THE REMEDIAL INVESTIGATION

Based on the investigation results, the Buildings F-15 and F-16 AOC has been adequately characterized and the recommended path forward is no further action for soil, sediment, and surface water to attain Unrestricted (Residential) Land Use. Further investigation is not warranted at this AOC for the following reasons: (1) the current nature and extent of impacted media has been sufficiently characterized; (2) the fate and transport modeling did not identify soil CMCOCs requiring further evaluation or remediation to protect groundwater; (3) there are no CERCLA release-related human health COCs identified in soil, sediment, or surface water requiring further evaluation in an FS or additional remediation; and (4) remedial actions to protect ecological resources are not warranted.

The next step in the CERCLA process is to prepare a PP to solicit public input with respect to no further action for soil, sediment, and surface water. The PP will briefly summarize the history, characteristics, risks, and the basis for no further action. Comments on the PP received from state and federal agencies and 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.

9.0 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 the Buildings F-15 and F-16 AOC. 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 AOC environmental investigation, restoration efforts, and the recommendation of no further action for these media.

9.1 STATE ACCEPTANCE

State acceptance considers comments received from agencies of the state of Ohio on the recommendation for no further action. Ohio EPA is the lead regulatory agency for supporting decisions regarding the AOC. This RI Report has been prepared in consultation with the Ohio EPA.

Ohio EPA has provided input during the ongoing investigation and report development to ensure the recommendation for the Buildings F-15 and F-16 AOC meets the needs of the state of Ohio and fulfills the requirements of the DFFO (Ohio EPA 2004). Ohio EPA provided comments on this RI Report and will provide comments on the subsequent PP and ROD. The Army will obtain Ohio EPA concurrence prior to the final selection and decision for soil, sediment, and surface water at the AOC.

9.2 COMMUNITY ACCEPTANCE

Community acceptance considers comments provided by community members. CERCLA 42 U.S.C. 9617(a) emphasizes early, constant, and responsive community relations. The Army has prepared a *Community Relations Plan 2016 for the Ravenna Army Ammunition Plant Restoration Program* (Vista 2016) 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. Code 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, RVAAP has 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 Report and the PP. As required by the CERCLA regulatory process and the Community Relations Plan (Vista 2016), the Army will hold a public meeting and request public comments on the PP for the Buildings F-15 and F-16 AOC. These comments will be considered prior to the final selection of no further action. Responses to these comments will be addressed in the responsiveness summary of the ROD.

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