FINAL

PHASE II REMEDIAL INVESTIGATION REPORT

FOR

LOAD LINE 3 AT THE RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO

VOLUME 1 – MAIN TEXT

PREPARED FOR

US Army Corps of Engineers®

LOUISVILLE DISTRICT
CONTRACT No. DACA45-03-D-0026
DELIVERY ORDER 0001

July 2004

Shaw® Shaw E & I

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Louisville District
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SHAW ENVIRONMENTAL, INC.
AND
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

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

CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Shaw Environmental, Inc. and Science Applications International Corporation (SAIC) have completed the Final Report for the Phase II Remedial Investigation for Load Line 3 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.

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

Independent technical review comments are recorded on an SAIC Document Review Record, per SAIC quality assurance procedure QAAP 3.1. 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.

Mike Fitzgerald

Vice President

Principal w/ A-E firm

7-29-04
Date

CONTENTS

FIGURES

TABLES

ACRONYMS

ADD	average daily dose
amsl	above mean sea level
AOC	Area of Concern
AT123D	Analytical Transient 1-,2-,3-Dimensional
AUF	area use factor
BAF	bioaccumulation factor
BCF	bioconcentration factor
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMCOC	contaminant migration contaminant of concern
CMCOPC	contaminant migration constituent of potential concern
COC	chemical of concern
COEC	chemical of ecological concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSF	cancer slope factor
CSM	conceptual site model
CX	Center of Excellence
DAF	dilution attenuation factor
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DLA	Defense Logistics Agency
DLF	dust-loading factor
DNB	1,3-dinitrobenzene
DNT	dinitrotoluene
DQA	data quality assessment
DQO	data quality objective
EDQL	Ecological Data Quality Level
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ESA	Endangered Species Act
ESV	ecological screening value
EU	exposure unit
FCM	food chain multiplier
FS	Feasibility Study
FWHHRAM	Facility-Wide Human Health Risk Assessor's Manual
GAF	gastrointestinal absorption factor
GPS	global positioning system
GSSL	generic soil screening level
HELP	Hydrologic Evaluation of Landfill Performance (model)
HI	hazard index
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HQ	hazard quotient
IDW	investigation-derived waste

IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	incremental lifetime cancer risk
IRP	Installation Restoration Program
LCS	laboratory control sample
LOAEL	lowest observed adverse effect level
MCL	maximum contaminant level
MDC	maximum detected concentration
MDL	method detection limit
MOA	Memorandum of Agreement
NAWQC	National Ambient Water Quality Criteria
NFA	No Further Action
NGB	National Guard Bureau
NOAEL	no observed adverse effect level
NWI	National Wetlands Inventory
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
ODOW	Ohio Department of Wildlife
OE	ordnance and explosives
Ohio EPA	Ohio Environmental Protection Agency
OHARNG	Ohio Army National Guard
OSC	Operations Support Command
PA	Preliminary Assessment
PAH	polycyclic aromatic hydrocarbon
PBT	persistent, bioaccumulative, and toxic
PCB	polychlorinated biphenyl
PEF	particulate emission factor
ppm	parts per million
PRG	preliminary remediation goal
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
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
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
SERA	screening ecological risk assessment
SESOIL	Seasonal Soil Compartment (leachate model)
SHHRA	screening human health risk assessment
SRC	site-related contaminant
STL	Severn Trent Laboratories, Inc.

SVOC	semivolatile organic compound
T&E	threatened and endangered
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TEF	toxicity equivalency factor
TNB	trinitrobenzene
TNT	trinitrotoluene
TOC	total organic carbon
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
UCL_{95}	95% upper confidence limit
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey
UTL	upper tolerance limit
UXO	unexploded ordnance
VOC	volatile organic compound
WBG	Winklepeck Burning Grounds
WOE	weight of analysis
WQS	Water Quality Standard
XRF	X-ray fluorescence

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EXECUTIVE SUMMARY

This Phase II Remedial Investigation (RI) Report presents 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 3 at the Ravenna Army Ammunition Plant (RVAAP) in Ravenna, Ohio. RVAAP, which consists of approximately 8,668.3 ha (21,419 acres), was constructed in 1940 and 1941 with the primary missions of depot storage and ammunition loading during World War II. Industrial operations at RVAAP consisted of 12 munitions-assembly facilities referred to as “load lines.” In 1992, the status of RVAAP changed from inactive-maintained to modified-caretaker and plans are currently underway to demolish dilapidated buildings and structures at some Areas of Concern (AOCs).

The overall purpose of this Phase II RI Report is to describe the investigation conducted at Load Line 3 to define the vertical and horizontal extent of contamination. The specific objectives of the Phase II RI are as follows.

- Characterize the physical environment of Load Line 3 and surroundings to the extent necessary to define potential contaminant transport pathways and receptor populations.

- Characterize nature and extent of contamination such that risk evaluations could be conducted and results compared to those from baseline risk assessments at risk extrapolation reference sites [Load Line 1 and Winklepeck Burning Grounds (WBG)]. The risk extrapolation process was developed among the U.S. Army, the U.S. Army Corps of Engineers (USACE), and the Ohio Environmental Protection Agency (Ohio EPA), and is currently under review as part of a RVAAP facility-wide risk assessment protocol. In addition, a baseline ecological risk assessment (BERA) has been applied, following current Army and Ohio EPA guidance.

- Identify whether releases of contamination beyond the AOC boundary are occurring by collecting environmental samples (surface water and sediment) downstream of the AOC boundary within exit conveyances and using applicable historical information, including results of the Phase I RI. Data collected prior to the Phase I RI are of limited use due to the lack of corresponding quality assurance/quality control data and information on detection limits and any verification/validation processes.

- Characterize sources of contamination at Load Line 3 sufficient to screen and evaluate remedial alternatives in a subsequent Feasibility Study (FS). Data on source locations, types and concentrations of contaminants, potential release mechanisms, physical and chemical properties of contaminants present, and geotechnical characteristics of environmental media were identified as key data needs.

- Provide recommendations for any additional investigations and/or actions.

This Phase II RI was conducted as part of the Army’s Installation Restoration Program approach to implement the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) process at RVAAP, which prioritizes environmental restoration at AOCs based on their relative potential threat to human health and the environment. The purpose of the Phase II RI is to determine the nature and extent of contamination in the environmental media so that screening level human health and ecological risk assessments (ERAs) can be performed. Results of the risk assessments will be used to determine whether an AOC requires no further action (NFA) or will be the subject of an FS.

PHYSICAL ENVIRONMENT

Load Line 3 is situated in the southeastern quadrant of the RVAAP facility. The load line is characterized by sloping topography on a reworked sandstone bedrock surface. Topographic elevations across most of the AOC generally decrease from east to the west and north towards Cobb's pond. Along the southern-most portion of the AOC, land surface elevations generally decrease south towards South Service Road. Cultural features of the AOC consist mostly of asphalt and gravel access roads, man-made ditches, sanitary and storm sewerlines, manholes, railroad beds, and buildings.

The regional geology at RVAAP consists of horizontal to gently dipping bedrock strata of Mississippian- and Pennsylvanian-age overlain by varying thicknesses of unconsolidated glacial deposits. At Load Line 3, subsurface characterization during the Phase I and II RIs identified bedrock at depths ranging from 1.0 to 4.6 m (3.5 to 15 ft) below ground surface (bgs). The average thickness of the unconsolidated interval was only 2.1 m (7 ft) within the load line. The composition of unconsolidated materials is fairly uniform and consists primarily of a yellowish-brown silt to clayey silt with intermittent gravel.

Sand and gravel aquifers are present in buried valley and outwash deposits in Portage County. Recharge of these units comes from surface water infiltration of precipitation and surface streams. Laterally, most groundwater flows along preferential pathways (sand seams, channel deposits, etc.). A facility-wide water table map prepared in August 2001 as part of the Phase II RI field investigation shows the water table to be a subdued representation of the surface topography. The predominant groundwater flow direction is to the east.

The primary surface water conveyances at Load Line 3 are ditches that drain to the west and, ultimately, to Cobb's Pond.

PREVIOUS INVESTIGATIONS

The Phase II RI at Load Line 3 was designed to collect data to supplement information obtained from two previous investigations at the site

- *Preliminary Assessment for the Ravenna Army Ammunition Plant* (USACE 1996a), and
- *Phase I Remedial Investigation of High Priority Areas of Concern at the Ravenna Army Ammunition Plant* (USACE 1998).

The preliminary assessment of Load Line 3 performed in 1996 included the site within the list of high priority sites based on a relative risk ranking methodology. Re-evaluation of the Load Line 3 risk ranking performed at the completion of the Phase I RI resulted in the site retaining its high risk rating.

The Phase I RI performed in 1996 included sampling and analysis of surface soils, sediment, and surface water. Phase I RI sampling data at Load Line 3 indicate that explosives contamination is present in surface soil surrounding former operations areas, including Buildings EB-4, EB-4A, and EB-10; the settling basin north of EB-4; and EB-3A (carrier washout building) above risk-based screening values.

PHASE II REMEDIAL INVESTIGATION INVESTIGATIVE APPROACH

The findings and data gaps identified during previous investigations guided the specific objectives and sampling design of the Phase II RI at Load Line 3. As detailed in the *Sampling and Analysis Plan*

Addendum No. 1 for the Phase II RI of Load Lines 2, 3, and 4 at the Ravenna Army Ammunition Plant, Ravenna Ohio (USACE 2001b), the Phase II RI sampling objectives, by medium, included the following.

Surface Soil and Sediment

- Determining the nature and horizontal extent of contaminations using biased sampling at each area within Load Line 3 having either explosives at concentrations ≥ 1 part per million (ppm), lead ≥ 100 ppm, and/or chromium ≥ 35 ppm, or polychlorinated biphenyls (PCBs) ≥ 10 mg/kg in surface soil during the Phase I RI. Primary areas of interest include Buildings EB-4, EB-4A, EB-6, EB-6A, and EB-10. Other areas of interest not characterized during the Phase I RI include the storm and sanitary sewer system.

- Comparing the surface soil and sediment data to the RVAAP facility-wide background dataset, which characterizes natural facility-wide variability for 23 target analyte list inorganics.

- Characterizing large non-production areas by random-grid sampling, using a statistical approach to ensure adequate area coverage and density.

- Assessing the suitability of field-based colorimetric analyses of trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) in soil and sediment samples. Results of these tests will determine the suitability of explosives field data for future environmental investigations and remedial activities.

Subsurface Soil

- Defining the vertical extent of contamination and studying transport pathways of any such materials.

Surface Water

- Determining whether runoff from contaminated areas around the former production area contribute contaminants in dissolved and suspended form to the surface water drainage system at Load Line 3, which is unlined and untreated.

- Determining whether drainages at Load Line 3 allow contaminants to migrate northward to the AOC boundary.

Groundwater

- Characterizing the Load Line 3 hydrogeologic flow system and chemical groundwater quality, with an emphasis on the water table zone downgradient of the most concentrated areas of soil contamination identified in the Phase I RI.

- Comparing groundwater results to the facility-wide background dataset.

These objectives were met through the field activities conducted in September and October 2001.

AVAILABLE DATA

The environmental database for the Load Line 3 Phase II RI includes data obtained from the field activities conducted in 2001. Data from the Phase I RI are mostly suitable for use considering that the

AOC remained relatively undisturbed between the Phase I and Phase II RIs. Other historical data did not have sufficient data quality documentation for use in this Phase II RI. The data collected under this Phase II RI include

- 131 surface soil samples,
- 27 subsurface soil samples,
- 26 sediment samples (includes 6 storm/sanitary sewer samples),
- 12 surface water samples (includes 2 storm/sanitary sewer samples),
- 13 groundwater samples, and
- 3 floor sweep samples.

Geological characterization was achieved through the collection of disturbed and undisturbed geotechnical samples from soil sampling stations, monitoring well borings, and test pits.

NATURE AND EXTENT

The RI evaluated the nature and extent of contamination in surface soil [0 to 0.3 m (0 to1 ft) bgs], subsurface soil to depths of 1 m (3 ft), sediment, surface water, and groundwater. The surface and subsurface soil, sediment, and surface water were divided into spatial aggregates based on former process operations and drainage areas. Surface soil and subsurface soil were divided in seven aggregates; those believed to be impacted by process-related activities and those believed to be relatively non-contaminated. Sediment and surface water were grouped by drainage area into three aggregates to facilitate examination of contamination nature and extent in these media and to focus on the receptor exposure points for the screening level human health and ERAs. Groundwater was considered on an AOC-wide basis. The results of this evaluation are summarized by medium.

Surface Soils

The occurrence and distribution of contaminants in surface soil differ within each aggregate; however, the types of constituents (i.e., explosives and inorganics) detected are relatively consistent throughout Load Line 3. The key results for contaminant nature and extent in soil are summarized by aggregate below.

Explosive Handling Areas Aggregate

- This exposure unit (EU) contained the highest concentrations and most extensive site-related contaminants (SRCs) within Load Line 3.

- Explosives within this aggregate are widespread in extent, with the highest concentrations near the major production and processing buildings. The highest detected concentration of 2,4,6-TNT (390,000 mg/kg) was identified near Building EB-10 and far exceeded any other detected concentration within the load line.

- Numerous inorganic SRCs were identified in this aggregate; aluminum, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, and zinc were most pervasive. Semivolatile organic compounds (SVOCs) were detected frequently, with the highest concentrations clustered near Buildings EA-6, EB-4, and EB-10.

- Volatile organic compounds (VOCs) were generally limited to toluene and acetone, all with low detected concentrations.

- PCBs were detected in a number of samples with the highest concentrations (up to 1,100 mg/kg) clustered in the vicinity of Building EB-4.

- Low concentrations of pesticides (e.g., maximum detect of 3.2 mg/kg for endrin) were detected throughout the aggregate.

Preparation and Receiving Areas Aggregate

- Explosives and propellants were detected in the surface soils immediate to Building EB-803. Explosive compounds were all less than 1 mg/kg.

- Nitrocellulose was present at a concentration of 29.9 mg/kg in the single sample analyzed.

- Pervasive inorganic SRCs include arsenic, barium, chromium, cobalt, copper, lead, manganese, nickel, vanadium, and zinc. Although their distribution is widely variable, the highest overall concentrations of inorganics appear to be clustered on the west side of Building EB-803.

- Low concentrations of polycyclic aromatic hydrocarbons (PAHs) [e.g., maximum detect of 0.96 mg/kg for benzo(*b*)fluoranthene] were detected; most observed detections were clustered near Buildings EB-3 and EB-803.

- PCBs were widely detected at relatively low concentrations, with the peak values being identified along the west side of Building EB-803.

- Four VOCs were detected at low concentrations associated with Building EB-3.

- Low concentrations of pesticides were detected. PCB-1254 was reported at 14 mg/kg at this location.

Packaging and Shipping Areas Aggregate

- Explosives concentrations were generally low, with a single peak concentration of 2,4,6-TNT (820 mg/kg) being associated with Building EB-11.

- Nitroguanidine was detected at low concentrations.

- Pervasive inorganic SRCs include barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, thallium, and zinc, with peak concentrations being identified west of Building EB-11.

- SVOCs (primarily PAHs) were detected as a single occurrence with all detected concentrations being less than 1 mg/kg.

- PCB-1254 was consistently detected, with the highest concentration (91 mg/kg) being reported near Building EB-11.

- VOCs and pesticides were not detected.

Change Houses Aggregate

- No explosives compounds greater than 1 mg/kg were detected during field analyses.

- Inorganic SRCs were widely detected within the surface soils of this aggregate, with the majority of constituents being detected at concentrations up to 2 times background values where established. Peak concentrations were associated with Building EB-8A.

- PCB-1254 was identified in four of six samples analyzed, with reported concentrations being confined to Buildings EB-8 and EB-8A.

- SVOCs, VOCs, and pesticides were not analyzed within this aggregate based on established data quality objectives (DQOs).

Perimeter Area Aggregate

- In general, low concentrations of explosive and propellant compounds were found associated with Buildings EA-21 and EA-5.

- Inorganic SRCs exceeding background concentrations were widely distributed, with peak concentrations of several metals being detected in the area of Building EA-21.

- SVOCs, specifically PAHs, were found associated with Building EA-21.

- The VOCs toluene and acetone were identified at a single location near Building EA-21 at concentrations less than 1 mg/kg.

- Low levels of several pesticides were identified near Building EA-21. PCB-1254 was reported at 110 mg/kg at this location as well.

DLA Storage Tanks Aggregate

- No explosives compounds greater than 1 mg/kg were detected during field analyses.

- Surface soils within this aggregate contain primarily elevated levels of inorganic SRCs. The most pervasive compounds were antimony and cadmium. Typically, elevated concentrations of inorganic SRCs were reported in the southernmost portion of the aggregate, specifically, just south of the former southernmost storage tank along the railroad track.

- Several SVOCs, primarily PAHs, were identified at a single location; however, all concentrations were less than 1 mg/kg.

- VOCs, pesticides, and PCBs were not detected in the surface soils.

West Ditches Aggregate

- Surface soil in this EU contained elevated levels of explosives, inorganics, SVOCs, and PCBs and, to a lesser extent, several pesticide compounds.

- Explosives and propellants were detected in this aggregate, typically at concentrations < 1 mg/kg. However, 2,4,6-TNT was identified as the most pervasive explosive compound reported at a peak concentration of 110 mg/kg, located at the western tip of the central ditch, just south of Building EB-8.

- Cadmium, lead, mercury, and zinc were the most pervasive inorganic SRCs, with consistent detections above background.

- SVOCs were commonly detected, with elevated concentrations of several PAHs reported in the areas of the confluence of the two southernmost ditches, north of Building EB-22.

- PCBs were detected at numerous locations with a peak concentration of 34 mg/kg associated with the central ditch, north of Building EB-8.

- Several pesticides were identified at low concentrations.

- VOCs were not analyzed for based on established project DQOs.

Subsurface Soils

Explosive Handling Areas Aggregate

- 2,4,6-TNT was identified in nearly all subsurface samples collected. The peak concentration of 270 mg/kg was reported near Building EA-6, with other elevated concentrations being reported in the same area and adjacent to Building EB-4. Several concentrations in subsurface soil samples in these areas were notably higher than those in the corresponding surface soil samples.

- The most pervasive inorganic SRCs were cadmium and lead (i.e., detected most frequently above background); however, other inorganic SRCs were found to be widely dispersed among all subsurface soil samples collected. The peak concentration accumulation areas for detected subsurface soil inorganics appear to be in the immediate vicinity of Buildings EB-4 and EA-6.

- PCBs were reported near Buildings EA-6 and EB-4, with the subsurface soil concentrations identified near Building EB-4 exceeding those reported in the corresponding surface sample.

- SVOCs, VOCs, and pesticides were not characterized in subsurface soils based on established DQOs.

Preparation and Receiving Areas Aggregate

- Concentrations of explosive compounds greater than 1 mg/kg were not detected during field analyses of subsurface soils.

- Inorganic SRCs consisting of arsenic, cadmium, lead, and zinc were identified, with peak concentrations exceeding background immediate to Building EB-3. All detected concentrations were, however, relatively low for those with background values, with all detects being less than 2 times background.

- SVOCs, VOCs, pesticides, and PCBs were not characterized in the subsurface soils based on established DQOs.

Perimeter Area Aggregate

- 2,4,6-Dinitrotoluene (DNT) was reported at 500 mg/kg near Building EA-5, along the railroad track. The corresponding surface soil sample exhibited a concentration of 0.83 mg/kg. Other explosive constituents were reported as single occurrences with low concentrations near Building EA-6.

- Arsenic, barium, beryllium, cadmium, chromium, copper, lead, and zinc were identified at concentrations above background near Building EA-21. Arsenic and beryllium concentrations exceeded those reported for the corresponding surface soil samples. Inorganic SRCs were not reported above background in the area of Building EA-5.

- SVOCs, VOCs, pesticides, and PCBs were not characterized within the subsurface soils of this aggregate based on established DQOs (SAIC 2000).

Sediment

Sediment samples were collected from the Cobb's Pond Tributary Aggregate. Those samples collected from the West Ditches were dry and addressed as surface soil samples.

- Explosive compounds were detected in the most downgradient sediment sample, although at low concentrations.

- Inorganic SRCs were identified in all sediment samples collected. The primary accumulation area for inorganics is near the confluence of the central ditch located north of Building EB-8 and the Cobb's Pond Tributary. The reported value for copper at this location was 8 times background.

- One PCB compound was detected at a concentration of less than 1 mg/kg.

- The Phase I RI reported generally low concentrations of pesticides and SVOCs in one sediment sample collected. Analysis of SVOCs, pesticides, and VOCs was not performed during the Phase II RI based on established DQOs.

Surface Water

Surface waters within Load Line 3 were divided into two aggregates: the Cobb's Pond Tributary Aggregate and the Miscellaneous Surface Water Aggregate.

Cobb's Pond Tributary Aggregate

- SRCs identified within the surface waters of the Cobb's Pond Tributary were limited to low concentrations of inorganics.

- An isolated occurrence of 2-butanone at low concentrations was identified at the most downgradient location of the tributary.

- SVOCs, pesticides, or PCBs were not detected in surface water in Cobb's Pond Tributary.

Miscellaneous Surface Water Aggregate

- Several explosive constituents were identified with all reported concentrations being less than 1 mg/L.

- Antimony and barium were identified as SRCs, although they occur at low concentrations.

- SVOCs, VOCs, pesticides, and PCBs were not detected in the Miscellaneous Surface Water Aggregate.

Sewer System Water and Sediment

Surface Water

- All explosive compounds detected in the water samples were reported at concentrations less than 1 mg/L.
- Water samples contained lead, nickel, and silver as inorganic SRCs, for which, no background values have been established. All concentrations were isolated detects at concentrations less than 0.01 mg/L.
- PCBs were not detected in the storm/sanitary sewer system waters.

Sediment

- Accumulation of explosives in sediment within the storm and sanitary sewer system of Load Line 3 appears limited to elevated concentrations (68 mg/kg) of 2,4,6-TNT. Several other explosive compounds were reported; however, concentrations were typically less than 1 mg/kg.
- Sediment collected from several manholes contained inorganic SRCs at concentrations between 1 (arsenic) and 143 (lead) times RVAAP background values for sediment.
- Other notable detections were chromium, copper, and barium with maximum concentrations at 25, 54, and 16 times RVAAP sediment background values, respectively. The peak concentrations were located in storm drain inlets near Building EB-803. Elevated inorganics were also present in the sediments from storm drain inlets near Buildings EB-11 and EB-10.
- PCB-1254 was identified in all sediment samples collected with the peak concentration (15 mg/kg) being detected in the storm drain inlet west of Building EB-4.
- SVOCs, VOCs, and pesticides were absent in sediment and water within the storm and sanitary sewer system of Load Line 3.

Groundwater

- Groundwater at Load Line 3 contained low concentrations of several explosive compounds in the area west of Building EB-4.
- Low concentrations of cobalt and manganese and several VOCs were identified throughout the aggregate. Organic constituents and cobalt were present at concentrations less than 1 mg/L.
- One SVOC [bis(2-ethylhexyl)phthalate] and two pesticide compounds [heptachlor epoxide and beta-benzene hexachloride (BHC)] were reported as isolated occurrences. All organic constituents and cobalt were present at concentrations less than 1 mg/L.
- PCBs were not detected.

Buildings and Structures

- Soil beneath building sub-floors exhibited low concentrations of explosives, several inorganic constituents, and PCB-1254 (Section 4.8.1).

- Explosive compounds were detected in the sediments collected from washout annexes and sedimentation basins with elevated concentrations being associated primarily with the washout basins in Building EB-4 and, to a lesser extent, the small sedimentation basin at Building EA-6.

- High levels of inorganic constituents, in particular, cadmium, chromium, copper, lead, and zinc, were identified. Primary accumulation areas with the highest reported values were the washout basins in Building EB-4 and the small sedimentation basin at Building EA-6.

- Relatively low concentrations of several SVOCs (maximum detect of 8.9 mg/kg RDX), primarily PAHs, and VOCs were identified in the washout annexes in Buildings EB-4 and EB-4A.

- Water samples collected from the washout basins reflected detectable concentrations of metals and explosives corresponding to those observed at high concentrations in sediment.

- Floor sweep samples were comprised of a high percentage of iron. Cadmium, chromium, lead, nickel, and zinc were present at elevated concentrations in all three buildings. Cyanide and As^{+3} were detected in the samples collected from all three buildings, although concentrations were low and relatively consistent. The highest levels of explosives were observed in Building EB-4. Low, estimated concentrations of a number of SVOCs and pesticides were detected in all of the floor sweep samples. Trace levels of acetone, benzene, and toluene were also detected in the samples collected from Buildings EB-10 and EB-3. PCB-1254 was detected in all three floor sweep samples with the highest values observed in Building EB-10.

- Cadmium and/or lead were detected in floor sweep sample toxicity characteristic leaching procedure (TCLP) extracts with concentrations exceeding their TCLP criteria at Buildings EB-10 and EB-3.

FATE AND TRANSPORT ANALYSIS

Contaminant fate and transport modeling performed as part of the Phase II RI included leachate modeling [Seasonal Soil Compartment (SESOIL)] at a selected source area within the Explosives Handling Areas Aggregate (i.e., Building EB-4) and groundwater modeling [Analytical Transient 1-,2-,3-Dimensional (AT123D)] from the sources to selected receptors or exit points from the AOC. Average precipitation, evapotranspiration rates, and other hydrologic parameters for the northeast Ohio region were input for the analyses.

SESOIL Modeling

One metal (selenium) and eight organic compounds (1,2-dinitrobenzene; 2,4-DNT; 2,6-DNT; 4-nitrotoluene; nitrobenzene; 1,3,5-trinitrobenzene; 2,4,6-TNT; and RDX) were identified as initial contaminant migration contaminants of potential concern (CMCOPCs) based on source loading predicted by the leachability analysis near the source (Building EA-4A) and were selected for SESOIL modeling. The SESOIL modeling results indicate that only RDX may leach from surface soil to groundwater with concentrations beneath the source area exceeding groundwater maximum contaminant levels (MCLs) or risk-based concentrations (RBCs). The predicted peak groundwater occurrence of RDX was 12 years, which, based on site history, may have already occurred. RDX was identified in groundwater at a concentration lower than the predicted value. The leaching model is conservative and migration of these constituents may be attenuated because of moderate to high retardation factors for these constituents.

AT123D Modeling

Modeling of contaminant transport in shallow groundwater was conducted for four CMCOPCs from the Building EB-4A source area to two endpoints. One of these four CMCOPCs (RDX) was identified from SESOIL modeling results, and the remaining three (manganese, beta-BHC, and heptachlor epoxide) were identified based on observed groundwater concentrations (those that exceeded their respective MCL or RBC). The first endpoint evaluated was the Cobb's Pond Tributary at the closest point to the source area; the tributary is presumed to be a discharge area for shallow groundwater based on potentiometric data. The second endpoint modeled was the RVAAP facility boundary at its closest point to the source area.

AT123D modeling results indicate that migration of RDX to the Cobb's Pond Tributary endpoint may occur with concentrations at the endpoint above RBCs. Modeling results indicate no migration of manganese, beta-BHC, or heptachlor epoxide to the Cobb's Pond Tributary and no migration of any of the CMCOPCs to the RVAAP boundary endpoints at concentrations exceeding MCLs or RBCs. Concentrations of RDX at the Cobb's Pond Tributary receptor point are predicted to reach a peak concentration of 0.375 mg/L. The predicted peak concentration for RDX at the RVAAP boundary point is 0.0000262 mg/L.

SCREENING LEVEL HUMAN HEALTH RISK ASSESSMENT

A screening human health risk assessment was conducted to identify chemicals of concern (COCs) and remedial goal options (RGOs) for contaminated media at RVAAP Load Line 3 for three potential future use scenarios: National Guard use, recreational use, and residential use. Results have been presented for all scenarios and exposure pathways. The following steps were used to generate conclusions regarding human health risks and hazards associated with contaminated media at Load Line 3:

- identification of chemicals of potential concern (COPCs);
- calculation of exposure point concentrations (EPCs) for COPCs;
- calculation of screening RGOs at a chemical hazard index (HI) of 0.1 or risk level of 10^{-6} for all identified COPCs;
- identification of COCs by comparing COPC concentrations against screening RGOs; and
- calculation of risk-based RGOs (HI of 1 or risk level of 10^{-5}) to move forward to the FS.

COCs were identified for National Guard receptors (Trainee, Security Guard/Maintenance Worker, and Fire/Dust Suppression Worker), recreational receptors (Hunter/Trapper/Fisher), and residential receptors (Resident Subsistence Farmer Adult and Child). A COC summary is presented in Table ES-1, with results discussed below for each medium. Risk-based RGOs were calculated for all chemicals identified as COCs (see Chapter 6.0) for any medium or receptor (e.g., arsenic is identified as a COC in surface water for the resident farmer only; however, risk-based RGOs are calculated for this metal for all receptors exposed to surface water).

Groundwater

One COC (2,4,6-TNT) was identified for the National Guard Trainee exposed via potable use of groundwater; this COC and five additional COCs (manganese, RDX, heptachlor epoxide, beta-BHC, and

Table ES-1. Chemicals Exceeding RGOs (COCs) by Receptor/Medium/Exposure Unit Combination at Load Line 3

COC	Groundwater			Surface Water					Sediment				
	National Guard Trainee	Resident Farmer Adult	Resident Farmer Child	Dust/Fire Control Worker	National Guard Trainee	Hunter/ Trapper/ Fisher	Resident Farmer Adult	Resident Farmer Child	Dust/Fire Control Worker	National Guard Trainee	Hunter/ Trapper/ Fisher	Resident Farmer Adult	Resident Farmer Child
Inorganics													
Aluminum													
Antimony													CP
Arsenic							CP	CP					
Barium													
Cadmium													
Manganese		LL3	LL3		CP		CP	CP					
Thallium													
Organic Explosives													
1,3-Dinitrobenzene													
2,4,6-Trinitrotoluene	LL3	LL3	LL3										
2,4-Dinitrotoluene													
RDX		LL3	LL3										
Organic PCBs													
PCB-1254													CP
PCB-1260													
Organic Pesticides													
4,4'-DDE													
Dieldrin													
Heptachlor													
Heptachlor Epoxide		LL3	LL3										
beta-BHC		LL3											
Organic Semivolatiles													
Benz(*a*)anthracene													
Benzo(*a*)pyrene												CP	CP
Benzo(*b*)fluoranthene													
Dibenz(*a,h*)anthracene													
Indeno(1,2,3-*cd*)pyrene													
Organic Volatiles													
Carbon Tetrachloride		LL3											

Table ES-1. Chemicals Exceeding RGOs (COCs) by Receptor/Medium/Exposure Unit Combination at Load Line 3 (continued)

COC	Shallow Surface Soil					Deep Surface Soil	Subsurface Soil	
	Security Guard/ Maintenance Worker	Dust/Fire Control Worker	Hunter/ Trapper/ Fisher	Resident Farmer Adult	Resident Farmer Child	National Guard Trainee	Resident Farmer Adult	Resident Farmer Child
Inorganics								
Aluminum					CH,EH,PS	CH,EH,PS		
Antimony				DL,WD	DL,EH,PR,PS,WD			
Arsenic	DL,EH,PA,PR,PS, WD			DL,EH,PA,PR,PS, WD	DL,EH,PA,PR,PS,WD	DL,EH,PA,PR,PS,WD	EH,PA,PR	EH,PA,PR
Barium					PS	PS		
Cadmium					PA,PS	PA,PS		PA
Manganese				PS	CH,DL,EH,PA,PR,PS, WD	CH,DL,EH,PA,PR,PS, WD		
Thallium					PR			
Organic Explosives								
1,3-Dinitrobenzene	EH			EH	EH			
2,4,6-Trinitrotoluene	EH,PS,WD	EH,PS	EH	EH,PS,WD	EH,PS,WD	EH,PA,PS	EH,PA	EH,PA
2,4-Dinitrotoluene	EH			EH,PS	EH,PS			
RDX	EH,PA			EH,PA,PR	EH,PA,PR		PA	PA
Organic PCBs								
PCB-1254	CH,EH,PA,PR,PS, WD	EH,PA,PS	EH,PA,PS	CH,EH,PA,PR,PS, WD	CH,EH,PA,PR,PS,WD	CH,EH,PA,PR,PS,WD	EH	EH
PCB-1260	EH			EH,PR	EH			
Organic Pesticides								
4,4'-DDE				PA	PA			
Dieldrin	EH			EH,WD	EH,WD			
Heptachlor				PA	PA			
Heptachlor Epoxide								
beta-BHC								
Organic Semivolatiles								
Benz(*a*)anthracene	EH,WD			EH,PA,WD	EH,WD			
Benzo(*a*)pyrene	EH,PA,PR,PS,WD	WD		EH,PA,PR,PS,WD	EH,PA,PR,PS,WD	EH,WD		
Benzo(*b*)fluoranthene	EH,WD			EH,PA,WD	EH,PA,WD			
Dibenz(*a,h*)anthracene	EH,WD			EH,PA,PR,WD	EH,WD			
Indeno(1,2,3-*cd*)pyrene	EH,WD			EH,WD	EH,WD			
Organic Volatiles								
Carbon Tetrachloride								

Table ES-1. Chemicals Exceeding RGOs (COCs) by Receptor/Medium/Exposure Unit Combination at Load Line 3 (continued)

COCs are shown for each medium/receptor/area of concern combination. Chemicals whose exposure point concentration exceeds its screening risk-based RGO are COCs. Area of concern codes are as follows:
LL3 = Load Line 3.
CH = Change Houses Aggregate
CP = Cobb's Pond Tributary Aggregate.
DL = DLA Tanks Aggregate.
EH = Explosives Handling Areas Aggregate.
PA = Perimeter Area Aggregate.
PR = Preparation and Receiving Areas Aggregate.
PS = Packaging and Shipping Areas Aggregate.
WD = West Ditches Aggregate.
BHC = Benzene hexachloride.
COC = Chemical of concern.
DDE = Dichlorodiphenyldichloroethylene.
PCB = Polychlorinated biphenyl.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
RGO = Remedial goal option. Screening risk-based RGOs are based on a cancer risk level of 10^{-6} or a hazard level of 0.1 (whichever is smaller) and are shown in Tables Q-10 through Q-15. Screening of Load Line 3 data to determine COCs is shown in Tables Q-16 through Q-21.

carbon tetrachloride) were identified for the On-Site Residential Farmer scenarios. For these groundwater COCs, ratios of EPCs to RGOs indicate that estimated cancer risks would be less than 10^{-6} for the National Guard Trainee and between 10^{-6} and 10^{-5} for the residential farmer scenarios. These are hypothetical future scenarios; no receptors are currently using groundwater from the AOC for any purpose.

Surface Water and Sediment

Exposure to surface water and sediment was evaluated for five receptor scenarios: National Guard Fire/Dust Suppression Worker, National Guard Trainee, Hunter/Trapper/Fisher, and Resident Farmer (adult and child). Manganese was the only surface water COC identified for the National Guard Trainee; this COPC and arsenic were identified for the On-Site Residential Farmer scenarios also. For the surface water COCs, ratios of EPCs to RGOs indicate that estimated cancer risks would be less than 10^{-6} for the two National Guard receptors, as well as for the Hunter/Trapper/Fisher; estimated cancer risks would be between 10^{-6} and 10^{-5} for the residential farmer scenarios.

Three chemicals were identified as sediment COCs for the Resident Farmer scenario only: antimony, PCB-1254, and benzo(*a*)pyrene. For the sediment COCs, ratios of EPCs to RGOs indicate that estimated cancer risks would be less than 10^{-6} for the two National Guard receptors, as well as for the Hunter/Trapper/Fisher; estimated cancer risks would be at or slightly above 10^{-6} for the residential farmer scenarios.

Soil

Surface soil was evaluated at seven EUs defined on the basis of Load Line 3 operational history and site characteristics; subsurface soil was evaluated in three EUs. Three vertical aggregations of the soil column were evaluated depending on the receptor scenario:

- shallow surface soil from 0 to 0.3 m (0 to 1 ft) bgs, as applied to all receptors, except the National Guard Trainee;
- deep surface soil from 0 to 1.3 m (0 to 4 ft) bgs, as applied to only the National Guard Trainee; and
- subsurface soil defined as all soil deeper than 0.3 m (> 1 ft) bgs for the Resident Farmer adult and child only.

The following summarizes the resulting COCs in soil at Load Line 3.

Shallow Surface Soil

Twenty-one Load Line 3 COCs were identified for shallow surface soil (Table ES-1). The number of shallow surface soil COCs varied for each receptor, with 2 COCs for the Hunter/Trapper/Fisher, 3 COCs for the Fire/Dust Suppression Worker, 13 COCs for the Security Guard/Maintenance Worker, 17 COCs for the Resident Farmer Adult, and 21 COCs for the Resident Farmer Child. The number of shallow surface soil COCs identified for each EU also varied: 3 for both the Defense Logistics Agency (DLA) Storage Tanks and Change Houses Aggregates, 8 for the Preparation and Receiving Areas Aggregate, 10 for the Packaging and Shipping Areas Aggregate, 11 for both the Perimeter Area and West Ditches Aggregates, and 16 for the Explosives Handling Areas Aggregate.

Ratios of EPCs to RGOs provide an indication of estimated cancer risks. Most COCs have EPCs that would produce cancer risks of less than 10^{-5}; a handful of COCs would produce risks in excess of 10^{-5} for receptors other than the resident farmer:

- PCB-1254 in six of the seven aggregates (all except the DLA Storage Tanks Aggregate; estimated risk for PCB-1254 would exceed 10-4 for the Security Guard/Maintenance Worker in the in the Explosives Handling Areas and Packaging and Shipping Areas Aggregates);
- 2,4,6-TNT in the Explosives Handling Areas and Packaging and Shipping Areas Aggregates; and
- benzo(*a*)pyrene in the Explosives Handling Areas and West Ditches Aggregates.

Estimated risks for several COCs would exceed the 10^{-5} risk level for the resident farmer scenarios, including:

- Arsenic (>10-4 in the Explosives Handling Areas Aggregate);
- 2,4,6-TNT (>10-4 in the Explosives Handling Areas Aggregate);
- 2,4-DNT;
- PCB-1254 (>10-4 in the Explosives Handling Areas, Packaging and Shipping Areas, and Perimeter Area Aggregates); and
- benzo(*a*)pyrene, benzo(*b*)fluoranthene, and dibenz(*a,h*)anthracene.

Deep Surface Soil

Eight Load Line 3 COCs were identified for the National Guard Trainee exposed to deep surface soil, including five metals (aluminum, arsenic, barium, cadmium, and manganese), one explosive (2,4,6-TNT), one PCB (PCB-1254), and one PAH [benzo(*a*)pyrene]. The number of deep surface soil COCs identified for each EU varied, ranging from two for the DLA Storage Tanks Aggregate to seven for the Packaging and Shipping Areas Aggregate.

Ratios of EPCs to RGOs indicate that estimated cancer risks would be at or slightly above 10^{-6} for most deep surface soil COCs; two COCs would result in estimated cancer risk to the National Guard Trainee of slightly larger than 10^{-5} at the Explosives Handling Areas Aggregate (2,4,6-TNT and PCB-1254), the Packaging and Shipping Areas Aggregate (PCB-1254), and the Perimeter Area Aggregate (PCB-1254).

Subsurface Soil

Five COCs were identified for the Resident Farmer (adult and child) exposed to subsurface soil at Load Line 3 (arsenic; cadmium; 2,4,6-TNT; RDX; and PCB-1254). The Perimeter Area, Explosives Handling Areas, and Preparation and Receiving Areas Aggregates had several identified COCs each.

Ratios of EPCs to RGOs provide an indication of estimated cancer risks. Estimated risks that would be greater than 10^{-5} for the resident farmer include arsenic and PCB-1254 (>10^{-4}) at the Explosives Handling Areas Aggregate; arsenic and 2,4,6-TNT at the Perimeter Area Aggregate; and arsenic at the Preparation and Receiving Areas Aggregate.

SCREENING AND BASELINE ECOLOGICAL RISK ASSESSMENT

Load Line 3 contains sufficient terrestrial and aquatic (surface water and sediment) habitat to support various types of ecological receptors, such as vegetation, small and large mammals, and birds. Due to the presence of suitable habitat and observed receptors at the site, a screening ERA was performed in accordance with written guidance from the U.S. Environmental Protection Agency, and also considered Ohio's water quality standards. Following the screening ERA, there was a Level III BERA performed on the preliminary COPECs. The methods followed the Army and Ohio EPA protocols and resulted in chemicals of ecological concern (COECs). Five terrestrial receptor classes (vegetation, soil-dwelling invertebrates, worm-eating and/or insectivorous mammals, mammalian herbivores, and terrestrial top predators) were evaluated. For aquatic receptor classes, sediment-dwelling organisms, aquatic organisms, and terrestrial top predators of aquatic organisms were evaluated. Groundwater was not evaluated, considering that direct exposure to receptors would be expected to occur as discharge to surface water features. Soil deeper than 0.3 m (1 ft) was also not evaluated, considering that contaminant concentrations in surface soil represent the probable worst-case exposures for most contaminants.

Soil

Risks were evaluated for seven EUs for surface soils based on historical use and geographic proximity. At all EUs, most preliminary contaminants of potential ecological concern (COPECs) were identified by comparing the maximum detection against an ecological screening value (ESV). One preliminary COPEC (PCB-1254) was identified at two of the six EUs in absence of an ESV. The number of preliminary COPECs that were identified by the rationale of the Load Line 3 mean concentrations > Load Line 1 mean concentrations per t-tests and the spatial distribution evaluation was generally small, ranging from six metals at the Explosives Handling Areas Aggregate and none at the Preparation and Receiving Areas and Perimeter Area Aggregates. All preliminary COPECs were further evaluated by calculating screening hazard quotients (HQs). BERA activities depended on the following ecological receptors: vegetation, soil invertebrates, cottontail rabbits, shrews, foxes, and hawks.

The Explosives Handling Areas Aggregate contained the most preliminary COPECs for soil (19, including 16 metals, 2 pesticides, and 1 PCB), whereas the West Ditches Aggregate contained the fewest preliminary COPECs for soil (6 metals each). The Preparation and Receiving Areas Aggregate had the second highest number of preliminary COPECs (12, including 9 metals, 1 explosive, 1 PCB, and 1 semivolatile). The Packaging and Shipping Areas Aggregate had nine preliminary COPECs (all metals). BERA activities reduced the number of COPECs in every location. The Explosives Handling Areas Aggregate had 11 COECs (down from 19 COPECs), the Preparation and Receiving Areas Aggregate showed 9 (down from 12), and the Packaging and Shipping Areas Aggregate had 8 (down from 9). The West Ditches Aggregate remained one of the lowest with five COECs (down from six) and the DLA Storage Tank Aggregate and Perimeter Area Aggregates were even less with COECs of four and three, respectively.

Sediment and Surface Water

Sediment

The Cobb's Pond Tributary Aggregate contained 29 preliminary COPECs for sediment (10 metals, 4 pesticides, 1 PCB, 2 explosives, and 12 semivolatiles). Approximately one-half of the preliminary COPECs for sediment were selected by virtue of being persistent, bioaccumulative, and toxic compounds (14 out of 29). Only five sediment analytes were identified as preliminary COPECs based solely on having no ESVs, and only three analytes were selected by having a maximum detect exceeding the ESV. All of these preliminary COPECs were further evaluated by calculating screening HQs. BERA activities utilized the following ecological receptors: benthic invertebrates, riparian herbivores (muskrats and mallards), and riparian carnivores (mink and herons). BERA activities reduced the number of COPECs. For example, at the Cobb's Pond Tributary Aggregate there are 18 COECs (down from 29 COPECs).

Surface Water

Three preliminary COPECs (three metals) were identified at the Cobb's Pond Tributary Aggregate. The rationales for identifying the preliminary COPECs included maximum detection exceeding ESV for iron and manganese, and no ESV for potassium. All of these preliminary COPECs were further evaluated by calculating screening HQs. BERA activities used the following ecological receptors: aquatic life, riparian herbivores (muskrats and mallards), and riparian carnivores (mink and herons). BERA activities further screened the three COPECs to two COECs.

CONCEPTUAL SITE MODEL

The preliminary Load Line 3 conceptual site model (CSM), developed as part of the Phase II RI Sampling and Analysis Plan Addendum, was summarized in Chapter 2.0. A revised CSM is presented in this section that incorporates Phase II RI data and the results of contaminant fate and transport modeling and risk evaluations. Elements of the CSM include

- primary contaminant source areas and release mechanisms,
- contaminant migration pathways and exit points, and
- data gaps and uncertainties.

Source-Term and Release Mechanisms

Results of the Phase II RI soil sampling indicate that the Explosives Handling Areas Aggregate, particularly areas surrounding Buildings EB-4 and EA-6, contain the greatest numbers and concentrations of contaminants. Metals, explosives, PAHs, and PCBs/pesticides are present in soil in these areas at concentrations greater than background or risk screening criteria. Other source areas defined by Phase II RI data include the areas surrounding Buildings EB-3 and EB-803 (inorganics and PCBs).

The majority of soil contamination at Load Line 3 is within the surface soil interval less than a depth of 0.3 m (1.0 ft). However, within the limited number of subsurface samples collected, explosives and several inorganic constituents were detected at elevated concentrations, primarily in the vicinity of Buildings EA-21 and EA-5 in the Perimeter Area Aggregate and Building EA-6 in the Explosives Handling Areas Aggregate.

Two primary mechanisms for release of contaminants from the source areas are identified (1) erosional and/or dissolved phase transport of contaminants from soil sources with transport into the storm drain network or drainage ditches, and (2) leaching of constituents to groundwater via infiltration of rainwater through surface and subsurface soils. Evaluation of these release mechanisms was done through sampling of the storm drainage network (ditches and storm sewers), sampling of the groundwater monitoring wells, and numerical modeling of soil leaching processes. Airborne dispersion of contaminants was not quantified or modeled. The chemical characteristics of the SRCs present high annual precipitation levels; heavy vegetation cover at Load Line 3 likely precludes any substantial dispersion of contaminants via this pathway.

Contaminant Migration Pathways and Exit Points

Surface Water Pathways

Migration of contaminants from soil sources via surface water occurs primarily by (1) movement of particle-bound (e.g., clays or colloids) contaminants in surface water runoff, and (2) transport of dissolved constituents in surface water. Surface runoff is directed to drainage ditches and the storm drainage network, most of which drain into the tributary to Cobb's Pond.

Upon reaching quiescent portions of surface water conveyances, flow velocities decrease and particle-bound contaminants are expected to settle out as sediment accumulation. Sediment-bound contaminants may be re-mobilized during storm events. Sediment-bound contaminants may also partition to surface water and be transported in dissolved phase. Sampling of the dry sediment from the West Ditches Aggregate indicates some contaminant accumulation from the Explosives Handling Areas Aggregate and sedimentation basins through these conveyances into the Cobb's Pond Tributary Aggregate that exits the AOC to the northwest. Results of sediment and water sampling from the storm sewer network indicate some accumulation of explosives and inorganics in sediment and only trace concentrations in water. Low levels of PCBs also appear to have accumulated. The sanitary sewer system is a closed system and is not open to receiving substantial surface water runoff.

Substantial contaminant accumulation within the Cobb's Pond Tributary is limited to inorganic constituents identified in isolated areas based on Phase I and II RI data. Inorganic SRCs were detected in tributary sediment and the highest concentrations appear to have accumulated near the confluence of the central west ditch located north of Building EB-8 and the Cobb's Pond Tributary. However, the magnitude of constituents exceeding background is generally low with the exception of copper, lead, and zinc. Partitioning of contaminants from sediment to water is not evident based on available data.

Accumulated explosive compounds were less than 1 mg/kg in tributary sediment and partitioning to water with subsequent dissolved phase transport is not evident. SVOCs, VOCs, pesticides, and PCBs were detected at low concentrations in stream sediments with no significant appearance in the tributary waters.

Leaching and Groundwater Pathways

Theoretical numerical modeling of leaching potential for soil source areas indicates that only 2,4,6-TNT and RDX may be expected to leach from the contaminated surface soil into the groundwater and reach concentrations exceeding groundwater MCLs or RBCs. The low measured concentrations of 2,4,6-TNT and RDX, and lack of overall substantial contamination, in groundwater at Load Line 3 suggest that retardation processes (e.g., sorption, degradation, etc.) effectively attenuate contaminants within the vadose zone. Shallow groundwater flow follows stream drainage and topographic patterns with flow to the west toward the AOC and RVAAP boundaries. Modeling results indicate that migration of RDX via shallow groundwater to the Cobb's Pond Tributary may occur at concentrations above RBCs. Concentrations of RDX at the Cobb's Pond Tributary receptor point are predicted to reach a peak concentration of 0.375 mg/L. The predicted peak concentration for RDX at the RVAAP boundary point is 0.0000262 mg/L. The conservative modeling results may not fully represent retardation and attenuation effects in the subsurface.

Given that several of the sanitary sewer manholes at Load Line 3 contained water, these utility networks may serve as preferential conduits for shallow groundwater movement. These systems were evaluated to determine if they facilitate transport of contaminants dissolved in groundwater or function as sources of dissolved phase contaminants to groundwater. As noted above, the storm drain network contains some accumulated inorganics and PCBs that appear to be partitioning to water, although concentrations are not grossly elevated relative to background values. Most contaminant accumulation is within the storm drain inlet basins. Accordingly, the storm drain network may act as a minor source of contaminant flux to groundwater and likely facilitates the movement of shallow groundwater in the vicinity of cracked or broken pipes where inflow or outflow may occur. The sanitary sewer system at Load Line 3 contains some accumulated inorganics and may contribute some level of contaminant flux to groundwater. However, the utility system is a closed system and contaminant concentrations were not grossly elevated; thus, it is not considered a primary source to groundwater or as a migration pathway.

Uncertainties

The CSM is developed based on available site characterization and chemical data. Uncertainties are inherent in the CSM where selected data do not exist or are sparse. The uncertainties within the CSM for Load Line 3 include the following.

- Groundwater monitoring wells installed during the Phase II RI targeted the water table interval only. The observed extent and magnitude of contamination in AOC soil and shallow groundwater do not indicate substantial contamination of groundwater within the AOC and conservative modeling results suggest that off-AOC migration of contaminants will not occur. However, groundwater within deeper flow zones was not characterized and conclusions regarding groundwater contaminant transport are representative of only the source areas modeled and hydrostratiographic intervals that were characterized.

- The exact source(s) of PAHs at Load Line 3 is unknown, although likely they may, in part, be anthropogenic combustion products derived from coal and/or fuel oil-fired power and boiler plant emissions.

- Leachate and transport modeling is limited by uncertainties in the behavior and movement of contaminants in the presence of multiple solutes. In addition, heterogeneity, anisotropy, and spatial distributions of permeable zones (e.g., sand or gravel zones) could not be fully characterized during the field investigation nor addressed in the modeling. Therefore, effects of these features on contaminant transport at Load Line 3 are uncertain and modeling results are considered as conservative representations.

- The exact source(s) of some inorganics (specifically manganese) in surface soils and sediments of Load Line 3 is unknown. Data evaluated in the nature and extent and risk evaluations address all accumulated contamination within the load line, whether from natural or anthropogenic sources. Results of the evaluations may reflect, in part, contributions from sources other than Load Line 3 (e.g., slag or pre-RVAAP activities).

- Limited data collected from beneath building floor slabs do not indicate substantial contamination of subfloor soils. However, additional data may be required to further characterize such soils if building floor slabs are removed as part of a future action.

CONCLUSIONS

The conclusions presented below, by medium, combine the findings of the contaminant nature and extent evaluation, fate and transport modeling, and the human health and ecological risk evaluations. To support remedial alternative selection and evaluation in future CERCLA documents (e.g., FS), RGOs were developed for identified COCs in surface soil, subsurface soil, surface water, sediment, and groundwater at Load Line 3. A summary of the results of the human health RGO comparisons is provided in Chapter 6.0.

Explosives Handling Areas Aggregate

The primary identified source areas in the Explosives Handling Areas Aggregate include Buildings EA-6 and EB-4. Metals, explosives, PAHs, and PCBs represent the most pervasive SRCs in the former production areas. The spatial distribution and concentrations of contaminants were highly variable in the vicinity of these source areas, with a general trend of contamination decreasing with depth.

Fate and transport modeling predict that leaching of metals and explosive compounds at Buildings EB-4 and EB-4A will result in concentrations of RDX at the groundwater table in excess of its RBC. The migration of metal constituents from the source areas to the closest groundwater baseflow discharge at concentrations in excess of RBCs is not predicted to occur within a timeframe of 1,000 years from Building EB-4. Migration of explosive compounds from Building EB-4, to the closest groundwater baseflow discharge points, is predicted to occur. Migration of most of the constituents is expected to be attenuated, due to moderate to high retardation factors, as well as degradation of organic compounds; these processes are not reflected in the conservative modeling results.

Comparison of concentrations of Load Line 3 COPCs in shallow surface soil to screening RGOs shows that a total of 16 chemicals exceeded the RGOs for at least one receptor scenario. Six deep surface soil COCs were identified for the National Guard Trainee. These subsurface soil COCs were identified for the Resident Farmer scenario (adult and/or child). COECs include numerous metals, two explosives, two pesticides, and PCB-1254.

Preparation and Receiving Areas Aggregate

The primary identified source areas in the Preparation and Receiving Areas Aggregate include Buildings EB-3 and EB-803. Metals, PAHs, and PCBs represent the most pervasive SRCs in these areas. The spatial distribution and concentrations of contaminants were highly variable. With respect to vertical distribution, the numbers and concentrations of SRCs in subsurface soil at these source areas deceased substantially relative to surface soil.

Comparison of concentrations of Load Line 3 COPCs in shallow surface soil to screening RGOs shows that a total of eight chemicals exceed the RGOs for at least one receptor scenario. Three COCs were identified for deep surface soil for the National Guard Trainee. One COC was identified for the Resident Farmer scenario in subsurface soil.

COECs include eight metals, one pesticide, one PAH, and PCB-1254.

Packaging and Shipping Areas Aggregate

The primary identified source area in the Packaging and Shipping Areas Aggregate is Building EB-11. Metals are the most pervasive SRCs in this area; low concentrations of PAHs and PCBs were detected sporadically. The spatial distribution and concentrations of contaminants were highly variable. No explosives compounds greater than 1 mg/kg were detected during field analyses. Accordingly, subsurface soil samples were not collected.

Comparison of concentrations of Load Line 3 COPCs in shallow surface soil to screening RGOs shows that a total of 10 chemicals exceed the RGOs for at least one receptor scenario. Seven deep surface soil COCs were identified for the National Guard Trainee. No COCs were identified for the Resident Farmer scenario in subsurface soil in this aggregate. COECs include nine metals and benzoic acid.

Change Houses Aggregate

Surface soil in this EU contains 14 inorganic SRCs with results exceeding RVAAP background values; however, concentrations were typically less than 2 times background values. Low levels of PCBs were also reported. No explosives compounds greater than 1 mg/kg were detected during field analyses. Accordingly, subsurface soil samples were not collected. Maximum levels of SRCs were detected in the vicinity of Buildings EB-8 and EB-8A.

Comparison of concentrations of Load Line 3 COPCs in shallow surface soil to screening RGOs shows that a total of three chemicals exceed the RGOs for at least one receptor scenario. Three deep surface soil COCs were identified for the National Guard Trainee. Subsurface soils were not evaluated, as no samples were collected.

Perimeter Area Aggregate

The primary contaminant source in this aggregate is Building EA-21 and, to a lesser extent, Building EA-5. Elevated concentrations of PCB-1254 were reported near Building EA-5. Elevated explosives and propellant compounds, specifically RDX and nitrocellulose, and inorganics (primarily antimony, barium, chromium, copper, lead, and zinc) were clustered in the vicinity of Building E-21. Lead and zinc concentrations were lower than those observed in surface soil; however, each was reported at concentrations greater than 4 times background. Minor concentrations of several PAH compounds, pesticides, and VOCs were also reported.

Comparison of concentrations of Load Line 3 COPCs in shallow surface soil to screening RGOs shows that a total of 11 chemicals exceed the RGOs for at least one receptor scenario. Five deep surface soil COCs were identified for the National Guard Trainee. Four subsurface soil COCs were identified for the Resident Farmer scenario (adult and/or child). COECs include seven metals.

West Ditches Aggregate

Surface soil in this EU exhibited elevated levels of explosives, inorganics, SVOCs, and PCBs. Generally, elevated explosives, SVOCs, and PCBs were confined to select locations and not widely distributed. Inorganic SRCs consistently exceeded background values by factors of more than 2 times background. Subsurface soil samples were not collected from this aggregate due to the lack of detectable field explosives in surface soil.

Comparison of concentrations of Load Line 3 COPCs in shallow surface soil to screening RGOs shows that a total of 11 chemicals exceed the RGOs for at least one receptor. Four COCs were identified for deep surface soil for the National Guard Trainee. Subsurface soil was not collected in this aggregate. COECs include nine metals and benzoic acid.

DLA Storage Tanks Area Aggregate

No explosives compounds greater than 1 mg/kg were detected during field analyses. Surface soils within this aggregate contain primarily elevated levels of inorganic SRCs. The most pervasive compounds were antimony and cadmium, with elevated concentrations of inorganics being reported in the southernmost DLA storage tank farm, specifically, just south of the southernmost storage tank along the railroad track. Several SVOCs, primarily PAHs, were identified at a single location; however, all concentrations were less than 1 mg/kg. VOCs, pesticides, and PCBs were not detected in the surface soils of the DLA Storage Tanks Aggregate.

Comparison of concentrations of Load Line 3 COPCs in shallow surface soil to screening RGOs shows that three chemicals exceed the RGOs for at least one receptor. Two COCs were identified in deep surface soil for the National Guard Trainee scenario. Subsurface soils were not collected in this aggregate. COECs include 10 metals.

Sediment and Surface Water

Sediment in the Cobb's Pond Tributary Aggregate

Explosives contamination in sediment of the Cobb's Pond Tributary Aggregate is confined to the most downgradient location and at low concentrations. Inorganic SRCs exceeded background criteria by factors of 2 (nickel) to 8 (copper) times. Trace concentrations of one PCB compound and several pesticides and SVOCs were detected.

Three sediment human health COCs were identified for the Resident Farmer (child): antimony, PCB-1254, and benzo(*a*)pyrene. Benzo(*a*)pyrene was also identified as a COC for the Resident Farmer (adult).

COECs include 10 metals, 2 explosives, 12 PAHs, 3 pesticides, and PCB-1254.

Surface Water in the Cobb's Pond Tributary and Miscellaneous Surface Water Aggregates

Explosives were not detected in water samples collected from any of the three EUs established within the main stream and settling pond. Vanadium and manganese were the only two inorganic SRCs detected consistently in surface water above background criteria; maximum concentrations of manganese occurred within the aggregate upstream of the Load Line 3 Perimeter Road. The pesticide 4,4'-dichlorodiphenyltrichloroethylene was detected in one water sample from the settling pond; no SVOCs or PCBs were detected. VOCs were only sporadically detected at low concentrations. Of the identified SRCs in surface water, manganese was identified as a COC for the National Guard Trainee and Resident Farmer (adult and child). Arsenic was also identified as a COC for the adult and child Resident Farmer.

Groundwater

Groundwater within the AOC contains low concentrations of several explosive compounds and minor contributions of cobalt and manganese; however, inorganic constituent occurrence and distribution above background criteria were sporadic. Low concentrations of VOCs and SVOCs were observed.

The Load Line 3 groundwater aggregate was evaluated to identify COCs. Comparisons of Load Line 3 COCs in groundwater to screening RGOs show that 2,4,6-TNT, (National Guard and/or Resident Farmer scenarios) manganese, RDX, heptachlor epoxide, beta-BHC, and carbon tetrachloride (Resident Farmer only) exceed RGOs.

Storm and Sanitary Sewer System

The sanitary sewer sediment does not contain accumulated explosives based on Phase II RI sampling results, although accumulated inorganics and low levels of PCBs are present. Inorganics and PCB partitioning to water appears limited within the system, as evidenced by low to non-detected concentrations of each in the sanitary sewer waters. Low levels of explosives were reported in the waters of the storm sewer indicating the introduction of explosive compounds through building drains and/or sumps. The sanitary sewer system does not receive large influxes of storm runoff and is largely a closed system, except where pipes may be cracked. Considering the characteristics of the sanitary sewer system and the fact that contaminant concentrations were not grossly elevated; it is not considered a primary source to groundwater or migration pathway.

The storm sewer system does contain accumulated sediment, explosives, inorganics, and PCBs based on Phase II RI sampling results. Although water samples were not collected from the storm sewer during rain events, significant flow enters the system. Therefore, the storm drain network may act as a minor source of contaminant flux to groundwater and likely facilitates the movement of shallow groundwater in the vicinity of cracked or broken pipes where inflow or outflow may occur.

Buildings and Structures

Soil beneath building sub-floors exhibited generally low concentrations of explosives, several inorganic constituents, and PCB-1254, based on a limited number of samples collected from beneath building floor slabs.

Any future demolition of the Building EB-4 washout basin should consider that sediment in this structure contained elevated levels of metals, explosives, propellants, PCBs, and pesticides. The associated water sample contained elevated levels of many constituents that were detected at high concentrations in sediment.

Any future demolition of the Building EA-6 sedimentation basin should consider that sediment in this structure contained elevated concentrations of several metals related to historical processes (cadmium, chromium, copper, lead, and zinc).

Floor sweeping samples collected from Buildings EB-4, EB-10, and EB-3 were comprised of a high percentage of iron. Copper, cadmium, chromium, and lead were present at high concentrations, particularly in Buildings G-8 and G-19. Low concentrations of explosives were detected in samples from G-8 and G-19. Low concentrations of PCBs, pesticides, and various PAHs were also detected. Cadmium and/or lead were detected in TCLP extracts with concentrations exceeding the TCLP criteria for hazardous waste determination at Buildings EB-10 and EB-3; however, no constituent exceeded their respective criteria for characteristically hazardous wastes.

LESSONS LEARNED

A key project quality objective for the Phase II RI at Load Line 3 was to document lessens learned so that future projects could constantly improve data quality and performance. The primary lessons learned through the recent activities associated with the Load Line 3 RI are as follows.

- The integration of RI activities for Load Lines 2, 3, and 4 was a valuable tool to minimize reporting costs (i.e., preparation of a single work document) and field mobilization costs for Science Applications International Corporation and its subcontractors. The integration also allowed field work for each load line to be accomplished consecutively, using the same personnel who were familiar with the sites and the project.

- The designation of a single, formal, investigation-derived waste (IDW) Compliance Officer, allowed all IDW issues to be handled through a single contact. This representative coordinated the on-site management and disposal of all IDW, which led to no compliance issues related to IDW during the course of the project.

- Analytical difficulties were encountered for some floor sweep and other sample types due to the suspected presence of paint chips, creosotes, or other materials. Prior notification to the laboratory is advised when such unusual samples may be collected so the laboratory can adjust extraction or analytical protocols, as needed, to avoid potential faulting of the instrumentation.

- The use of field-portable X-ray fluorescence (XRF) analysis was not employed during the Phase II RI field activities. However, this field procedure may have provided useful information regarding the distribution of inorganic constituents in soil. Upon completion of the evaluation and testing of new method(s), use of the field XRF to help guide characterization sampling activities or to conduct remediation verification should be considered.

- The incorporation of undesignated contingency samples into the project plan afforded the project greater flexibility to sample select locations based on field observations and site-specific conditions.

- The on-site presence of Ohio EPA and USACE staff during field operations was beneficial in that potential changes to the project work plan due to field conditions could quickly be discussed, resolved, and implemented.

- The availability of on-site facilities for field operations use was extremely beneficial. Having high quality shelter facilities for sample storage, equipment decontamination, and management operations improves the overall project quality and efficiency.

- Field operations were temporarily suspended for 5 days beginning September 12, 2001, due to RVAAP security measures in response to the terrorist attacks of September 11, 2001. As a result, field operations were placed in a safe and compliant standby condition. Future work plans for RVAAP may include a section containing instructions for unplanned events resulting in the immediate suspension of field operations.

RECOMMENDATIONS

To provide decision makers with the information necessary to evaluate remedial alternatives and to reduce or eliminate potential risks to human and/or ecological receptors, it is recommended that Load Line 3 proceed to the FS phase under the RVAAP CERCLA process. It is recommended that the FS phase employ a streamlined remedial alternative evaluation process based on the most likely land use assumptions by evaluating a range of effective alternatives, technologies, and associated costs. The intent of this strategy is to accelerate site-specific analysis of remedies by focusing the FS efforts on appropriate remedies that have been evaluated for other sites with operational histories similar to Load Line 3.

The future land uses and controls envisioned for Load Line 3 should be determined prior to selection of the path forward for the site. Establishment of the most likely land use scenario(s) will equip decision makers with the initial information necessary to determine the correct remedial action, such as source removal, land use controls, and/or continued monitoring, to achieve requisite protection of human health and the environment. The envisioned future use of the AOC, or a portion of the AOC, is an important consideration in determining the extent of remediation necessary to achieve the required degree of protectiveness. For example, a residential versus a National Guard land use scenario influences how much cleanup is needed to lower the risk to protective levels. Establishment of land use will also allow streamlined evaluation of remedies and will be necessary for documentation in a remedial action.

Areas having the same projected land use within Load Line 3 (and at other melt-pour lines at RVAAP) will incorporate the same RGOs into remedial alternative development. Also, the FS should consider potential future separate actions related to surface water systems and recognize the connection of surface water exit pathways among the four major melt-pour lines (Load Lines 1 through 4), as well as Load Line 12.

The FS should apply results of the ecological field truthing effort at WBG (pending agreement by Ohio EPA) to remedial goal development for Load Line 3 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, which are necessary to evaluate remedial alternatives, are deferred to the FS planning stage. The following components may be necessary for a thorough FS evaluation or may be considered under a separate remedial action process for integrator media, such as surface water or groundwater.

- Refinement of EU boundaries if remedial decisions by EU are to be considered most feasible by decision makers. Such a delineation would allow

    1. Prioritization of EUs or areas from highest potential risk to lowest potential risk.

    2. Selection of cleanup actions and exit strategies per EU and/or per buildings each EU, (e.g., certain areas may be remediated by soil removal, whereas remediation of other areas, such as a process building vicinity, may require an alternate approach).

    3. Potential elimination of all or portions of certain EUs from additional investigation or further action, such as portions of the Perimeter Area Aggregate, thus reducing the footprint of the AOC.

- Assessment of shallow groundwater at Load Line 3 indicated contamination related to historical process operations. Subsurface soil data at Load Line 3 indicated the presence of explosives and metals SRCs above levels of concern. Although definitive evidence of vertical migration of contaminants does not exist, assessment of deep groundwater at the site has not been performed and may be a potential data gap. Characterization or monitoring of deeper groundwater may be necessary to evaluate certain potential remedial actions or support future resource use decisions.

- Sediment in the Cobb's Pond Tributary Aggregate and dry conveyances in the Western Ditches Aggregate was characterized to typical depths of 0.15 m (0.5 ft). Characterization of deeper sediment in drainage conveyances is a potential data gap and additional sampling at deeper intervals may be necessary to evaluate potential remedial actions or to support future resource use decisions.

- The requirements of the Toxic Substances and Control Act (TSCA) should be evaluated to determine if they may be warranted. Likewise, TSCA may be an applicable or appropriate and relevant requirement for future remedial actions involving soil or sediment containing PCBs above certain threshold criteria.