

FINAL

**PHASE II REMEDIAL
INVESTIGATION REPORT**

FOR THE

**LOAD LINE 1 AT THE RAVENNA ARMY
AMMUNITION PLANT, RAVENNA, OHIO**

VOLUME 1—MAIN TEXT

PREPARED FOR



**US Army Corps
of Engineers®**

**U.S. Army Corps of Engineers – Louisville District
Contract No. DACA62-00-D-0001
Delivery Order CY09**

June 2003



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Prepared by

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SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

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

CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

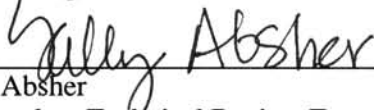
Science Applications International Corporation (SAIC) has completed the Final Remedial Investigation Report for Load Line 1 at the Ravenna Army Ammunition Plant, Ravenna, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and 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 Corps policy.



Kevin Jago
Study/Design Team Leader

6-11-03

Date



Sally Absher
Independent Technical Review Team Leader

6-11-03

Date

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

Resolution of comments on the draft final are documented on a comment response table appended to this report. Changes to the report addressing the comments have been verified by the Independent Technical Review Team Leader and documented on a Document Review Record per SAIC quality assurance procedure QAAP 3.1.

As noted above, all concerns resulting from independent technical review of the project have been considered.



Principal w/ A-E firm

6/11/03

Date

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ACRONYMS

AA	atomic absorption
AAP	Army Ammunition Plant
ADD	average daily dose
ALM	Interim Adult Lead Methodology
amsl	above mean sea level
AOC	area of concern
AT123D	Analytical Transient 1-, 2-, 3-Dimensional (model)
AUF	area use factor
BAF	bioaccumulation factor
BCF	bioconcentration factor
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
BSAF	biota to sediment accumulation factor
CAR	corrective action report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMCOPC	contaminant migration constituent of potential concern
CNS	central nervous system
COC	chain-of-custody
COC	chemical of concern
COPC	chemical of potential concern
cPAH	Polycyclic Aromatic Hydrocarbon
CQAR	Chemical Quality Assessment Report
CRF	Central Records Facility
CRREL	Cold Regions Research and Engineering Laboratory
CSF	Cancer Slope Factor
CSM	conceptual site model
CX	Center of Excellence
DAD	dermally absorbed dose
DAF	dilution attenuation factor
DER	duplicate error ratio
DNB	dinitrobenzene
DNT	dinitrotoluene
DoD	U.S. Department of Defense
DQA	data quality assessment
DQCR	Daily Quality Control Report
DQO	data quality objective
EBG	Erie Burning Ground
Eh	oxidation-reduction potential
EKG	electrocardiogram
EPA	U. S. Environmental Protection Agency
EPC	exposure point concentration
ERA	Ecological Risk Assessment
ESV	ecological screening value
EU	exposure unit
FCO	field change order
FS	Feasibility Study
GAF	gastrointestinal absorption factor
GOCO	government-owned, contractor-operated

GPS	geopositioning system
GSSL	generic soil screening level
HI	hazard index
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HPLC	High Pressure Liquid Chromatography
HQ	hazard quotient
HSA	hollow-stem auger
ICP	inductively coupled plasma
ILCR	Incremental Lifetime Cancer Risk
IOC	Industrial Operations Command
IR	U. S. Army Industrial Readiness Command
IRP	Installation Restoration Program
LCS	laboratory control standard
LL	Load Line
LOAEL	lowest-observed-adverse-effect level
M&TE	Measuring and Testing Equipment
MCL	maximum contaminant limit
MOA	Memorandum of Agreement
MPR	Monthly Progress Report
MRD	Missouri River Division
MS	matrix spike
MSD	matrix spike duplicate
NAVD88	National American Vertical Datum of 1988
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCR	Nonconformance Report
NOAEL	no-observed-adverse-effect level
NPL	National Priorities List
ODNR	Ohio Department of Natural Resources
OE	ordnance and explosive
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
ONG	Ohio National Guard
OSC	U. S. Army Operations Support Command
OVA	organic vapor analyzer
PA	Preliminary Assessment
PAH	polynuclear aromatic hydrocarbon
PBT	persistent, bioaccumulative, and toxic
PCB	polychlorinated biphenyl
PETN	pentaerythritol tetranitrate
PID	photoionization detector
PM	Project Manager
PRG	preliminary remediation goals
PVC	polyvinyl chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QCSR	Quality Control Summary Report
RAGS	Risk Assessment Guidance for Superfund
RBC	risk-based concentration
RDA	recommended daily allowance
RDI	recommended daily intake

RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RfC	reference concentration
RfD	reference dose
RGO	remedial goal option
RI	Remedial Investigation
RME	reasonable maximum exposure
RPD	relative percent difference
RRSE	Relative Risk Site Evaluation
RTLS	Ravenna Training and Logistics Site
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SDG	sample delivery group
SERA	Screening Ecological Risk Assessment
SOW	Statement of Work
SRC	site-related contaminant
SSL	Soil Screening Level
STL	Severn Trent Laboratories
SVOC	semivolatile organic compound
TAL	Target Analyte List
TCE	trichloroethene
TEF	Toxicity Equivalency Factor
TNB	1,3,5-trinitrobenzene
TNT	2,4,6-trinitrotoluene
TOC	Total Organic Carbon
TRV	toxicity reference value
TUF	temporal use factor
UCL	upper confidence limit
USACE	U. S. Army Corps of Engineers
USACHPPM	U. S. Army Center for Health Promotion and Preventive Medicine
USCS	Unified Soil Classification System
USFWS	U. S. Fish and Wildlife Service
UTL	upper tolerance limit
UXO	unexploded ordnance
VOC	volatile organic compound
WBG	Winklepeck Burning Ground
XRF	X-ray fluorescence

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EXECUTIVE SUMMARY

INTRODUCTION

This Phase II Remedial Investigation (RI) Report characterizes the nature and extent of contamination, evaluates the fate and transport of contaminants, and assesses potential risk to human health and the environment resulting from former operations at Load Line (LL) 1 at the Ravenna Army Ammunition Plant (RVAAP), Ravenna, Ohio. LL 1 was a munitions assembly and demilitarization facility from 1941 until 1971. The area of concern (AOC) for LL 1 includes the former production facility and some outlying areas and covers approximately 188.43 hectares (465.6 acres). The load line operated at full capacity during World War II (1941 to 1945) and the Korean War (1951 to 1957) assembling munitions. From 1961 to 1967, LL 1 was the site of munitions demilitarization activities. All buildings with residual explosive dust were washed down, and the freestanding equipment was removed from the buildings before the load line was declared inactive in 1971. LL 1 was the subject of a Phase I RI in 1996 (USACE 1997a). The purpose of that investigation was to confirm whether contamination was present within the AOCs and to determine the nature of the chemicals of potential concern (COPCs). Most of the LL 1 buildings were recently demolished and removed, with salvage and demolition activities complete as of June 2000.

The overall purpose of this Phase II RI Report is to describe the investigations conducted at LL 1, to define the vertical and horizontal extent of contamination, and to identify contaminants that present risks or chemical hazards to potential human and ecological receptors. The specific objectives of the Phase II RI are listed below.

- To characterize the physical environment at LL 1 and its surroundings to the extent necessary to define potential transport pathways and receptor populations.
- To characterize the sources, types, chemical properties, and quantities of contaminants; potential contaminant release mechanisms and contaminant fate and transport; to obtain sufficient engineering data to develop a conceptual site model (CSM) suitable for use in a baseline risk assessment; and to evaluate remedial action alternatives.
- To conduct baseline human health and screening ecological risk assessments using characterization data and the CSM to evaluate the potential threats and to develop remedial goal options (RGOs) for use in determining areas that may require remediation.
- To assess the suitability of field-portable-X-ray fluorescence (XRF) spectrometry for performing in-situ and ex-situ analyses of metals in soil and sediment samples. Results of these tests will determine the suitability of metals field analyses for future environmental investigations and remedial activities at RVAAP.

This Phase II RI was conducted as part of the U. S. Army's Installation Restoration Program approach to implement the Comprehensive Environmental Response, Compensation, and Liability Act process at RVAAP, which prioritizes environmental restoration at AOCs on the basis of their relative potential threat to human health and the environment. The RVAAP Phase I RI, conducted in 1996, investigated 11 high-priority AOCs and resulted in the lowering of the Relative Risk Site Evaluation ranking score for four of the sites. Despite the revised ranking, all AOCs involved in the study will require further investigation. The purpose of the Phase II RI is to determine the nature and extent of contamination in environmental media so that quantitative human health and ecological risk assessments can be performed.

Results of the risk assessments will be used to determine whether an AOC requires no further action or will be the subject of a Feasibility Study (FS).

The term significant is used occasionally in this report as a descriptor of site conditions or nature and extent of contamination. Additionally, the term is used in a statistical connotation to describe statistical confidence or differences of values. It is noted in the former usage that statistical significance is not implied (e.g., significant migration of contaminants).

PAST AND CURRENT INVESTIGATIONS

The Phase II RI at LL 1 was designed to collect data to supplement information obtained from four previous investigations at the site, as follows:

1. The Water Quality Surveillance Program (USATHAMA 1980 – 1992);
2. *Phase I Remedial Investigation for 11 High-Priority Areas of Concern at the Ravenna Army Ammunition Plant* (USACE 1997a);
3. The Cold Regions Research and Engineering Laboratory (CRREL) study of explosives contamination in surface soils (USACE 1997b); and
4. The residential well sampling effort conducted by Ohio EPA in 1997 (Ohio EPA 1988a and 1988b).

The Water Quality Surveillance Program included monitoring of nine surface water locations throughout RVAAP between 1980 and 1992. In addition, groundwater samples were collected from former production wells. Of particular interest to LL 1 is a Parshall flume located near the eastern boundary of the installation (station PF534). Surface water from LL 1, in part, is discharged off the installation through this point; however, the station receives drainage from a large area in addition to LL 1. Isolated detections of an explosive—hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)—and several metals were noted in the historical data at this station. Due to the lack of available quality assurance/quality control documentation and use of older analytical methods, these data are of limited value for characterization purposes.

The Ohio EPA's 1997 residential well groundwater survey detected no explosive compounds in domestic water supplies. One arsenic result exceeded its maximum contaminant level.

The 1997 CRREL study evaluated only explosives in soils; 2,4,6-trinitrotoluene (TNT); dinitrotoluene (DNT); and RDX were detected in LL 1 soils during this investigation.

OBJECTIVES OF THE PHASE II REMEDIAL INVESTIGATION

The Phase I RI performed in 1996 included sampling and analysis of groundwater, surface soil, ditch sediment, and sediment from two ponds within the AOC border. The Phase I results indicated elevated concentrations of explosive, inorganic, and organic compounds occurring in soil in the central portion of the production area.

The findings and data gaps identified for these previous investigations guided the objectives and sampling design of the Phase II RI at LL 1. As detailed in *the Sampling and Analysis Plan Addenda for the Phase II*

RI at Load Line 1 at RVAAP (USACE 1999a, 2000b), the Phase II RI sampling objectives, by medium, included those listed below.

Surface Soil and Sediment

1. Determining the nature and horizontal extent of contamination using biased sampling at each area within LL 1 that has either explosives at concentrations greater than or equal to 1 parts per million (ppm) or lead in excess of 100 ppm in surface soil during the Phase I RI. Primary areas of interest include Buildings CB-17, CB-13, CB-13B, CB-14, CB-10, CB-4 and CB-4A, and CA-6 and CA-6A; the former concrete settling tanks east of Building CB-4 and south of CB-4A; CB-2; and the former Water Tower.
2. Identifying site-related contaminants (SRCs) by comparing the surface soil and sediment data to the RVAAP facility-wide background data set, which characterizes natural facility-wide variability for 23 Target Analyte List (TAL) metals.
3. Characterizing large non-production areas by random-grid sampling, using a statistical approach to ensure adequate area coverage and density.
4. Assessing the suitability of field-portable XRF spectrometry for performing in-situ and ex-situ analyses of metals in soil and sediment samples. Results of these tests will determine the suitability of metals field data for future environmental investigations and remedial activities.

Subsurface Soil

1. Defining the horizontal and vertical extent of contamination at depth resulting from dispersal of explosives and studying transport pathways of any such materials.

Surface Water

1. Determining whether runoff from contaminated areas around the former production area may contribute contaminants in dissolved and suspended form to the surface water system at LL 1.
2. Determining whether drainages at LL 1 allow contaminants to migrate eastward or northward beyond the AOC boundary.

Groundwater

1. Augmenting existing information on the LL 1 hydrogeological flow system and chemical groundwater quality, with emphasis on the shallow groundwater upgradient and downgradient of the most concentrated areas of soil contamination identified in the Phase I RI and other studies.
2. Comparing groundwater results to the facility-wide background data set.

These objectives were met through the field activities conducted in September 1999 and September and October 2000.

PHASE II REMEDIAL INVESTIGATION INVESTIGATIVE APPROACH

Field investigation activities at LL 1 included surface and subsurface soil sampling; surface water and sediment sampling in drainages and in Charlie's and Criggy's ponds; installation, sampling, and

hydrogeological testing of eight new monitoring wells; and sampling of six existing monitoring wells. A brief description of the sampling rationale and methodology is presented by media.

Surface and Subsurface Soil

A biased sampling strategy was used to focus on areas having the highest concentrations of soil contamination, which were originally suggested by earlier investigation results. Field colorimetry was used for both soil and sediment as a screening method to evaluate the extent of TNT and RDX contamination, and to reduce the number of samples that required fixed-base laboratory analysis for explosives. This screening method was verified by the use of confirmatory fixed-base laboratory analysis on all samples that had detectable levels of TNT or RDX in the field, in addition to confirmatory fixed-base laboratory analysis of 15% of samples that were non-detects in the field.

In addition to the field colorimetry screening for explosives, all soil and dry sediment samples collected were also screened in the field for metals using a portable XRF spectrometer. In-situ measurements of the concentrations of 24 metals were collected at each surface soil/sediment sampling location. In addition, an aliquot of each homogenized soil/sediment sample was subjected to ex-situ analysis by an on-site laboratory. The XRF method was not used to select samples for fixed-base laboratory analysis; rather, all soil and sediment samples were sent to the laboratory for analysis with the standard SW-846 technique for TAL metals and cyanide, regardless of the field result.

A total of 314 surface soil [from 0 to 0.3 m (0 to 1 ft) below ground surface (bgs)] and 37 subsurface soil [from 0.3 to ~0.9 m (1 to ~3 ft bgs)] samples were collected for the Phase II RI. Sample areas included the exterior of the former production area building pads, the area around the base of the former Water Tower, the former Change Houses, the railroad track bed, and beneath the slabs of six buildings. Random samples were also collected within the AOC perimeter area using a statistical approach to determine an appropriate triangular grid spacing. The actual sample locations were determined by using a random number generator to select a grid block. This sampling design was used to acquire representative information on areas between known or suspected sources within and beyond the operational area of the load line.

Sediment and Surface Water

Sediment and surface water samples were collected at eight drainage features. For some of these areas, a sediment sample was collected, but the corresponding surface water sample was not collected, typically due to dry conditions. A total of 38 sediment samples and 14 surface water samples were collected.

Groundwater

Groundwater samples were collected from five of the six existing Phase I RI and eight new Phase II RI monitoring wells in 1999 and 2000. One existing Phase I RI monitoring well (LL1mw-063) could not be sampled because it was dry during both sampling events. The 26 groundwater samples evaluated in this RI include the Phase I samples and both rounds of Phase II samples. Field parameters and water levels were measured during sampling events.

Storm Drain and Sanitary Sewer Investigation

The investigation of the storm and sanitary sewer systems was attempted using a remotely controlled camera in order to assess the integrity of the pipes and sediment accumulation. Seven samples of sediment and two surface water samples were collected at manhole locations.

CONCEPTUAL SITE MODEL

Information gathered during the Phase II RI of LL 1 has been used to develop a conceptual site model (CSM) for this AOC. The elements of the CSM are listed below.

- The topography of LL 1 consists of gently undulating slopes and level areas with elevations ranging from 297.2 to 309.6 m (975 to 1,016 ft) above mean sea level (amsl) in the production area. The topography is the result of the reworking of the original glaciated bedrock surface to accommodate the buildings and other infrastructure of LL 1. Topographic relief southeast of the main load line varies from 285.9 to 298.7 m (938 to 980 ft) amsl, where glacial cover is present. The thickness of glacial material varies in this area from less than 2 to >10.7 m (6.6 to >35 ft).
- Soil cover is thin to nonexistent at many locations inside the main production area at LL 1, except where non-native fill material was brought in during construction of RVAAP or was redistributed during the demolition of buildings during 1999 and 2000. Bedrock is exposed at locations throughout the production area. A thicker soil covers the glacial materials southeast of the main production area.
- Groundwater is present in the sandy interbeds found in glacial materials that occur south of the load line proper, with the water table at depths from about 3.35 to 4.57 m (11 to 15 ft) bgs. The water-bearing sand units may be laterally discontinuous. Groundwater in the production area of LL 1 occurs in the highly porous, permeable, and fractured Sharon Sandstone with the water table occurring at depths from 5.2 to 10.7 m (17 to 35 ft) bgs. Groundwater flows radially from a groundwater high located just south of the melt-pour complex in the central portion of the load line. The water-bearing sandstone behaves as an unconfined system and a high degree of hydraulic connectivity is presumed in the shallow bedrock zone.
- Most surface water from precipitation collects in storm water catch basins and unlined ditches throughout the production area. Most runoff is discharged through the following exit pathways: (1) Outlets A and B, which discharge ultimately to the Parshall flume on Sand Creek at State Route 534 (PF534) northeast of the AOC; (2) Outlet C and Charlie's Pond east of the AOC; (3) Outlets D, E, and F discharging through Criggy's Pond southeast of the AOC; and (4) an unnamed drainage outlet in the northwest corner of the AOC that flows into Sand Creek. Water levels at Charlie's and Criggy's Pond may vary by several in. in response to seasonal variations in precipitation.
- Historic contaminant sources at LL 1 were the individual buildings, now demolished, within the production areas. Building CB-801 was used for storage of inert materials, such as empty shell casings. In adjacent Building CB-3, several operations were performed including mixing of paint for shells, conveyor truck repair and maintenance, and storage of materials. Buildings CB-6/-6A received and prepared the bulk high explosives (TNT, RDX, and Composition B) for transfer via a pipeline to Buildings CB-4/-4A. At Buildings CB-4/-4A, the melting and pouring of the explosives into the shell casings were performed. The processing of shells continued at Buildings CB-10 and CB-3, where boosters were added after drilling of the explosives in each shell. The CB-13 group of buildings prepared and processed the shells for shipment.
- Contaminants released from LL 1 sources include metals, explosives, propellants, and semivolatile organic compounds (SVOCs). Explosive residues are present in the soil surrounding these building pads and nearby settling tanks. Precipitation or recent demolition activities may have caused these contaminants to migrate into subsurface soil and to groundwater. The crushed slag that was used throughout RVAAP for roads, railroad beds, and parking areas may also be a source of aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, magnesium, and zinc contamination.

- The washdown of the process buildings generated “pink water” that was collected in settling basins for filtration. Settling tank effluent exited the process area via Outlet A and flowed northeast off of the AOC via an unlined drainage ditch. Storm runoff and any entrained contaminants from the main production area also exited through several outlets (C, D, E, and F).
- The potential for human exposure to potential contaminants migrating from the AOC is mitigated by the lack of permanent residents within RVAAP. Permanent residents do reside on adjacent private properties east and south of the AOC. No signs of ecological stress were noted during the field investigation.

NATURE AND EXTENT OF CONTAMINATION

The Phase II RI evaluated the nature and extent of contamination of five aggregates as follows: surface soil [from 0 to 0.3 m (0 to 1 ft) bgs], subsurface soil [from 0.3 to 0.9 m (1 to 3 ft) bgs], sediment, surface water, and groundwater. The soil, sediment, and surface water were further divided into area aggregates based on building proximity and production processes (e.g., melt-pour operation) and drainage area. The data collected within the area exterior to the production was considered separately (i.e., the AOC perimeter aggregate). The results of this evaluation are summarized by media and aggregate here. This summary of results is based on fixed-base analytical laboratory results.

Surface Soil

In general, the Phase II RI surface soil sampling results indicate that 16 explosive and propellant compounds are present, with the most common being 2,4,6-TNT (85 detections) and nitrocellulose (65 locations). Chromium, copper, lead, and zinc are consistently detected in several of the production areas at concentrations significantly above their respective background values. The most commonly detected organic contaminants are SVOCs, polychlorinated biphenyls (PCBs), and a suite of polyaromatic hydrocarbons (PAH).

At the former melt-pour buildings (Buildings CB-4/-4A) and bulk explosives preparation buildings (Buildings CA-6/-6A) and settling basins area

- the immediate area around the Building CB-4A pad is the most heavily contaminated area at LL 1 with high concentrations of explosives (maximum 4,800 mg/kg of 2,4,6-TNT), propellants, and metals.
- octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) and RDX detections occurred frequently at the Building CB-4A pad but were not detected at the Building CB-4 pad. The maximum RDX concentration was 2,300 mg/kg from a sample location adjacent to the Building CB-4A pad.
- nitrocellulose was detected frequently across the entire load line. Nitroglycerine and nitroguanidine were detected only once at the load line, at stations near the Building CB-4 pad. The maximum concentration of nitrocellulose measured for the LL 1 area was 2,300 mg/kg at the Building CB-4A pad.
- samples collected in the vicinity of the settling basins had frequent detections of explosives compounds, yet the overall concentrations were less, relative to the melt-pour buildings. 2,4,6-TNT concentrations ranged from non-detect to 11 mg/kg for the basin adjacent to Building CB-4A. The basin adjacent to the Building CA-6 pad had 2,4,6-TNT concentrations at 300 mg/kg at the site of a former collection tank, yet very low concentrations were found in the surrounding soil samples.

- relative to the melt-pour buildings, the former bulk explosive preparation buildings (Buildings CA-6/-6A) are less contaminated (i.e., both in number and concentration of detected compounds) with 2,4,6-TNT in the range from non-detect to 180 mg/kg for sample stations closely placed around the perimeter of these building pads.
- sampling along the pipeline between Buildings CB-4A and CA-6A indicated detections of explosives (maximum of 0.07 mg/kg 2,4-DNT) in only 3 of the 11 samples collected.

At the booster installation (Building CB-10/13) area

- 2,4,6-TNT concentrations around the perimeter of the building pad are highly variable, ranging from non-detect to 230 mg/kg at Building CB-10. Fourteen of 19 samples had concentrations less than 1 mg/kg. The southeastern sides of the buildings are more heavily contaminated than any other area around the buildings, suggesting that this is where the washdown effluent was directed.
- at stations around Buildings CB-10 and CB-13, nitrocellulose was detected at a maximum concentration of 46.5 mg/kg.
- the washdown of nitrocellulose from Building CB-13 is reflected in samples from the adjacent ditch. Station LL1-109, which is in a ditch south of the Building CB-13 pad, had nitrocellulose concentrations of 103 mg/kg. The 2,4-DNT concentration was 9.3 mg/kg at this station.

At the demilitarization processing area (Buildings CB-14, CA-15, and CB-17)

- the perimeter area of these buildings was sampled thoroughly (26 samples), yet minimal explosives contamination was detected. 2,4,6-TNT and nitrocellulose were detected in only two of the four samples sent for laboratory analysis, with maximum concentrations of 4.5 and 90 mg/kg, respectively. Relative to the other production area buildings, this aggregate is not significantly contaminated with explosive compounds.
- there is less metals contamination when compared to the other building groupings in the load line. However, lead is elevated in some stations in both surface and subsurface soil.

At the load line storage and maintenance facilities (Buildings CB-3 and CB-801) and Water Tower area

- the detection of explosives in this area is sporadic and variable, reflecting the operational history of the buildings as storage/maintenance areas. When detected, explosive concentrations are low (e.g., maximum concentration of 2,4,6-TNT was 1.2 mg/kg). The highest metals contamination in this area is associated with slag on the railroad bed.
- paint residue (in the area of the Water Tower) is the likely cause of elevated lead, chromium, and zinc. No PCB contamination associated with paint chips from the demolition of the Water Tower is evident in surface soil.

In the non-production area of the AOC (Perimeter Area)

- no explosives or propellants were detected in the perimeter area, indicating minimal migration of contamination from the major production facilities to the perimeter area.
- minimal metals contamination is present (a few metals at 2× background).

Subsurface Soil

At the former melt-pour and bulk explosives preparation buildings (Buildings CB-4/-4A and CA-6/-6A) and settling basins area

- occurrences of explosive compounds in the subsurface soils are concentrated around the melt-pour buildings (including the former settling basin). The maximum concentration of any explosive in subsurface soil was encountered at LL1-325 near Building CA-6A, with TNT at 4,500 mg/kg. The maximum concentration of nitrocellulose (the only propellant identified in subsurface soils), at 29.3 mg/kg, was also encountered at LL1-325.
- HMX and RDX are present with maximum concentrations at LL1-015 in Building CB-4A. HMX was detected twice only at Building CB-4A, and RDX was present at Buildings CB-4/-4A only.
- concentrations of metals in the subsurface are generally lower than in the surface soil, except where soil was disturbed during the demolition of buildings—most notably at LL1-006 and LL1-007 at Building CB-4, and at LL1-265 and LL1-266 at the site of the former settling basin.
- barium, chromium, mercury, and selenium were only detected above background in the melt-pour area and at LL1-109 next to Building CB-13. Selenium occurrences above background appear to be associated with the former settling basin.
- cyanide was present at the two melt-pour buildings, at LL1-001 and LL1-156 (1.2 and 0.63 mg/kg, respectively). The background value for cyanide is zero, as it was not detected in the background data set; thus, concentrations are difficult to assess.

At the booster installation area (Buildings CB-10 and CB-13)

- explosives were not detected in subsurface soil, and only a single detection of propellants was observed in subsurface soil from this aggregate. The ditch south of Building CB-13 also had 29.3 mg/kg of nitrocellulose in the subsurface soil at LL1-109, less than the 103 mg/kg detected in the surface soil.
- the highest concentrations of cadmium, zinc, and lead were detected in one sample, LL1-109, in the ditch between Buildings CB-10 and CB-13. Barium, chromium, mercury, and selenium were only detected above background in the melt-pour area and at LL1-109. The highest concentrations of antimony, silver, and chromium in LL 1 subsurface soils come from LL1-109. Selenium occurrences above background appear to be associated with these buildings at station LL1-109.

At the munitions demilitarization area (Buildings CB-14, CB-15, and CB-17)

- a single detection of explosives in subsurface soil occurred in this aggregate. One sample at Building CB-17 (LL1-087) contained nitrocellulose at 8.8 mg/kg and TNT and 2,4-DNT at concentrations < 1 mg/kg.
- cadmium, lead, and zinc were the only metals measured at concentrations exceeding their respective background values at LL1-087 at Building CB-17.

In the railroad bed area

- Track CB is generally free of explosives contamination, except for one laboratory detection at LL1-241 (3-nitrotoluene at 0.17 mg/kg). Two of 10 samples collected for field explosives analysis from Track CB had evidence of explosives, but only LL1-241 contained detectable quantities in the confirmatory laboratory analysis.
- LL1-244 and LL1-245 on Track CB are the only railroad bed samples that have detections of metals that exceed background. Cadmium and zinc were found above the background values in both samples.

Sediment

Analysis of Phase I RI data showed that sediment in drainage ditches did not contain detectable concentrations of explosives in most areas and did not convey explosives to the ponds on the eastern edge of the AOC. PCBs in sediment were detected in the southern third of the load line, primarily in drainage ditches near Building CB-3. Thirty-two locations were sampled during the Phase II RI to determine nature and extent of contamination in the five aggregate areas: Outlets A and B, Outlet C and Charlie's Pond, Outlets D, E, and F and Criggy's Pond, North Area, and off-AOC. This sampling indicated

- Ditch sediments near Buildings CB-13 and CB-13B contain the greatest quantity of explosives, propellants, and total organic carbon.
- Explosive contamination does not appear to have migrated far along drainages exiting LL 1. The primary source of all explosives in ditch and pond sediments is believed to be from pink wastewater discharged directly from the load line, with migration from surface soil contamination being a secondary source.
- Metals were detected in all sediment samples, but were concentrated and most abundant along Outlet A, Outlet C, and Outlets D, E, and F upstream of the ponds. Metals detected in off-AOC areas were most likely transported to those locations in production-related effluents exiting the site through Outlet C. However, the presence of metals in sediments at LL1-318, which is upstream of the confluence with LL 1 drainages, indicates that other areas at RVAAP may be contributing contaminants to downstream off-AOC locations.
- PCBs were detected only at isolated locations within drainage ditches, indicating that erosion and transport of surface soil has not resulted in widespread dispersal of PCBs within drainages at LL 1.

Surface Water

A total of 14 surface water samples were collected from eight locations during the Phase II RI to determine nature and extent of contamination. Six of these samples were co-located with sediment samples, while the remaining two were collected from both Charlie's and Criggy's Ponds. The majority of surface water samples were collected from off-AOC areas in order to more fully characterize potential AOC-related impacts on surface water quality as it exits the installation to the east through PF534.

- Of the 17 explosive and propellant compounds analyzed in surface water, only two compounds were detected in four samples, all with concentrations less than 0.5 µg/L. The detections occurred at locations in which sediment samples tested negative for field explosives and were not analyzed for laboratory explosives. The detections occurred at stations located within the Outlets A and C ditchlines.

- Metals were detected in all surface water samples, but were most abundant at Charlie's Pond at the AOC boundary along Drainage C and at station LL1-318, which is upstream of the confluence with LL 1 drainages. The presence of metals in surface water at LL1-318 indicates that other areas at RVAAP may be contributing contaminants to downstream off-AOC locations.
- No SVOCs, volatile organic compounds (VOCs), or PCBs/pesticides were detected in surface water within the AOC. These compounds, where present within LL 1, are most likely not migrating from source areas to the drainages due to high sorption potential to soils and sediments. One minor detection in the off-AOC area is most likely due to contributions from other areas.

Groundwater

Groundwater samples were collected in 1999 and 2000 from the eight newly installed Phase II RI monitoring wells and five of six existing monitoring wells from the Phase I RI. One monitoring well (LL1mw-063) was not sampled because it was dry. Twelve monitoring wells are screened in the sandstone bedrock, while two wells are screened in the shallower unconsolidated glacial sediment. Groundwater samples from each well were analyzed and screened against background values to determine if contaminants are site-related. Unfiltered samples were collected for all constituents. Additionally, filtered samples were collected for TAL metals analysis.

- Twelve explosive and propellant compounds were detected in groundwater samples collected during the Phase II RI with the most frequently detected being 1,3-DNB and 2,4,6-TNT. Though most detections were less than 1 µg/L, the highest concentrations of explosives and propellants were found at monitoring wells located within the main process areas. The highest concentration was for RDX (88 µg/L) at monitoring well LL1mw-080. The overall low concentrations and the distribution of detections suggest that the occurrence of explosives in groundwater is localized in the vicinity of source areas and that migration of explosives from soil to groundwater is minimal.
- Eleven of the 23 detected TAL metals are considered site-related based on the SRC screening process. The most frequently detected SRCs were aluminum, arsenic, cobalt, manganese, nickel, and zinc. Of this suite of metals, the maximum detections occurred at three monitoring wells located in the main process areas. In contrast, samples from monitoring wells located at the AOC boundary have lower concentrations, suggesting that migration of contaminants is limited due to attenuation.
- Zinc concentrations, where detected, were significantly higher for most monitoring wells in the 2000 sampling event than the 1999 sampling event. No clear time patterns exist for other metals in groundwater.
- Minor detections of SVOCs and PCBs/pesticides were observed in a few monitoring wells near the main production areas, indicating that migration of these contaminants from soil sources to groundwater is minimal.
- Three VOCs—chloroform, methylene chloride, and toluene—were detected in several monitoring wells in the former production area. However, these compounds were also detected in upgradient monitoring wells LL1mw-059 and LL1mw-060 southwest of LL 1; therefore, the presence of these VOCs most likely represents periodic laboratory contamination within the range of normal concentrations and frequency.

Sanitary Sewer Surface Water and Sediment

Two water samples were collected from the sanitary sewer system, one from the outlet line from the LL 2 ejector station, which is the collection point for all sanitary effluent from the load line, and the other from a line near Building CA-6 (bulk explosives preparation). Explosives were detected in low concentrations (<0.1 mg/L) in the sample from the Building CA-6 line. Metals were detected in both water samples, but no background data set is available for comparison. The highest metals concentration detected was 16.1 mg/L for iron from the northwest corner of the load line. This location also showed very low estimated concentrations (<0.01 mg/L) of SVOCs.

Seven sediment samples were collected and analyzed from the sanitary sewer manholes and storm drain inlets. Explosives and propellants were detected in six of the seven samples. TAL metals were commonly detected in the sewer sediment samples. The highest concentrations of many metals occurred in samples from manholes 208 and 213, corresponding to the melt-pour complex and an area adjacent to former Building CB-14, respectively. Other sewer sediment samples from the vicinity of the melt-pour complex also had relatively high concentrations of some metals.

Only two sediment samples, one from within the melt-pour complex and one adjacent to former Building CB-14, were analyzed for organic compounds. Isolated VOCs were detected at concentrations less than 0.01 mg/kg. PAHs were detected in both samples with concentrations ranging from 0.41 to 25 mg/kg. Pesticides and PCBs were also detected in both samples. The pesticides were commonly used for insect control throughout RVAAP, but the specific sources of the PAHs are not known.

FATE AND TRANSPORT ANALYSIS

Fate and transport modeling was used to simulate: (1) the vertical transport of contaminants from source areas to groundwater, and (2) horizontal transport within the groundwater system to receptor locations. The Seasonal Soil Compartment (SESOIL) model was used to predict the maximum concentration of leachate in the soil profile (ground surface to upper level of saturated soil zone) beneath the source areas. Analytical Transient 1-, 2-, 3-Dimensional (AT123D) modeling was performed to predict the transient spread of a contaminant plume through the groundwater aquifer in the LL 1 area. The following primary conclusions can be drawn from this analysis:

- Leachate modeling indicates some of the explosives compounds are expected to migrate from the contaminated surface soil into the groundwater, with predicted concentrations exceeding the groundwater RGOs in the source areas. Based upon numerical modeling results, these contaminants are not anticipated to migrate off of the AOC via the groundwater pathway at detectable concentrations. Migration of most of the constituents is attenuated because of moderate to high retardation factors.
- Metals, PCBs, and PAHs within LL 1 soil are not expected to leach to groundwater beneath the sources within the modeled time frame of 1,000 years.
- The extensive system of storm and sanitary sewers represents a possible preferred migration pathway for water-borne contaminants. Leaks from the pipes may rapidly introduce contaminants from surface soil sources to the groundwater.

BASELINE HUMAN HEALTH RISK ASSESSMENT

A Baseline Human Health Risk Assessment (BHHRA) was conducted to evaluate risks and hazards associated with contaminated media at LL 1. A number of potential future land use scenarios were evaluated, including National Guard use, Open Industrial, Open Recreational, and Open Residential. The most likely future receptors are the National Guardsmen, as well as a Hunter/Trapper, Security Guard/Maintenance Worker, and Industrial Worker. A Child Trespasser is also considered a potential receptor. The Open Residential scenario was evaluated as an upper-bound (i.e., worst-case) scenario for this BHHRA. To support the remedial alternative selection process, RGOs were developed for each chemical identified as a chemical of concern (COC) in the direct exposure pathways for this LL 1 BHHRA.

Direct and Indirect Contact with Surface Soil

Potential human health risks/hazards were evaluated for exposure to COPCs in soil at seven exposure units (EUs). Direct contact (ingestion, dermal contact, inhalation) with surface soil was evaluated for eight receptors: Child Trespasser, Hunter/Trapper, National Guard, Security Guard/Maintenance Worker, Recreator, Industrial Worker, and On-Site Resident Farmer (adult and child). In addition to these direct exposure pathways, indirect exposure via ingestion of venison by the Hunter/Trapper and ingestion of venison, beef, milk, and vegetables by the On-Site Resident Farmer was evaluated.

The results of the BHHRA for direct and indirect contact with surface soil in the production area aggregates are summarized in Table ES-1. Total hazards greater than 1 are considered unacceptable. An Incremental Lifetime Cancer Risk (ILCR), denoted as Exposure Risk in the following tables, was calculated based upon the scenarios. EPA (1990b) indicates that remediation goals should represent an ILCR to an individual between 10^{-6} to 10^{-4} with a cancer risk of 10^{-6} serving as the point of departure. While the 10^{-6} point of departure expresses EPA's preference for setting cleanup levels at the more protective end of the risk range, it is not a presumption that the final cleanup will attain that risk level. Consideration of site-specific and remedy-specific factors (i.e., exposure, uncertainty, and technical) enter into the determination of where within the acceptable risk range of 10^{-6} to 10^{-4} final remediation decisions will fall. As indicated in Table ES-1, a hazard or risk is associated with this medium in each of the production area aggregates. The highest risk and hazard are associated with the soil in the Buildings CB-4/-4A and CA-6/-6A aggregate. The contaminants of concern associated with large risks due to direct contact with surface soil are PCB-1254, benzo(a)pyrene, and 2,4,6-TNT.

The Water Tower, Change House, and Perimeter Area aggregates have significantly lesser risks for this medium. The reader should consult the Chapter 6.0 discussion of the assumptions and limitations regarding these scenarios and calculations. In addition, the magnitude of the risk numbers and hazards should be examined for each aggregate and scenario. An understanding of these is necessary for making appropriate remedial action decisions.

The highest concentrations of lead in surface soil were found in the Water Tower area. Modeling indicates that exposure to lead in surface soil in this area could result in probabilities of exceeding acceptable fetal blood levels of <10 to <65% for six of the seven adult receptors and <93% for the On-Site Resident Farmer child. The Buildings CB-3 and CB-801 aggregate had probabilities of <12% of exceeding acceptable fetal blood lead levels for all adult receptors and <27% for the On-Site Resident Farmer child. Acceptable probabilities were modeled for the remaining aggregates, except the Perimeter Area aggregate, where lead is not a contaminant of potential concern.

Table ES-1. Summary of Total Hazards/Risks for Direct and Indirect Contact with Surface Soil

Receptors	Child Trespasser	Hunter/Trapper	National Guard Soldier	Security Guard/Maintenance Worker	Recreator	Industrial Worker	On-Site Resident Farmer (adult)	On-Site Resident Farmer (child)
Buildings CB-3 and CB-801 Aggregate								
Hazards >1				✓ ^a			✓ ^{a,b}	✓ ^{a,b}
Exposure Risk ≥10 ⁻⁴			✓ ^a	✓ ^a		✓ ^a	✓ ^{a,b}	✓ ^{a,b}
Exposure Risk Between 10 ⁻⁶ to 10 ⁻⁴	✓ ^a	✓ ^a			✓ ^a			
Buildings CB-4/4A and CA-6/6A Aggregate								
Hazards >1	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^{a,b}	✓ ^{a,b}
Exposure Risk ≥10 ⁻⁴	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^{a,b}	✓ ^{a,b}
Exposure Risk Between 10 ⁻⁶ to 10 ⁻⁴		✓ ^b						
Buildings CB-13 and CB-10 Aggregate								
Hazards >1							✓ ^{a,b}	✓ ^{a,b}
Exposure Risk ≥10 ⁻⁴							✓ ^b	✓ ^b
Exposure Risk Between 10 ⁻⁶ to 10 ⁻⁴	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^a
Buildings CB-14, CB-17, and CA-15 Aggregate								
Hazards >1				✓ ^a			✓ ^{a,b}	✓ ^{a,b}
Exposure Risk ≥10 ⁻⁴							✓ ^{a,b}	✓ ^b
Exposure Risk Between 10 ⁻⁶ to 10 ⁻⁴	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^a	✓ ^a		✓ ^a

^a Direct contact.

^b Indirect contact via ingestion of foodstuffs—evaluated for Hunter/Trapper, On-Site Resident Farmer adult, and On-Site Resident Farmer child.

✓ = Total hazard or risk falls into the noted category.

Direct contact with subsurface soil was evaluated for the National Guard, Industrial Worker, and On-Site Resident Farmer scenarios for three production area aggregates (Buildings CB-4/4A and CA-6/6A; Buildings CB-10 and CB-13; and Buildings CB-14, CB-17, and CA-15) and the Perimeter Area aggregate. In the Buildings CB-4/4A and CA-6/6A aggregate only, a potential hazard >1 exists with potential unacceptable risk ranging from 2E-06 to 1E-04. The COCs for direct contact with subsurface soil in this aggregate area are 2,4,6-TNT and RDX. At Buildings CB-13 and CB-10, a potential hazard >1 was estimated for the On-Site Resident Farmer child due to antimony.

Surface Water and Sediment

Exposure to surface water and sediment was evaluated for six receptor scenarios: Child Trespasser, Hunter/Trapper, National Guard, Recreator, and On-Site Resident Farmer (adult and child). Exposure units (EUs) were based on data aggregates developed for contaminant nature and extent evaluation. The Hunter/Trapper and On-Site Resident Farmer are assumed to ingest fish from the affected EUs in addition to direct contact with surface water and sediment.

No hazards >1 were identified for the Child Trespasser, National Guard, or Recreator exposed to surface water or sediment at Outlet C and Charlie’s Pond; off-AOC, Outlets D, E, and F and Criggy’s Pond; or Outlets A and B (sediment only). Arsenic was the only COC identified with a risk >10⁻⁶ for these three receptors for all EUs, except Outlets A and B sediment where PAHs contribute to a total risk > 10⁻⁶.

No chemical hazards >1 were identified for the Hunter/Trapper directly exposed to surface water or sediment in these EUs. Direct exposure to arsenic results in a risk >10⁻⁶ for this receptor at off-AOC, Outlet C and Charlie’s Pond, and Outlets D, E, and F and Criggy’s Pond. Direct exposure to PAHs in sediment results in risk >10⁻⁶ at Outlets A and B. Ingestion of fish from Outlet C and Charlie’s Pond, and

off-AOC results in a hazard index (HI) ≥ 1 due primarily to manganese at background concentrations. Ingestion of fish by the Hunter/Trapper from off-AOC surface water results in a risk of 2×10^{-4} , primarily associated with bis(2-ethylhexyl)phthalate.

Chemical hazards > 1 and risks $> 10^{-6}$ were identified for the On-Site Resident Farmer exposed to surface water, sediment, and fish at Outlet C and Charlie's Pond and off-AOC; surface water and sediment at Outlets D, E, and F and Criggy's Pond; and sediment at Outlets A and B.

Lead is a COPC in sediment at the Outlet C and Charlie's Pond, Outlets A and B, and Outlets D, E, and F and Criggy's Pond aggregates. With the exception of the On-Site Resident Farmer, all adult receptors had probabilities of fetal blood lead concentrations lower than the acceptable levels of less than 5%. For the On-Site Resident Farmer adult, probabilities are less than 9% at Outlets A and B, less than 1% in Outlet C and Charlie's Pond, and less than 29% in Outlets D, E, and F and Criggy's Pond. For the On-Site Resident Farmer child, the estimated probabilities of exceeding the target blood lead level of concern are less than 1% at Outlet C and Charlie's Pond, 19% at Outlets A and B, and 66% at Outlets D, E, and F and Criggy's Pond.

Groundwater

Risks and hazards were estimated for the National Guard and On-Site Resident Farmer scenarios (hypothetical future scenarios) for potable use of groundwater. Risks and hazards estimated for monitoring wells north and south of Criggy's Pond are below levels of concern (i.e., no HI > 1 or risk $> 10^{-6}$) for both receptors. A total HI of 1 was estimated for monitoring wells in the LL 1 building area for the National Guard and is associated primarily with natural background levels of manganese. The total risk for this receptor (5E-05) falls within the range of 10^{-6} to 10^{-4} .

The estimated HIs of 4 (adult) and 14 (child) and total risk (2E-04) exceed the target ranges for the On-Site Resident Farmer scenario. The primary contributor to the total hazard is manganese, which is naturally present in groundwater. The primary contributors to risk for both the National Guard and On-Site Resident Farmer scenarios are explosives; 4,4'-DDE; and chloroform. Arsenic also contributes significantly to the total risk to these receptors, but it is naturally present in groundwater.

Arsenic and manganese are naturally present in groundwater in the Ravenna area with reported background concentrations and exposure point concentrations used in the BHHRA shown in Table ES-2.

Table ES-2. Background Values and Exposure Point Concentrations for Arsenic and Manganese in Groundwater

Aquifer	Background Criteria (µg/L)		Exposure Point Concentration (µg/L)	
	As	Mn	As	Mn
Unconsolidated (filtered)	11.7	1,020	NA	NA
Unconsolidated (unfiltered)	215	2,868	--	--
Bedrock (filtered)	NA	1,340	7.8	3,047
Bedrock (unfiltered)	19.1	1,260	--	--

NA – not a chemical of potential concern in this aquifer.

-- only filtered data were used in risk assessment.

SCREENING ECOLOGICAL RISK ASSESSMENT

A Screening Ecological Risk Assessment (SERA) was performed in accordance with written guidance from EPA and also considered Ohio's water quality standards (Ohio EPA 1999). The Ohio water quality

standards are applicable or relevant and appropriate requirements and the first benchmarks to be utilized when evaluating surface water conditions. The present SERA adheres to the screening process that includes problem formulation, followed by exposure assessment and effects assessment, and culminating in risk characterization with attention to uncertainties and summarization.

The AOC contains sufficient terrestrial and aquatic (sediment and surface water) habitat to support various classes of ecological receptors. Various classes of receptors such as vegetation, small and large mammals, and birds have been observed at the site. The EUs considered for this SERA, based on contaminant nature and extent evaluation aggregates, are listed in Table ES-3 below.

Table ES-3. Load Line 1 EUs for the Screening Ecological Assessment

Terrestrial EUs	Sediment EUs	Surface Water EUs
Water Tower area	Outlets A and B channel	Outlets D, E, and F channel and Criggy's Pond
Buildings CB-3 and CB-801	Outlet C channel and Charlie's Pond	Outlet C channel and Charlies' Pond
Buildings CB-4/-4A, CA-6/-6A and associated settling basins	Outlets D, E, and F channel and Criggy's Pond	Off-AOC channel
Buildings CB-10 and CB-13 (CB-13A and CB-13B)	North Area channel	
Buildings CB-14, CA-15, and CB-17	Off-AOC channel	
Perimeter Area		

EU = exposure unit.

Of the many observed plant and animal taxa, five terrestrial classes (vegetation, soil-dwelling invertebrates, worm-eating and/or insectivorous mammals, mammalian herbivores, and terrestrial top predators) were selected for terrestrial receptors. For aquatic classes, the sediment-dwelling organisms, aquatic organisms, and terrestrial top predators of aquatic organisms were selected.

In brief, the SERA screening process is progressive and consists of

- determination of SRCs by comparisons of maximum concentrations to background values;
- a comparison of SRC concentrations to Ohio EPA ambient water quality criteria and preferred toxicity screening values with an additional screen to determine persistent, bioaccumulative, and toxic (PBT) compounds; and
- determination of preliminary contaminants of potential ecological concern (COPECs).

The preliminary COPECs were retained for further evaluation in a second screen: an EU- and receptor-specific screening for each of the ecological receptors for the medium, using the EU-specific reasonable maximum exposures and receptor-specific no-observed-adverse-effect level toxicity reference values (whenever available).

Based on regulatory guidance, a hazard quotient (HQ) >1 indicates a possibility for negative impact on ecological receptors in the environment. From a technical viewpoint, a range of HQs strongly implies a range of risk. Any analyte with an HQ of 1.1 or higher based on the EU- and receptor-specific screening is considered a COPEC. Table ES-4 is a listing, by EU, of the soil, sediment, and surface water COPECs. HQs range from 1 to >1,000 for the listing of metals and organics.

Table ES-4. Soil, Sediment, and Surface Water COPECs at Load Line 1

EU	HQs>1
<i>Soil</i>	
Water Tower area	6 metals
Buildings CB-3 and CB-801	12 metals, PAH, pesticides, herbicides, Aroclor-1254
Buildings CB-4/-4A, CA-6/-6A and associated settling basins	13 metals, pesticides, 2,4,6-TNT, PCBs
Buildings CB-10 and CB-13	13 metals, pesticides, Aroclor-1254
Buildings CB-14, CA-15, and CB-17	11 metals, Aroclor-1254
Perimeter Area	10 metals
<i>Sediment</i>	
Outlets A and B channel	8 metals, PAH, pesticides, 1,3,5-TNB
Outlet C channel and Charlie's Pond	4 metals, 4,4-DDE, 2,6-DNT
Outlets D, E, and F channel and Criggy's Pond	8 metals
North Area channel	1 metal (nickel)
Off-AOC channel	1,3-DNB
<i>Surface Water</i>	
Outlets D, E, and F channels and Criggy's Pond	None
Outlet C channel and Charlie's Pond	1 metal (iron)
Off-AOC channel	2 metals (iron, manganese)

COPEC = contaminant of potential ecological concern.
 EU = exposure unit.
 HQ = hazard quotient.
 PAH = polyaromatic hydrocarbon.

In summary, surface soil from the six terrestrial EUs had the most COPECs and the highest HQs for the most receptors among the three media. Sediments at the five sediment EUs had fewer COPECs than the soil EUs, but potential risks to sediment-dwelling biota were also indicated. Surface water EUs had comparatively few COPECs relative to sediment. Thus, of the three media studied for this SERA, surface water appears to present the least amount of risk to ecological receptors.

RECOMMENDATIONS

To provide decision makers with the information necessary to evaluate the alternatives available to reduce or remove the potential risk to receptors, it is recommended that an FS be performed. The FS should evaluate a range of possible remedial actions, such as excavation, fencing, access restriction, etc., and the associated costs. It is also recommended that the FS employ a streamlined approach with selected alternatives based on most likely land use assumptions. The intent of this strategy is to accelerate site-specific analysis of remedies by focusing the FS efforts to anticipated land use and appropriate remedies that have been tested and evaluated at other sites with similar operational histories as LL 1.

The future land uses and controls envisioned for the LL 1 should be determined prior to preparation of the FS. Establishment of the most likely land use scenario(s) will allow decision makers the initial information necessary to determine the correct remedial action, such as source removal, land use controls, and/or continued monitoring, to achieve the central objective of the remediation process—protection of human health and the environment. The envisioned future use of a parcel of land is an important consideration in determining the extent of remediation necessary to achieve the required protectiveness. For example, the On-Site Resident scenario versus the National Guard scenario influences how much cleanup is needed to lower the risk to protective levels. Establishment of land use will also allow for streamlined evaluation of remedies and will be necessary for documentation in a Record of Decision and attendant Land Use Controls Assurance Plan.

It is noted that areas within LL 1 with the same projected land use (and at other load lines at RVAAP) will incorporate the same RGOs into remedial alternative development. Also, the FS should integrate surface water systems and recognize the connection of surface water exit pathways among the four adjacent major melt-pour lines (LLs 1 through 4), as well as LL 12. The FS should apply results of the ecological field truthing effort at the Winklepeck Burning Grounds (pending agreement by Ohio EPA) to remedial goal development for LL 1 to the extent practicable.

Key data uncertainties have been identified in the RI to help guide any future sampling efforts. Details of additional nature and extent assessment, as needed to fill any remaining data gaps in order to evaluate remedial alternatives, are deferred to the FS planning stage. The following components may be necessary for a thorough FS evaluation.

1. Definitive establishment of aggregate boundaries, if an aggregate-by-aggregate remediation process is considered most feasible by decisions makers. Such a delineation would allow
 - prioritization of areas presenting higher potential risk versus lowest potential risk;
 - selection of cleanup actions and exit strategies per aggregate and/or per building area in each aggregate, (e.g., it is anticipated that cleanup of Water Tower area soil could be accomplished by removal, whereas remediation of a process area aggregate may require an alternate approach); and
 - elimination of certain areas from additional investigation or further action, such as portions of the perimeter AOC aggregate, thus reducing the footprint of the AOC.
2. Additional groundwater sampling data for determination of any trends in groundwater contamination. Such information would help to validate the fate and transport modeling predictions and the likelihood of future groundwater contaminant migration. As such, a characterization monitoring plan for AOC groundwater is recommended. This should not be considered as a long-term monitoring action, but rather as the establishment of a data set for baseline conditions.
3. The installation of one or more “sentry” wells is recommended at a location downgradient of the melt-pour complex (Buildings CB-4/-4A and CB-6/-6A). Potentiometric mapping indicates an eastward-directed gradient from this area. One or more wells located east to southeast of LL1mw-083 and LL1mw-084, similar in position to LL1mw-067 (i.e., to the east and outside of the fence), would serve to monitor groundwater conditions impacted by this area of significant surface soil contamination.
4. Although little evidence of vertical migration exists, the assessment of deep groundwater at the site has not been performed and is considered a potential data gap, particularly in the former production area. Characterization of deep groundwater may be necessary, if such data are required in order to achieve remedial action objectives identified in the FS stage.
5. Collection of characterization data for the areas between production area aggregates for PAH and PCB extent. This information may be critical in determining areas and volumes for removal of hot spots. The data collection could be performed prior to remedial design or performed as confirmatory sampling following removal. Additionally, information regarding PCBs from point sources and investigation at LLs 2, 3, and 4 should be evaluated to help identify or fill potential data gaps related to these classes of compounds. Potential metals in paint sources should also be profiled.

6. Lack of groundwater data from well LL1mw-063 (dry during both the 1999 and 2000 sampling events) is a potential data gap with respect to source area characterization. It is recommended that this well be sampled (under wet season conditions) to fill this potential data gap.
7. Sediment in drainage ditches was characterized to a depth of 0.5 ft. Characterization of deeper sediment in drainage conveyances/ponds is a potential data gap and additional sampling at deeper intervals may be necessary as part of an FS phase to fully evaluate remedial alternatives.