FINAL

PHASE II REMEDIAL INVESTIGATION REPORT

FOR THE

OPEN DEMOLITION AREA #2 (RVAAP-04)
AT THE
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO

VOLUME I

PREPARED FOR

US Army Corps of Engineers®

LOUISVILLE DISTRICT

CONTRACT No. GS-10F-0076J
DELIVERY ORDER W912QR-05-F-0033

September 2005

FINAL

PHASE II REMEDIAL INVESTIGATION REPORT
FOR THE
OPEN DEMOLITION AREA #2 (RVAAP-04)
AT THE
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO

September 2005

Prepared for

U.S. Army Corps of Engineers
Louisville District
Contract No. GS-10F-0076J
Delivery Order W912QR-05-F-0033

Prepared by

Spec Pro Inc.
8451 State Route 5
Ravenna, OH 44266

Revised by

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
8866 Commons Boulevard, Suite 201
Twinsburg, Ohio 44087

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES
(PRESENTED AT THE END OF EACH SECTION)

LIST OF ACRONYMS

amsl	above mean sea level
AOC	Area of Concern
AT123D	Analytical Transient 1-, 2-, 3-Dimensional
bgs	below ground surface
BERA	Baseline Ecological Risk Assessment
BTOC	below top of casing
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMCOC	contaminant migration chemical of concern
CMCOPC	contaminant migration chemical of potential concern
COC	chemical constituent of concern
COI	chemical of interest
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSF	cancer slope factor
CSM	conceptual site model
DAD	dermally absorbed dose
DAF	dilution attenuation factor
DDD	dichlorodiphenyldichloroethane
DNT	dinitrotoluene
DoD	U.S. Department of Defense
DQA	data quality assessment
DQO	data quality objective
DQSR	Data Quality Summary Report
ECSM	ecological conceptual site model
EDQL	ecological data quality level
EP	extraction procedure
EPC	exposure point concentration
ERA	ecological risk assessment
ESA	Endangered Species Act
ESV	ecological screening value
EU	exposure unit
FEMA	Federal Emergency Management Agency
FFHHRAM	Facility Wide Human Health Risk Assessor Manual
FS	Feasibility Study
GAF	gastrointestinal absorption factor
GI	gastrointestinal
GOCO	government-owned, contractor-operated
GSA	U.S. General Services Administration
GSSL	generic soil screening level
HEAST	Health Effects Assessment Summary Table
HELP	Hydrologic Evaluation of Landfill Performance

LIST OF ACRONYMS (CONTINUED)

HHBRA	human health baseline risk assessment
HHRA	human health risk assessment
HI	hazard index
HQ	Hazard quotient
HMX	high melting explosive (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)
IDW	investigation-derived waste
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
JMC	Joint Munitions Command
LOAEL	lowest-observed-adverse-effect level
MF	modifying factor
MS/MSD	matrix spike/matrix spike duplicate
MCL	maximum contaminant level
MDC	maximum detected concentration
MDL	method detection limit
MEC	munitions and explosives of concern
MMRP	Military Munitions Response Program
NEPA	National Environmental Policy Act
NGB	National Guard Bureau
NOAEL	no-observed-adverse-effect level
NPL	National Priority List
OAC	Ohio Administrative Code
ODA2	Open Demolition Area #2
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
OVA	organic vapor analyzer
PAH	polycyclic aromatic hydrocarbon
PBC	Performance Based Contract
PBT	persistent, bioaccumulative, and toxic
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PRG	preliminary remediation goal
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan

LIST OF ACRONYMS (continued)

QC	quality control
QHEI	Qualitative Habitat Evaluation Index
RAGS	Risk Assessment Guidance for Superfund
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
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
SCM	site conceptual model
SERA	Screening Ecological Risk Assessment
SESOIL	Seasonal Soil Compartment Model
SMDP	Scientific Management Decision Point
SRC	site-related contaminant
SRV	sediment reference value
SVOC	semi-volatile organic compound
T&E	threatened and endangered
TAL	target analyte list
THI	target hazard index
TKN	total Kjeldahl nitrogen
TNT	Trinitrotoluene
TOC	total organic carbon
TR	target risk
UCL_{95}	95% upper confidence limit
UF	uncertainty factor
USACE	U. S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventative Medicine
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
UTL	upper tolerance limit

LIST OF ACRONYMS (continued)

UXO	unexploded ordnance
VF	volatilization factor
VOC	volatile organic compound
WOE	weight-of-evidence
WQC	water quality criteria

EXECUTIVE SUMMARY

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 Open Demolition Area #2 (ODA2) at the Ravenna Army Ammunition Plant (RVAAP) in Ravenna, Ohio. ODA2 consists of approximately 25 acres. It has been used since 1948 to detonate large caliber munitions and off-spec bulk explosives that could not be deactivated or demilitarized by any other means due to their condition. Materials treated by open detonation in ODA2 have included primer elements, bombs, and various caliber munitions. More recent burning and detonation activities related to facility operations occurred until 1994 in a 2.5 acre area covered under a Resource Conservation and Recovery Act (RCRA) permit application. Since 1994, Explosive Ordnance Disposal (EOD) personnel from Wright Patterson Air Force Base, and other contractor Unexploded Ordnance (UXO) professionals have used this area for non-routine and emergency detonations. A geophysical survey of the area in July of 1999 indicated the presence of large amounts of metallic debris with several large anomalies possibly indicating Munitions and Explosives of Concern (MEC) contamination. MEC clearance to a depth of 4 feet was performed by Vista (now SpecPro) in 1999-2000, during which over 100,000 MEC items and over 150,000 pounds of scrap metal were recovered. In addition, past operations at this Area of Concern (AOC) may have included the burial of munitions and ordnance components.

The RCRA Unit at ODA2 will remain open until its use is no longer required, and is not included in the scope of this investigation as it will be closed under RCRA regulations. However, previous investigations are summarized in this report and were used to assist with definition of nature and extent (but were not included in the HHRA or ERA). Rocket Ridge is within the limit of assessment for ODA2; however, it is not included in the scope of this investigation. MEC concerns related to Rocket Ridge will be addressed under the Military Munitions Response Program (MMRP) currently evolving. While the future MMRP has yet to determine basic parameters for this AOC, the vast amount of already unearthed and suspected large amounts of buried MEC, including burial of white phosphorus, will in all probability dictate that this AOC will never be utilized for anything but ordnance disposal related activities, and almost certainly would never be releases to the public.

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 (CERCLA) process at RVAAP, which prioritizes environmental restoration at AOCs based on their relative potential threat to human health and the environment. The investigation evaluated and characterized the nature and the vertical and horizontal extent of contamination to the shallow and deep soils, groundwater, surface water and sediment media resulting from activities at this site. The specific objectives of the Phase II RI are to:

- determine the boundaries of environmental contamination of the AOC at ODA2,
- measure the AOC physical characteristics,
- identify the sources of contamination, especially south of Sand Creek,

- characterize the nature and extent of contamination at ODA2, especially south of Sand Creek,
- assess the risk posed to human health and the environment
- establish a system to monitor potential off-site migration of contaminants

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).

PREVIOUS INVESTIGATIONS

Previous investigations of the 2.5-acre RCRA site within ODA2 included surface and subsurface soil, surface water, sediment, surface runoff, and aquatic organism sampling (USAEHA 1992). The Phase II RI at ODA2 was designed to collect data to supplement information obtained from eight previous investigations at the site:

(1) *Hazardous Waste Management Study No. 37-26-0442-84* (USAEHA 1984);
(2) *Geohydrologic Study No. 38-26-KF95-92* (USAEHA 1992);
(3) *Preliminary Assessment for the Ravenna Army Ammunition Plant* (USACE 1996);
(4) *Phase I Remedial Investigation of High Priority Areas of Concern at the Ravenna Army Ammunition Plant* (USACE 1998);
(5) *RCRA Closure Field Investigation Report for the Deactivation furnace Area, Open Detonation Area, Building 1601, and Pesticides Building, Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 1998);
(6) *Report of Analytical Results Demolition Area #2 CERCLA Sites* (USIOC 2000); and
(7) *Archive Search Report for the Ravenna Army Ammunition Plant* (USACE 2004).
(8) *Facility-wide Biological and Water Quality Study 2003, Ravenna Army Ammunition Plant, Part 1 – Streams and Part II – Ponds*. (USACE 2005)

The Preliminary Assessment of ODA2 performed in 1996 included the ODA2 site in the list of High Priority sites based on a relative risk ranking methodology. Reevaluation of the ODA2 risk ranking performed at the completion of the Phase I RI resulted in the site retaining its “High Risk” rating.

Samples collected from the previous investigations include:

- 1984 USAEHA Study: 10 surface soil samples
- 1992 USAEHA Study: four monitoring wells, 47 surface and subsurface soil samples, and three surface water and sediment samples
- 1998 RCRA Closure: 32 surface soil locations and 29 subsurface soil locations
- 1998 Phase I RI: Surface soil and subsurface soil from 30 soil locations and 3 sediment locations
- 2000 Report of Analytical Results Demolition Area #2: 12 surface and subsurface soil samples and 12 sediment samples

- 2005 Facility-wide Biological and Water Quality Study: Surface water and sediment samples collected upstream and downstream of ODA2 in Sand Creek.

PHASE II RI INVESTIGATIVE APPROACH

The findings and data gaps identified during previous investigations guided the specific objectives and sampling design of the Phase II RI at ODA2. As detailed in the *Sampling and Analysis Plan Addenda for the Phase II RI at Demolition Area 2 at RVAAP* (USACE 2001), the Phase II RI sampling objectives, by medium, included:

Surface Soil and Subsurface Soil: Based on previously collected characterization data, the contaminated soil within and adjacent to former demolition pits and suspected burial areas is a potential secondary source of contamination in sediment, surface water, and groundwater. Primary sources of contamination include explosive residues from incomplete explosions, and metals from demolition of casings, as steel (primarily iron), brass (zinc and copper), and aluminum, with minor amounts of cadmium and chroming plating. Contaminants may be released from the soil and migrate into storm runoff either in the dissolved phase or adsorbed to particulates and/or colloids. Further characterization of suspected areas of soil contamination was conducted to define the contaminant nature and extent and to provide sufficient data for a remedial alternatives analysis in a subsequent feasibility study. Subsurface soil characterization was also conducted to determine if leaching may be a potential mechanism for contaminant migration to groundwater. The Phase I RI and other historical sampling did not characterize all of the suspected former demolition pits and burial areas. Thus, those areas not previously characterized were specifically targeted for biased sampling in the Phase II RI.

Sediment: Site characteristics and available field data show that the primary surface water and sediment exit pathways for the ODA2 AOC follow unnamed ditches and tributaries that ultimately feed into Sand Creek. For the portion of the AOC that is located south of Sand Creek, drainage flows to the north and east; for the portion of the AOC that is located north of Sand Creek, drainage flows to the south and east. Considering the available data and the conceptual site model (CSM), both confirmed and additional suspected source areas, as well as the exit pathways, were specifically targeted for biased sediment sampling in the Phase II RI.

Surface Water: Surface water represents the likely primary medium for mobilization and transport of contamination within and from ODA2. Most chemical transport via surface water is presumed to occur along the ditches within the AOC and is primarily episodic and related to storm events that produce flushing of the surface water system and mobilization of contaminated soil and sediment through erosion. Based on the CSM, upstream and downstream locations in Sand Creek were specifically targeted for biased surface water sampling in the Phase II RI.

Groundwater: No hydrogeologic and analytical data existed from previous investigations for groundwater for the portion of ODA2 that lies south of Sand Creek. Wells were thus installed in the vicinity of known or suspected source areas both north and south of Sand Creek to evaluate whether contaminants are leaching to groundwater. Monitoring wells were also placed in close proximity to Sand Creek to determine whether groundwater flow and potential contaminant transport is occurring into Sand Creek and off of the AOC.

These objectives were met through the field activities conducted in July 2002 through April 2003. The data collected under this Phase II RI include:

- 66 surface soil samples
- 66 subsurface soil samples
- 15 sediment samples
- 12 surface water samples, and
- 16 groundwater samples.

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

NATURE AND EXTENT OF CONTAMINATION

The RI evaluated the nature and extent of contamination in surface soil (0 to 0.3 meter [0 to 1 foot below ground surface {bgs}]); subsurface soil from depths of 0.3 to 1 meter (1 to 3 feet) bgs, subsurface soil that ranged to 2.1 meters (7 feet) bgs, sediment, surface water, and groundwater. The surface and subsurface soil, sediment, and surface water were divided into spatial aggregates based on drainage areas. Surface soil and subsurface soil were divided into two aggregates:

- Area A – area north of Sand Creek, not including the RCRA area
- Area B – southern floodplain downgradient of the Sand Creek Disposal Area (Rocket Ridge).

For surface water samples, ODA2 was separated into two aggregates:

- Upstream of suspected source areas.
- Downstream of suspected source areas.

For sediment samples, ODA2 was separated into 4 aggregates:

- Upstream of suspected source areas.
- Downstream of suspected source areas.
- North of Sand Creek.
- South of Sand Creek.

For this Phase II RI, the groundwater medium was not subdivided into spatial aggregates. All of the monitoring wells installed during the RI monitor the water table interval, and all wells were screened in the unconsolidated zone. Groundwater was considered on an AOC-wide basis. The results of this evaluation are summarized by medium.

Surface Soils

Based on the evaluation of the occurrence and distribution of contaminants in surface soil, Site Related Contaminants (SRCs), are generally found in two areas of the AOC; the floodplain north and south of Sand Creek. The following observations can be made concerning SRCs in surface soil:

- Explosives and propellants are found at the highest concentration at sample locations DA2-053 and DA2-072 (south of Sand Creek) and DA2-045 (north of Sand Creek). Explosives and propellants are found at 11 sampling locations south of Sand Creek, mostly in the floodplain adjacent to Sand Creek. The limits of explosives and propellant occurrences have been delineated in the floodplain south of Sand Creek. Adequate amounts of samples with non-detections of explosive and propellant occurrences encompass the area of concern (AOC). Explosives and propellants are found at 10 sampling locations north of Sand Creek, mostly to the north and west. Additional sampling may be required in this area to further delineate the nature and extent of explosive and propellant occurrences to the north of Sand Creek. The occurrences to the north of Sand Creek are surrounded by a few samples that did not have detections of explosives and propellants. However, these perimeter samples without detection do not provide confidence that this AOC has been delineated. Additional sampling will be performed to delineate extent of explosives and propellants at the perimeter. Results of the additional sampling will be presented in the FS Report.

- Metals exceeding background concentrations are found at surface soil sample locations throughout the AOC. The area north of Sand Creek has eight surface soil sampling locations that have eight or more SRCs above background. These sample locations are generally centrally located in the AOC north of Sand Creek. The area south of Sand Creek had three surface soil sampling locations that had eight or more SRCs above background. These locations south of Sand Creek are in the floodplain adjacent to Sand Creek. The lateral extent of inorganic SRCs in surface soil has not been delineated based on the sampling results.

- SVOCs, VOCs, pesticides, and PCBs are either not detected in surface soil, or detections are limited to low concentrations in a limited number of sample locations.

Subsurface Soil

Based on the evaluation of the occurrence and distribution of contaminants in subsurface soil at ODA2, the following observations can be made:

- Explosives and propellants are present in subsurface soil at eight sampling locations north of Sand Creek. 2,4,6-TNT and tetryl are the most common explosives north of Sand Creek and sample location DA2-045 having the highest number (five) of explosive and propellants detected. South of Sand Creek, explosives and propellants were detected at eleven locations, with sample location DA2-067 and DA2-111 having the highest number detected (four). 2,4,6 Trinitrotoluene and tetryl was detected in subsurface soil at six sampling locations south of Sand Creek.

- All subsurface samples had at least one SRC inorganic compound detected above background. Sample locations, DA2-044, -045, -046, and -084, north of Sand Creek had six or more SRCs. Sample locations, DA2-068 and -074, south of Sand Creek, had six or more SRCs detected.
- Toluene, tetrachloethylene, and 2-Butanone were detected in one of seven subsurface soil samples analyzed for VOCs at ODA2. SVOCs di-n-butyl phthalate, (four detects in seven samples), bis(2-ethyhexyl) phthalate (five detects in seven samples), and n-Nitrosodiphenylamine (one detect in seven samples) were also detected.
- Pesticides and PCBs were not detected in subsurface soil samples.

Sediment

The interpretation of chemical data obtained from ODA2 sediment is summarized as follows:

- The following inorganic SRCs (with the maximum concentration detected) occur in sediment above background levels:
    - Aluminum (17,300 mg/kg at DA2-100)
    - Barium (317 mg/kg at DA2-097)
    - Beryllium (1.2 mg/kg at DA2-100)
    - Cadmium (2.3 mg/kg at DA2-097)
    - Chromium (19.4 mg/kg at DA2-100)
    - Hexavalent chromium (6.1 mg/kg at DA2-099)
    - Cobalt (10.5 mg/kg at DA2-097)
    - Copper (62.3 mg/kg at DA2-091)
    - Lead (31.3 mg/kg at DA2-097)
    - Mercury (0.37 mg/kg at DA2-089)
    - Nickel (25.2 mg/kg at DA2-100)
    - Nitrate/Nitrite (9.1 mg/kg at DA2-100)
    - Sulfide (1,100 mg/kg at DA2-099)
    - Vanadium 30.9 mg/kg at DA2-100)
- SRCs in sediment above background levels that have migrated to the furthest downstream location east of the AOC (station DA2-103) include beryllium and cadmium.
- The sample locations that had the highest concentration of inorganic SRCs in sediment sample are as follows:
    - DA2-089 (downstream floodplain of Sand Creek) – mercury
    - DA2-091 (upstream floodplain south of Sand Creek) – copper
    - DA2-097 (ditch north of Sand Creek) – barium, cadmium, cobalt, and lead

  - DA2-099 (Sand Creek downstream) – hexavalent chromium and sulfide
  - DA2-100 (ditch upgradient of Sand Creek Disposal Area) – beryllium, chromium, nickel, nitrate/nitrite and vanadium

Surface Water

The interpretation of SRC data obtained from ODA2 surface water is summarized below:

- **July 9 & 10, 2002**: Carbon disulfide and sulfide were only detected in the downstream location DA2-099. Nitrate/nitrite was detected in all three sampling locations, with the concentration remaining basically unchanged between all three locations.

- **September 9 & 10, 2002**: Nitrocellulose was detected at all three sample locations. Nitrate/nitrite was detected in the upstream sample DA2-095 and the furthest downstream sample DA2-102. Carbon disulfide was detected in the furthest downstream sample DA2-102.

- **November 26, 2002**: Chloroform was detected above background at all three sampling locations. Nitrate/nitrite was detected above background at DA2-095 and DA2-099.

- **April 04, 2003**: Nickel and chromium were detected above background at DA2-095. Carbon disulfide was only detected at DA2-099. Bis(2-ethylhexyl) phthalate was only detected at DA2-102. Nitrate/nitrite was detected above background at DA2-095 and DA2-102.

Groundwater

ODA2 groundwater chemical data is summarized as follows:

- Groundwater in all monitoring wells contained site-related metals with the exception of DA2-110, DA2-112, and DA2-DET4. DA2-104 located in the northern portion of the AOC generally has the highest number of inorganic SRCs.

- Only monitoring wells WBG-012 and WBG-013 contain explosives and/or propellants.

- Di-n-Butyl-Phthalate was detected at two wells (DA2-110 and DA2-113). Carbon Disulfide was detected at five wells (DA2-107, DA2-108, DET1, DET4, and WBG-012).

- No pesticides or PCBs were detected in any of the wells sampled.

FATE AND TRANSPORT ANALYSIS

Metals and explosive residue were detected in surface/subsurface soil and groundwater beneath two areas of the site:

- Area A – area north of Sand Creek, and
- Area B – floodplain area downgradient of Rocket Ridge and south of Sand Creek.

Contaminant fate and transport modeling performed as part of the Phase II RI included leachate modeling (SESOIL) and groundwater modeling (ATD123) of the two source areas. Fate and transport modeling indicates that metals and explosives may leach from contaminated soil into the groundwater beneath the source areas. Migration of many of the constituents, however, has been attenuated because of moderate to high retardation factors. Summary results for these models are as follows.

SESOIL Modeling

SESOIL modeling results indicate that beneath the source areas, the following contaminant migration chemicals of potential concern (CMCOPCS) are predicted to leach to groundwater with concentrations exceeding the groundwater Risk-based concentrations (RBCs)/MCLs beneath sampling points:

Area A
- Arsenic
- Barium
- Chromium
- Hexavalent Chromium
- Copper

Area B
- RDX
- Tetryl
- Antimony
- Chromium
- Hexavalent Chromium
- Copper
- Selenium

In addition the following compounds are observed in groundwater at the site at concentrations exceeding their respective RBCs/MCLs:

- Arsenic
- Hexavalent Chromium
- Manganese

The three compounds listed above were combined with the compounds identified in the SESOIL modeling as CMCOPCs as final CMCOPCs to be modeled for lateral migration using AT123D.

AT123D Modeling

Based on AT123D modeling, all compounds except manganese that were identified as CMCOPCS in the SESOIL modeling were identified as contaminant migration chemicals of concern (CMCOCs). The maximum groundwater concentrations of these compounds were predicted to exceed RBCs/MCLs at Sand Creek at the closest point downgradient of the source areas. Summary results of AT123D modeling including receptor concentration at Sand Creek are presented in Table 5-3.

BASELINE HUMAN HEALTH RISK ASSESSMENT

The HHRA was conducted to evaluate risks and hazards associated with contaminated media at the RVAAP ODA2 AOC for one potential receptor (Security Guard/Maintenance Worker) exposed to one medium (surface soil, from a depth interval of 0 to 1 ft bgs). Results are presented in Section 6 for all exposure scenarios and pathways. The following steps were used to generate conclusions regarding human health risks and hazards associated with contaminated surface soil at ODA2:

- identification of chemicals of potential concern (COPCs);
- exposure assessment;
- calculation of risks and hazards;
- identification of chemicals of concern (COCs); and
- calculation of remedial goal option (RGOs).

Identification of COPCs

The surface soil data at ODA2 data was evaluated as a single exposure unit (EU). Data from the RCRA unit was not included within this HHRA. Twelve COPCs were identified for the surface soil EU. The 12 surface soil COPCs are:

- Nine inorganics (aluminum, arsenic, cadmium, hexavalent chromium, copper, manganese, mercury, nitrate/nitrite, and sulfide); and
- Three explosives (2,4,6-TNT, 2-amino-4,6-DNT, and 4-amino-2,6-DNT).

Risks and hazards cannot be quantified for three of the 12 surface soil COPCs listed above (2-amino-4,6-DNT, 4-amino-2,6-DNT, and sulfide) due to a lack of toxicity information.

Exposure Assessment

Based on the exposure assessment, the scenario of a National Guard Security Guard/Maintenance Worker exposed to surface soil was selected for further evaluation of toxicity effects and risk characterization.

Identification of COCs

For all COPCs in the EU, ILCRs were calculated to estimate cancer risk to the Security Guard/Maintenance Worker at ODA2. ILCRs below 10^{-6} are considered acceptable; ILCRs above 10^{-}

^{4} are considered unacceptable. HI values were also calculated to estimate overall non-carcinogen health risks. An HI greater than 1 is defined as the level of concern for potential adverse non-carcinogenic health effects. COCs are defined for the surface soil EU as those contaminants that have an ILCR greater than 1 x 10^{-6} and/or an HI greater than 1 for one receptor in the HHRA.

One metal (arsenic) was identified as a COC for the Security Guard/Maintenance Worker at ODA2. The total HI is 0.051, which is below the threshold of 1.0. Therefore, no non-carcinogenic COCs are identified at ODA2. The only carcinogenic COC identified is arsenic, with a total cancer risk from exposure to this chemical of 5.3 x 10^{-6}.

Risk-based RGOs were computed for arsenic at a TR of 10^{-5} and a THI of 1; however, the EPC used in this HHRA for arsenic (13.8 mg/kg) was smaller than the most conservative risk-based RGO (26 mg/kg, based on a TR of 10^{-5}), as well as the surface soil background concentration for RVAAP (15.4 mg/kg).

SCREENING ECOLOGICAL RISK ASSESSMENT

The ODA2 site contains sufficient terrestrial and aquatic (surface water and sediment) habitat to support various classes of ecological receptors. For example, terrestrial habitats at ODA2 include old fields, woodlots, and grassy areas. Various classes of receptors, such as vegetation, small and large mammals, and birds, have been observed at the site. The presence of suitable habitat and observed receptors at the site along with presence of chemically contaminated media warrants a SERA. Thus, Ohio EPA protocol (Level I) was met and Level II was needed. The RVAAP Facility Wide Ecological Risk Work Plan was used to guide the work.

A Level II SERA was performed for ODA2 soils, sediment, and surface water using Ohio EPA guidance methods. The Level II Screen consisted of a media-specific data and media evaluation of detected chemicals of interest (COIs), as well as a media-specific media screen. The COI results for each medium are as follows:

- Surface soil – 26 chemicals retained as COIs;
- Subsurface soil – 18 chemicals retained;
- Sediment – 9 chemicals retained as downstream sediment COIs, 10 chemicals retained as upstream sediment COIs; and
- Surface water – 7 chemicals retained as downstream COIs, 4 chemicals retained as upstream COIs.

Because COPECs were identified and retained for soil, sediment, and surface water, ecological site conceptual models (ESCMs) were prepared, along with the identification of site-specific ecological receptors, relevant and complete exposure pathways, and candidate assessment endpoints. These types of information will be used to prepare a Level III Baseline if it is deemed necessary to conduct a Level III ERA. Another factor in this SMDP is that both upstream and downstream sampling stations in Sand Creek show healthy aquatic ecology and full attainment status according to Ohio EPA guidelines.

Based on the presence of multiple COPECs in soil, sediment, and surface water, as well as the presence of site-specific ecological receptors and complete exposure pathways to those COPECs at the ODA2 site, a recommendation is made to move to a Scientific Management Decision Point (SMDP). The most likely outcomes associated with the SMDP, in order of likelihood for the ecological risk assessment, as mentioned in Sections 7 and 8 are: 1) risk management of the ecological resources based on the military land-use or other reasons that many include development of RGOs or weight-of-evidence analysis that no RGOs are required, 2) remediation of some of the source material, if required, to reduce ecological risks, or 3) conduct of more investigation, such as Level III. In the FS, a weight-of-evidence approach to the COPECs involved at ODA2 would assist in defining the best outcome or decision. The information in this Level II SERA can be used to assist risk managers in making their decision associated with the SMDP.

SITE-SPECIFIC CONCEPTUAL MODEL

Based on results of the Phase II RI soil sampling, the southern floodplain of Sand Creek downgradient from the Sand Creek Disposal Area, and the area west/northwest of Sand Creek contain the greatest numbers and concentrations of SRCs. Metals and explosives are present in soil in these areas at concentrations greater than background or risk screening criteria. The majority of SRCs are at less than a depth of 0.3 meter (1.0 foot), but some explosives and metals were detected in subsurface soil in areas of high surface soil contamination. Arsenic in the soil poses potential risk through direct contact to National Guard Security Guard/Maintenance Workers.

Primary Contaminant Source and Release Mechanisms

The primary mechanism for release of contaminants from the source areas is the leaching of constituents via infiltration of rainwater trough surface and subsurface soils. Modeling indicates that several metals and explosives are expected to leach from the surface soil into the groundwater and reach concentrations exceeding MCLs/RBCs. Based on conservative modeling results (Section 5), maximum groundwater concentrations of arsenic, antimony, barium, chromium, hexavalent chromium, copper, selenium, RDX, and tetryl are expected to reach Sand Creek from the groundwater at concentrations exceeding MCLs/RBCs. The presence of arsenic, hexavalent chromium, and manganese in groundwater at concentrations exceeding MCLs/RBCs confirms that some leaching of contaminants from soil to groundwater has already occurred.

Contaminant Migration Pathways and Exit Points

Migration of many constituents has been attenuated because of moderate to high soil retardation factors. In general, groundwater flow within the AOC flow is towards Sand Creek. The primary exit pathway from ODA2 is via surface water and groundwater flow to Sand Creek. The low concentrations of the metals and explosive SRCs detected in sediment and surface water at station DA2-103 suggest that these processes are effective at attenuating constituents and restricting their migration beyond the site boundary. However, storm events may produce flushing of the surface water system and result in periodic transport beyond the site boundary. The migration of contaminants from ODA2 to off-AOC areas was not confirmed by sampling during the Phase II RI. The facility-wide biological and water quality study supports the mentioned attenuation because immediately downstream of ODA2, aquatic life is healthy and full attainment status was given based on Ohio EPA guidance.

Uncertainties

The SCM is developed based on available site characterization and chemical data. Uncertainties are inherent in the SCM where selected data do not exist or are sparse. The uncertainties within the SCM for ODA2 include the following:

- Soil and groundwater samples were not collected from an area of the site known as Rocket Ridge. This area was a disposal area for munitions and munitions components and has not been cleared of MEC hazards. It was therefore unsafe at the time of the Phase II RI to collect samples from this area. It can be inferred from the contamination present downgradient of this area (Area B), that Rocket Ridge is a source of soil and groundwater contamination. Although this area is a likely source area for soil and groundwater contamination, the presence or extent of contamination in this area is unknown.

- 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 ODA2 are uncertain.

CONCLUSIONS

The conclusions presented below, by medium, combine the findings of the contaminant nature and extent, evaluation, fate and transport modeling, and the HHBRA and SERA.

Surface/Subsurface Soil

- 2,4,6-TNT; tetryl; arsenic; barium; cadmium; chromium; chromium (hexavalent); copper; mercury; nickel; and PCE were identified as initial CMCOPCs for Area A based on soil screening analysis.

- 2,4,6-TNT; 2,4-DNT; RDX; tetryl; antimony; barium; cadmium; chromium; chromium (hexavalent); copper; manganese; mercury; nickel; selenium; and PCE were identified as initial CMCOPCs for Area B based on soil screening analysis.

- Arsenic, barium, chromium, chromium (hexavalent), and copper were identified as final CMCOPCs for Area A based on source loading predicted by the SESOIL modeling.

- RDX, tetryl, antimony, chromium, chromium (hexavalent), copper, and selenium were identified as final CMCOPCs for Area B based on source loading predicted by the SESOIL modeling.

- One metal (arsenic) was identified as a COC for the Security Guard/Maintenance Worker at ODA2. Risk-based RGOs were computed for arsenic at a TR of 10^{-5} and a THI of 1; however, the EPC used in this HHRA for arsenic (13.8 mg/kg) was smaller than the most conservative risk-based RGO (26 mg/kg, based on a TR of 10^{-5}), as well as the surface soil background concentration for RVAAP (15.4 mg/kg).

- The lateral and vertical extent of SRCs in the surface/subsurface soil both north and south of Sand Creek has not been fully determined. Additional surface/subsurface soil samples will be collected to determine lateral and vertical extent of SRCs. Results of the additional sampling will be presented in the FS Report.

Sediment/Surface Water

- Nitrocellulose was detected in sediment at DA2-100 and in surface water at DA2-095, DA2-099, and DA2-102.

- Surface water at DA2-095 contains the most inorganic SRCs with concentrations above background levels. DA2-095 is located in the southwest corner of the AOC near where the stream flows into the AOC.

- SVOCs, VOCs, pesticides, and PCBs are either not detected in sediment, or detections are limited to low concentrations in a limited number of sample locations

Groundwater

- Groundwater in all monitoring wells contains site-related metals with the exception of DA2-110, DA2-112, and DA2-DET4. DA2-104, located in the northern portion of the AOC contained the most inorganics at the maximum concentration in groundwater.

- Wells WBG-012 and WBG-013 contain explosives and/or propellants.

- Arsenic, antimony, barium, chromium, chromium (hexavalent), copper, selenium, RDX, and tetryl were identified as CMCOCs based on AT123D modeling. The maximum groundwater concentrations of the constituents were predicted to exceed MCLs/RBCs at Sand Creek at the closest point downgradient of the source areas.

RECOMMENDATIONS

Nature and Extent of Contamination

It is recommended that a Feasibility Study (FS) be performed for ODA2. This study should be designed to provide the information necessary for decision-makers to consider possible remedial actions that may be used to reduce risks to the environment and potential receptors.

Future land uses at ODA2 was determined to be “Restricted Access – Authorized Personnel Only” as described in the FW Human Health Assessment Risk Manual. Upon finalization of RGOs, definitive delineation of source areas where RGOs are exceeded may then be performed. These factors directly determine the required extent and cost of remediation needed to achieve protection of the receptor(s). Identification of future land use will also allow consideration of presumptive remedies and will be necessary for documentation in a Record of Decision.

The following uncertainty will be addressed in the FS to allow for a complete evaluation of possible remedial actions:

1. Determine the vertical and horizontal extent of soil contamination both north and south of Sand Creek.

Human Health Risk Assessment

Only arsenic was identified as a COC for Security Guard/Maintenance Worker at ODA2; however, the EPC for arsenic (13.8 mg/kg) is less than surface soil background (15.4 mg/kg).

Ecological Risk Assessment

The Screening Ecological Risk Assessment (SERA) identified the presence of multiple COPECs in soil, sediment, and surface water, as well as the presence of site-specific ecological receptors and complete exposure pathways to those COPECs at the ODA2 site, and a recommendation is made to move to a SMDP. The SMDP will consider the positive findings, e.g., healthy stream ecology and full attainment status, of the facility-wide biological and surface water measurements upstream and downstream of ODA2. The most likely outcomes associated with the SMDP (in order of likelihood) for the ecological risk assessment, as mentioned in Sections 7 and 8, are: 1) risk management of the ecological resources based on the military land-use or other reasons that may include development of RGOs or weight-of-evidence analysis that no RGOs are required, 2) remediation of some of the source material, if required, to reduce ecological risks, or 3) conduct of more investiagation, such as a Level III. In the FS, a weight-of-evidence approach to the COPECs involved at ODA2 would assist in defining the best outcome or decision. The information in the Level II SERA presented in this report can be used to assist risk managers in making their decision associated with the SMDP

1.0 INTRODUCTION

This report documents the results of the Phase II Remedial Investigation (RI) at Open Demolition Area #2 (ODA2) at the Ravenna Army Ammunition Plant (RVAAP), Ravenna, Ohio (Figures 1-1 and 1-2). The Phase II RI was conducted under the U.S. Department of Defense (DoD) Installation Restoration Program (IRP) by SpecPro, Inc., and its subcontractors, under contract number DAAA09-01-G-0009, Delivery Order No. 0003. The Phase II RI was conducted in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 following work plans reviewed and commented on by the U.S. Army Corps of Engineers (USACE) and the Ohio Environmental Protection Agency (Ohio EPA). The RI Report is being completed on behalf of the USACE in accordance with U.S. General Services Administration (GSA) Environmental Advisory Services Contract GS-10-F-0076J (Delivery Order W912QR-05-F-0033) under a Performance Based Contract (PBC).

This document summarizes the results of the Phase II RI field activities primarily conducted in July, August, and September 2002 at ODA2. The field program, environmental setting, and nature and extent of contamination are discussed in this report. Contaminant fate and transport modeling, a human health baseline risk assessment (HHBRA), and screening ecological risk assessment (SERA) are used to develop a revised conceptual model for ODA2 to support the investigation summary and conclusions that is the framework for decisions regarding future IRP actions at this Area of Concern (AOC).

1.1 PURPOSE AND SCOPE

Figure 1-3 presents the approach to implementing the CERCLA process under the guidance of the IRP. Priorities for environmental restoration at AOCs at RVAAP are based on their relative potential threat to human health and the environment, derived from Relative Risk Site Evaluations (RRSEs). Thirty-eight AOCs were identified in the *Preliminary Assessment for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 1996a). Thirteen new AOCs were identified in 1998 as a result of additional records searches and site walkovers. These were ranked by the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) and entered into the Army database. Those AOCs ranked as high-priority sites (i.e., those with high RRSE scores) have been targeted first for Phase I RIs. Medium- and low-priority sites will be characterized in Phase I RIs following completion of the high-priority AOCs RIs. Investigations and remedial actions under the CERCLA process are implemented at the AOCs in order of priority as funding is available or unless other priorities surface, such as land use needs.

The purpose of the Phase II RI is to determine the nature and extent of contamination so that a quantitative human health risk assessment (HHRA) and ecological risk assessment (ERA) can be performed. Depending upon the outcome of the risk assessments, an AOC will either require no further action or will be the subject of a Feasibility Study (FS) to evaluate potential remedies and future actions.

The scope of this investigation is to determine the extent of contamination in affected media (soils, sediments, surface water, and groundwater) identified during the Phase I RI at ODA2. The primary objectives of the Phase II RI are as follows:

- determine the boundaries of the AOC at ODA2;
- measure the AOC physical characteristics;
- identify the sources of contamination, especially south of Sand Creek;
- characterize the nature and extent of contamination at ODA2, especially south of Sand Creek;
- assess the risk posed to human health and the environment; and
- establish a system to monitor potential off-site migration of contaminants.

To meet the primary project objectives, investigation-specific data quality objectives (DQOs) were developed using the approach presented in the Facility Wide Sampling and Analysis Plan (SAP) (USACE 2001a). The DQOs specific to the ODA2 Phase II RI are discussed in Section 1.3.4.

The Resource Conservation and Recovery Act (RCRA) unit located within ODA2 is not within the scope of this report as this portion of the AOC is being evaluated separately in the RCRA Closure Report and associated activities. Any data presented or discussed in this report is specific to the CERCLA portion; however, previous data collected from the RCRA unit are summarized in this report and were used to assist in nature and extent definition. Data collected from the RCRA unit were not utilized in the HHRA or ERA.

The investigation approach for the Phase II RI at ODA2 involved a combination of field and laboratory activities to characterize the AOC. Field investigation techniques included soil boring and sampling, as well as surface water, sediment, and groundwater sampling. The field program was conducted in accordance with the Facility Wide SAP (USACE, 2001a) and the *Work Plan and Sampling and Analysis Plan Addenda for the Phase II Remedial Investigation of Demolition Area 2 at the Ravenna Army Ammunition Plant, Ravenna, Ohio* (SAP Addendum) (USACE 2002).

1.2 GENERAL FACILITY DESCRIPTION

1.2.1 Historical Mission and Current Status

RVAAP is a 1,481 acre portion of the 21,419 acre Ravenna Training and Logistics Site (RTLS) of the Ohio Army National Guard (OHARNG). The OHARNG is currently accountable for 19,938 acres of the installation. RVAAP was previously operated as a government-owned, contractor-operated (GOCO) Joint Munitions Command (JMC) facility. RVAAP/RTLS is located in northeastern Ohio within Portage and Trumbull counties, approximately 4.8 kilometers (3 miles) east northeast of the town of Ravenna and approximately 1.6 kilometers (1 mile) northwest of the town of Newton Falls. The installation consists of a 17.7-kilometer (11-mile) long, 5.6-kilometer (3.5-mile)-wide tract bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad on the south; Garrett, McCormick and Berry roads on the west; State Route 534 to the east, and the Norfolk Southern Railroad on the north (see Figures 1-1 and 1-2). The installation is surrounded by several communities: Windham on the north, Garrettsville 9.6 kilometers (6 miles) to the northwest, Newton Falls 1.6 kilometers (1 mile) to the east, Charlestown to the southwest, and Wayland 4.8 kilometers (3 miles) southeast.

Industrial operations at RVAAP began in 1941 and eventually consisted of 12 munitions assembly facilities referred to as "load lines". Load Lines 1 through 4 were used to melt and load trinitrotoluene (TNT) and Composition B into large-caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically the floors and walls were cleaned with water and steam. The liquid, containing TNT and Composition B, was known as "pink water" for its characteristic color. Pink water was collected in concrete holding tanks, filtered, and pumped into unlined ditches for transport to earthen settling ponds. Load Lines 5 through 11 were used to manufacture fuzes, primers, and boosters. Potential contaminants in these load lines include lead compounds, mercury compounds, and explosives.

RVAAP also used several areas on the facility for the burning, demolition, and testing of munitions. These burning/demolition areas consist of large parcels of open space or abandoned quarries. Potential contaminants at these AOCs include explosives, propellants, metals, waste oils, and sanitary waste.

RVAAP has been inactive since 1992. The only activities still carried out from the wartime era are the infrequent demolition of munitions and explosives of concern (MEC) found at the installation. The Army has completed the demolition of excess buildings at Load Lines 1 and 12, and is currently planning the decontamination and demolition of excess buildings at Load Lines 2, 3, and 4.

1.2.2 Demography and Land Use

RVAAP/RTLS consists of 8,998.3 hectares (21,419 acres) and is located in northeastern Ohio, approximately 37 kilometers (23 miles) east-northeast of Akron and 48.3 kilometers (30 miles) west-northwest of Youngstown. RVAAP/RTLS occupies east-central Portage County and southwestern Trumbull County. U.S. Census Bureau population estimates for 2001 indicate that the populations of Portage and Trumbull counties are 152,743 and 223,982, respectively. Population centers closest to RVAAP/RTLS are Ravenna, with a population of 12,100, and Newton Falls, with a population of 4,866.

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

Until May 1999, about 364 hectares (900 acres) of land and some existing facilities at RVAAP were used by the National Guard Bureau (NGB) for training purposes administered by the OHARNG. Training and related activities included field operations and bivouac training, convoy training, equipment maintenance, and storage of heavy equipment. In May 1999, NGB assumed operational control of 16,164 acres of RVAAP and licensed OHARNG to use the facility for training and other activities. In December 2001, operational control of an additional 3,774 acres of RVAAP was transferred to the NGB.

1.3 ODA2 SITE DESCRIPTION

A detailed history of process operations and waste processes for the original 38 identified AOCs at RVAAP, including ODA2, is presented in the *Preliminary Assessment for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE, 1996a). The following is a summary of the history and related contaminants for ODA2.

1.3.1 Operational History

1.3.1.1 History of Operation

ODA2, designated as RVAAP-04, covers approximately 25 acres and is situated in the central portion of the facility (see Figure 1-2). Figure 1-4 provides a photograph of the AOC circa 2000 showing areas disturbed due to past and recent site operations. Based on historic aerial photographs, multiple configurations, different from Figure 1-4, of this AOC have been utilized during its operation, including demolition on the south side of Sand Creek (Figure 1-5). ODA2 was used since 1948 to detonate large caliber munitions and off-spec bulk explosives that could not be deactivated or demilitarized by any other means due to their condition. Materials treated by open detonation in ODA2 have included primer elements, bombs, and various caliber munitions. The past standard operating procedures for demolition by open detonation were to place the explosives to be detonated in a pit that had been excavated to a minimum depth of 4 feet. The trench was then backfilled with 2 feet of soil, and the explosives were detonated. After detonation, the site was carefully policed for shrapnel, scrap metal, or any unexploded ordnance. It should be noted, however, that fragments of exploded or unexploded ordnance items forcefully propelled away from the detonation pits during detonation activities (kickouts) can be found several thousand feet away from the detonation site. Default distances for fragment protection range from 1,250 feet for non-fragmenting explosives materials to 4,000 feet for munitions 5-inch caliber or larger (DoD 1999). In addition, past operations at this AOC have included the burial of munitions and ordnance components; including the disposal of white phosphorus on the south side of Sand Creek.

There are five known potential source areas at ODA2 (VISTA Technologies, 2000) (Figure 1-6):

- **Open Detonation Areas (including the RCRA Unit)**: areas in which detonation was accomplished in backhoe-dug pits with a minimum depth of 4 feet. After detonation, metal parts were typically removed from the site, and the pits were backfilled, mulched, and seeded.

- **Open Burning Area**: an area within the RCRA unit in which, from 1981-1986, the sludge from Load Line 6 Evaporation Unit was thermally destroyed.

- **Prototype Testing Range**: an area where projectiles were fired into targets

- **Burial Sites 1 and 2**: areas where possible MEC may have been buried. Burial Site 1 is approximately two acres in size, located approximately 200 feet northeast of Building 1501. Burial Site 2 is approximately one acre in size, and is located approximately 100 feet north of Building 1503.

- **Sand Creek Disposal Area (also known as "Rocket Ridge")**: an area that is posted, "Off Limits, Dangerous Material" and is located along a 70-feet embankment northeast of Building 1503 overlooking Sand Creek where MEC have been disposed on the surface.

- Other major structures at ODA2 site include three explosive storage bunkers (Buildings 1501, 1502, and 1503).

1.3.2 Previous Investigations at ODA2

Six previous investigations have been conducted at ODA2:

(1) *Hazardous Waste Management Study No. 37-26-0442-84* (USAEHA 1984);
(2) *Geohydrologic Study No. 38-26-KF95-92* (USAEHA 1992);
(3) *Preliminary Assessment for the Ravenna Army Ammunition Plant* (USACE 1996);
(4) *Phase I Remedial Investigation of High Priority Areas of Concern at the Ravenna Army Ammunition Plant* (USACE 1998a);
(5) *RCRA Closure Field Investigation Report for the Deactivation furnace Area, Open Detonation Area, Building 1601, and Pesticides Building, Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 1998b); and
(6) *Report of Analytical Results Demolition Area #2 CERCLA Sites* (USIOC 2000).
(7) *Archive Search Report for the Ravenna Army Ammunition Plant* (USACE, 2004).

Three of the six previous investigations (Investigations 1, 2 and 5 above) focused exclusively on the 2.5-acre RCRA unit within ODA2. A summary of the previous investigations is provided in the following sections.

1.3.2.1 *CERCLA Unit*

The Preliminary Assessment of ODA2 performed in 1996 included the ODA2 site in the list of High Priority sites based on a relative risk ranking methodology. Reevaluation of the ODA2 risk ranking performed at the completion of the Phase I RI resulted in the site retaining its "High Risk" rating.

The Phase I sampling at ODA2 included surface soil, subsurface soil, and sediment sampling of areas north of Sand Creek. Samples were collected from 30 soil locations and 3 sediment locations (Figure

1-7). Contamination of surface and subsurface soil by explosive compounds and inorganic analytes was identified during the Phase I. Explosive compounds were identified in five surface soil and six subsurface soil samples at concentrations ranging from 0.420 to 4.4 mg/kg. Inorganic analytes were detected above Phase I site-wide background in surface soil, subsurface soil and sediment samples: aluminum, arsenic, barium, cadmium, chromium, lead, magnesium, mercury, nickel, potassium, selenium, sodium, thallium, and zinc in surface soils; arsenic, barium, cadmium, lead, mercury, sodium, thallium, and zinc in subsurface soils; and cadmium, sodium, and thallium in sediment samples. No contamination from volatile organic compounds (VOCs) or semi-volatile organic compounds (SVOCs) was indicated in the samples analyzed during the Phase I investigation.

In 2000, sampling of surface soils, subsurface soils, and sediment was conducted at three suspected disposal/burial sites within ODA2 – Burial Site #1, Burial Site #2, and Sand Creek. Soil samples were collected from two locations and three depths (to 4 feet depth) at Burial Sites #1 and #2; and at four locations and three depths (to 4 feet depth) at Sand Creek. Explosives were detected at all locations, and the propellant nitrocellulose was detected at Burial Site #2 and at Sand Creek. Metals above site-wide background criteria were also found in all three areas: antimony, barium, beryllium, cadmium, cobalt, copper and lead at Burial Site #1; arsenic, chromium, copper, magnesium, nickel, and zinc at Burial Site #2; and antimony, barium, cadmium, copper, magnesium, manganese, lead, silver, and zinc at Sand Creek.

1.3.2.2 RCRA Unit

Previous investigations of the 2.5-acre RCRA unit within ODA2 included surface and subsurface soil, surface water, sediment, surface runoff, and aquatic organism sampling. The RCRA unit within ODA2 is being evaluated separately and will be closed under RCRA at the appropriate time. However, previous investigations are summarized here and were used to assist with definition of nature and extent (but were not included in the HHRA or ERA).

In 1983, a total of ten surface soil samples were taken within the "horseshoe" bermed area. The samples were analyzed for Extraction Procedure (EP) toxicity (arsenic, barium, cadmium, chromium, mercury, lead, selenium, and silver) and explosives. Analyses indicated that explosives were present in all ten samples; EP toxicity analysis showed detectable amounts of heavy metals in four samples (barium in one sample; lead in three samples). One of the samples exceeded the EP toxicity level for lead; all other results were below EP toxicity levels (USAEHA 1984).

In 1992, four groundwater monitoring wells (one upgradient, three downgradient) were installed and sampled at the RCRA unit and were sampled for explosives, RCRA metals, phosphorus, nitrates, TKN, and VOCs. Initial groundwater results did not indicate the presence of explosives or VOCs in samples, and the analytical results for metals did not indicate contamination when compared to background determined for this study (USAEHA 1992). The groundwater monitoring wells installed at the ODA2 RCRA unit have been sampled on a quarterly basis since 1992. In April of 2000, the upgradient groundwater monitoring well (DET-1) was abandoned and replaced with a well designated DET-1B. DET-1 was abandoned and replaced with DET-1B because demolition activities approximately 30 feet from DET-1 may have compromised the integrity of the well, and the closeness of the demolition activities limited the effectiveness of this well as an upgradient well. The monitoring well was abandoned by overdrilling the casing to a depth of 43 ft, then pressure grouting the open borehole with a cement-bentonite mix in accordance with the Facility Wide Work Plan. Analytical results from quarterly sampling have since shown the detection of explosives in all wells, including the newly-installed upgradient well. In addition, metals exceeding site-wide background values were detected in DET-2 (arsenic) and in DET-4 (selenium) in 2000.

Also in 1992, 47 surface and subsurface soil samples were collected and analyzed for explosives, metals, phosphorus, nitrates, and TKN. A total of 24 samples were also collected for background comparison purposes from a fire break located approximately one mile northeast of ODA2. For explosive parameters, any detectable amounts in sample results were considered to be indicative of contamination. For other naturally occurring parameters, results were considered indicative of contamination if they exceeded the corresponding background mean plus the 95 percent confidence interval using a one-tailed t-test. Soil sample analysis indicated the presence of explosives in seven of the 47 samples, and the presence of arsenic, barium, cadmium, mercury, lead, nitrate-nitrates, phosphorus, and TKN above background values in several of the samples (USAEHA 1992).

Three co-located surface water and sediment samples were collected from Sand Creek, one upstream and two downstream from the RCRA unit. A grab sample of surface runoff from the RCRA unit to Sand Creek was also taken during a rain event as part of the study. The surface water, sediment, and runoff samples were analyzed for explosives, RCRA metals, phosphorus, nitrates, and TKN, and VOCs. As part of the surface water investigation, benthic macroinvertebrates were also collected. Surface water and surface runoff samples indicated the presence of explosives, along with levels of lead, copper, iron, zinc, and mercury that exceeded the state ambient water quality criteria for warmwater habitats. There was no evidence of contamination within the sediment samples. Benthic macroinvertebrates were sampled by Hester Dendy and Surber sampling methods in Sand Creek above and below the RCRA unit. Results from the biological data diversity analysis indicated that the RCRA unit was not adversely affecting the macroinvertebrate community (USAEHA 1992).

In 1998, as part of a RCRA Closure Field Investigation Report, 29 soil borings to 8 feet in depth or greater (two of these were taken to a depth of 14 feet, and one was taken to a depth of 20 feet), and 32 surface locations were sampled within and around the RCRA unit at ODA2. Metals exceeding site-wide background criteria were indicated in several of the samples; explosives were present in five of the samples; and the propellant nitrocellulose was detected in two surface soil samples.

In 1999, MEC removal to a depth of 4 feet was performed in the RCRA unit. The removal action involved excavating soil in the unit to a total depth of 4 feet, screening the excavated soil and removing any MEC, shrapnel, or scrap metal found, and placing the screened soil back on site. The area was then graded and seeded. Over 100,000 items were recovered during this effort, including over 45,000 primer detonators, 19,000 T-bars, several thousand fuzes of various sizes, and several thousand artillery rounds ranging from 22 mm to 155 mm in size (USIOC 2000).

1.3.3 Chemicals of Potential Concern

Based on available process knowledge and previous investigation results, waste constituents and chemicals of potential concern (COPC) at ODA2 include white phosphorus, explosive compounds, propellants, and metals from the demilitarization or disposal of munitions and ordnance components.

1.3.4 ODA2 Phase II RI DQOs

The Facility Wide site conceptual model (SCM), operational information, historical data and records, and data collected during previous investigations at ODA2 were used to design the Phase II RI sampling effort using the DQO approach presented in the Facility Wide SAP (USACE 2001a). The DQOs for the Phase II RI at ODA2 were presented in detail in the SAP Addenda for the ODA2 Phase II RI (SpecPro, 2002). A summary of DQOs is presented below for reference purposes.

1.3.4.1 Soil

Based on characterization data to date, contaminated soil within and adjacent to former demolition pits and suspected burial areas are potential secondary sources of contamination in sediment, surface water, and groundwater. Contaminants may be released from soil and migrate in storm runoff either in dissolved phase or adsorbed to particulates and/or colloids. Further characterization of suspected areas of soil contamination was conducted to define contaminant nature and extent and to provide sufficient data for remedial alternatives analysis in a subsequent FS. Subsurface soil characterization was also conducted to determine if leaching processes may be a potential mechanism for contaminant migration to groundwater. The Phase I RI and other historical sampling did not characterize all of the suspected former demolition pits and burial areas. Thus, those areas not previously characterized were specifically targeted for biased sampling in the Phase II RI.

1.3.4.2 Sediment

Sediment within ditches and tributaries represents a receptor media for contaminants eroded or leached from soil and transported by storm runoff. In addition, sediment may function as a transport mechanism considering that contaminants adsorbed to particulates may be mobilized by surface water flow. Operational data suggest that the ditches in the vicinity of former demolition pits and suspected burial areas represent the most likely locations where contaminants may have accumulated through erosional transport.

Site characteristics and available field data show that the primary surface water and sediment exit pathways for the ODA2 AOC follow unnamed ditches and tributaries that ultimately feed into Sand Creek. For the portion of the AOC that is located south of Sand Creek, drainage flows to the north and east; for the portion of the AOC that is located north of Sand Creek, drainage flows to the south and east. Considering the available data and the SCM, both confirmed and additional suspected source areas, as well as the exit pathways, were specifically targeted for biased sediment sampling in the Phase II RI.

1.3.4.3 *Surface water*

Surface water represents the likely primary mechanism for mobilization and transport of contamination within and off of ODA2. Most chemical transport via surface water is presumed to occur along the ditches within the AOC and is primarily episodic and related to storm events that produce flushing of the surface water system and mobilization of contaminated soil and sediment through erosion. Based on the SCM, upstream and downstream locations in Sand Creek were specifically targeted for biased surface water sampling in the Phase II RI.

1.3.4.4 *Groundwater*

No hydrogeologic and analytical data existed from previous investigations for groundwater for the portion of ODA2 that lies south of Sand Creek. Wells were thus installed in the vicinity of known or suspected source areas both north and south of Sand Creek to evaluate whether contaminants are leaching to groundwater. Hydrogeologic and analytical data for the portion of ODA2 that includes the RCRA unit have been gathered since the 1992 installation of four groundwater monitoring wells at that site. Quarterly measurement of groundwater levels indicate that the groundwater flow within that area generally follows topography and flows in a general south and east direction toward Sand Creek. For the purposes of DQO development and investigation planning, the SCM presumes that the general groundwater flow patterns south of Sand Creek at ODA2 would also mimic the site topography and surface water drainage patterns, following a north and east direction toward Sand Creek.

Analytical evidence for groundwater contamination by site-related contaminants (SRCs) identified in source area soil (i.e., explosives and metals) is indicated in the groundwater monitoring wells located around the RCRA unit north of Sand Creek. Since 1992, explosives have been subsequently detected in all four wells, and metals exceeding Phase I site-wide background criteria were detected in wells DET-2 and DET-4 in 2000. However, because of the limited available data for ODA2, other than the RCRA unit, contaminant migration from source areas to groundwater (via leaching or surface water infiltration) was an unknown element of the SCM. Potential source area SRCs identified to date have low mobility in groundwater. However, previous sampling data from wells around the RCRA unit indicate groundwater contamination at this AOC. Subsequently, the presence of groundwater contamination and potential migration pathways was evaluated as part of the Phase II RI.

Groundwater characterization efforts included installation of monitoring wells to provide data on general hydrogeologic characteristics and groundwater flow patterns. Wells were installed in the vicinity of known and suspected source areas to evaluate whether contaminants are leaching to groundwater. Monitoring wells were also placed in close proximity to Sand Creek to determine whether groundwater flow and potential contaminant transport into Sand Creek and off of the AOC is occurring.

1.4 REPORT ORGANIZATION

This Phase II RI Report is organized to meet Ohio EPA requirements in accordance with U.S. Environmental Protection Agency (USEPA), CERCLA Superfund process, and USACE guidance. The report consists of an Executive Summary, Sections 1 through 10, and supporting appendices. The Sections are organized as follows:

- Section 1.0 describes the purpose, objectives, and organization of this report and provides a description and history of ODA2.
- Section 2.0 describes the environmental setting at RVAAP/RTLS and ODA2, including the geology, hydrogeology, climate, population, and ecological resources.
- Section 3.0 describes the specific Phase II RI methods used for field data collection and the approach to analytical data management and laboratory programs.
- Section 4.0 presents the data generated during the Phase II RI and discusses the occurrence and distribution of contamination at ODA2.
- Section 5.0 presents contaminant fate and transport evaluation.
- Section 6.0 includes the methodology and results of the human health evaluation.
- Section 7.0 summarizes the ecological risk evaluation.
- Section 8.0 provides results and conclusions of this study.
- Section 9.0 presents the recommendations, and
- Section 10.0 provides a list of referenced documents used to support this Phase II RI.

Appendices (A through T) to this Phase II RI Report for ODA2 contain supporting data collected during the Phase II RI and are consist of the following:

- Appendix A contains the geotechnical analysis report.
- Appendix B presents the monitoring well installation logs.
- Appendix C consist of soil logs
- Appendix D present Investigation-Derived Waste (IDW) information
- Appendix E contains sediment and surface water sampling logs.
- Appendix F presents the topographic survey report.
- Appendix G contains the monitoring well development and groundwater sampling logs.
- Appendix H presents the laboratory analytical data.
- Appendix I contains the monitoring well slug test logs.
- Appendices J and K contain the Project Quality Assurance Summary and the Data Quality Control Summary Report.
- Appendix L presents details of the unexploded ordnance (UXO) survey.
- Appendix M contains Fate and Transport modeling results.
- Appendix N contains the supporting data for the SERA.

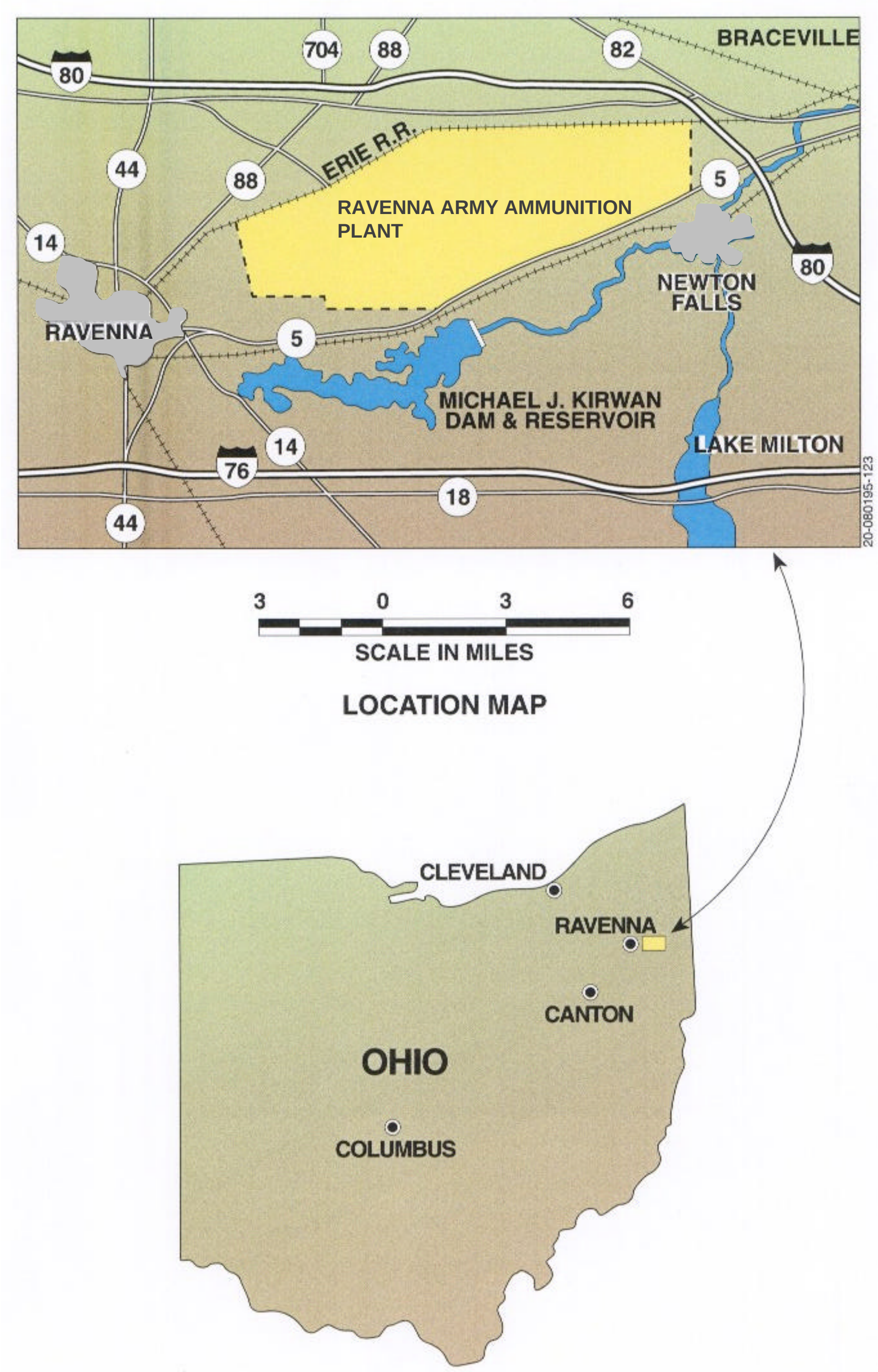
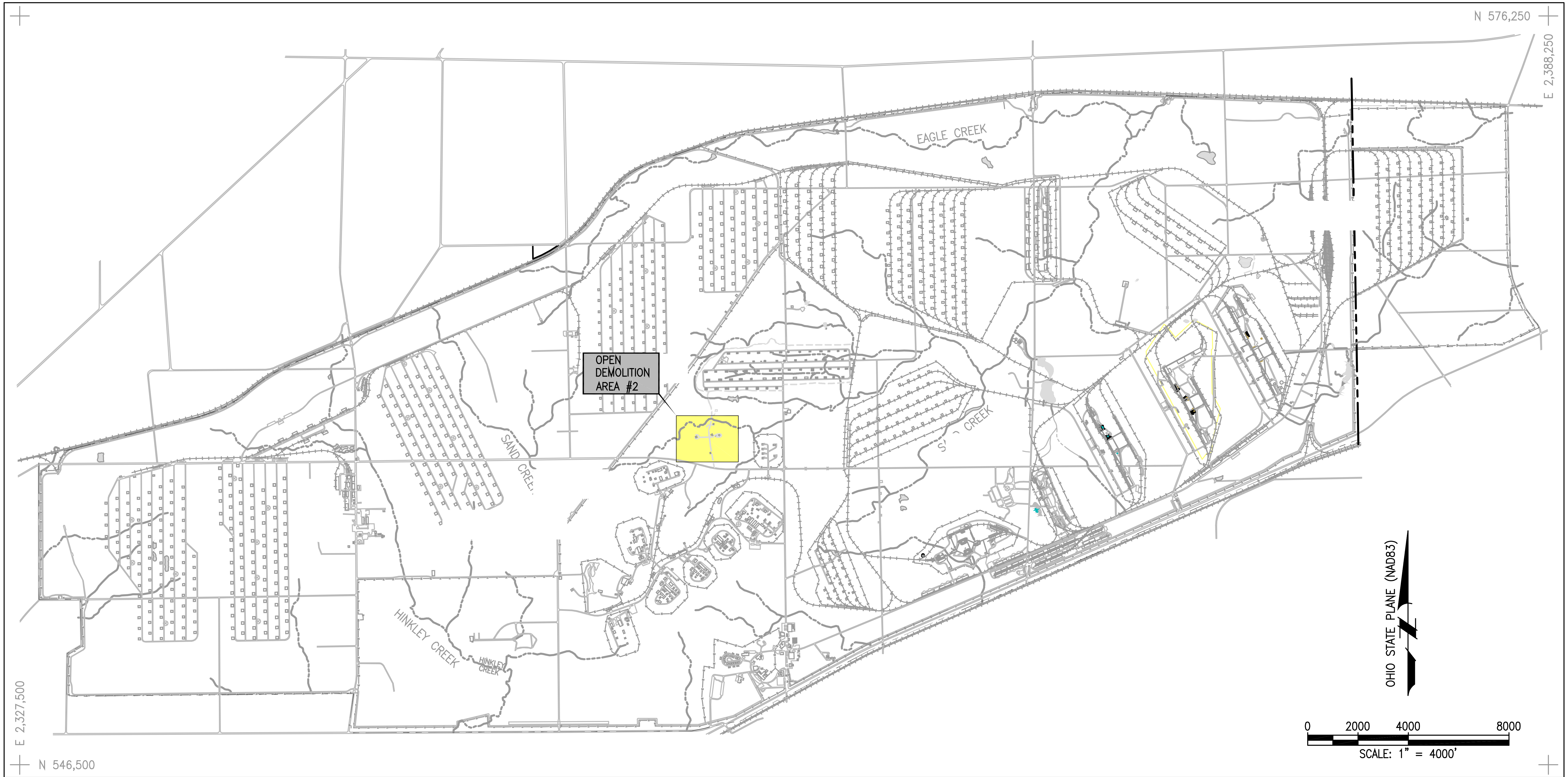


Figure 1-1. Ravenna Army Ammunition Plant Location Map



LEGEND:

1	RAMSDELL QUARRY LANDFILL	13	BUILDING 1200 AND DILUTION/SETTLING POND	25	BUILDING 1034 MOTOR POOL WASTE OIL TANK	37	PESTICIDE STORAGE BUILDING T-4452	49	CENTRAL BURN PITS
2	ERIE BURNING GROUNDS	14	LOAD LINE 6, EVAPORATION UNIT	26	FUZE BOOSTER AREA SETTLING TANKS	38	NACA TEST AREA	50	ATLAS SCRAP YARD
3	DEMOLITION AREA #1	15	LOAD LINE 6, TREATMENT PLANT	27	BUILDING 854 PCB STORAGE	39	LOAD LINE 5/FUZE LINE 1	51	DUMP ALONG PARIS-WINDHAM ROAD
4	OPEN DEMOLITION AREA #2	16	QUARRY LANDFILL/FORMER FUZE AND BOOSTER BURNING PITS	28	MUSTARD AGENT BURIAL SITE	40	LOAD LINE 7/BOOSTER LINE 1	○	CERCLA
5	WINKLEPECK BURNING GROUNDS	17	DEACTIVATION FURNACE	29	UPPER AND LOWER COBB'S POND COMPLEX	41	LOAD LINE 8/BOOSTER LINE 2	○	RCRA
6	C BLOCK QUARRY	18	LOAD LINE 12 PINK WASTEWATER TREATMENT	30	LOAD LINE 7 PINK WASTEWATER TREATMENT PLANT	42	LOAD LINE 9/DETONATOR LINE	○	OTHER REGULATORY
7	BUILDING 1601 HAZARDOUS WASTE STORAGE	19	LANDFILL NORTH OF WINKLEPECK BURNING GROUND	31	ORE PILE RETENTION POND	43	LOAD LINE 10/PERCUSSION ELEMENT	┼┼┼┼┼	RAILROAD TRACKS
8	LOAD LINE 1 AND DILUTION/SETTLING POND	20	SAND CREEK SEWAGE TREATMENT PLANT	32	40- AND 60-MM FIRING RANGE	44	LOAD LINE 11/ARTILLERY PRIMER	—x—x—	FENCE LINE
9	LOAD LINE 2 AND DILUTION/SETTLING POND	21	DEPOT SEWAGE TREATMENT PLANT	33	FIRESTONE TEST FACILITY	45	WET STORAGE AREA	— · —	PROPERTY BOUNDARY
10	LOAD LINE 3 AND DILUTION/SETTLING POND	22	GEORGE ROAD SEWAGE TREATMENT PLANT	34	SAND CREEK DISPOSAL ROAD LANDFILL	46	BUILDINGS F-15 AND F-16	~	STREAM OR CREEK
11	LOAD LINE 4 AND DILUTION/SETTLING POND	23	UNIT TRAINING SITE WASTE OIL TANK	35	BUILDING 1037 LAUNDRY WASTEWATER SUMP	47	BUILDING T-5301 DECONTAMINATION		
12	LOAD LINE 12 AND DILUTION/SETTLING POND	24	RESERVE UNIT MAINTENANCE AREA WASTE OIL TANK	36	PISTOL RANGE	48	ANCHOR TEST AREA		

US Army Corps
of Engineers
Louisville District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

RAVENNA ARMY AMMUNITION
PLANT RAVENNA, OHIO

FIGURE 1-2. RVAAP/RTLS
INSTALLATION MAP

DRAWN BY:	REV. NO./DATE:	CAD FILE:
P.H. / S.D.	REV. 2 / 07-27-04	/00064/DWGS/R73SITE2

XREF Files: Xrav IMAGE Files:
File: W:\CAD Gov\Ravenna\PBC 2005\RVAAP_LocMapDEMO2.dwg Layout: Layout1 User: williamsbe Jul 08, 2005 - 10:08am

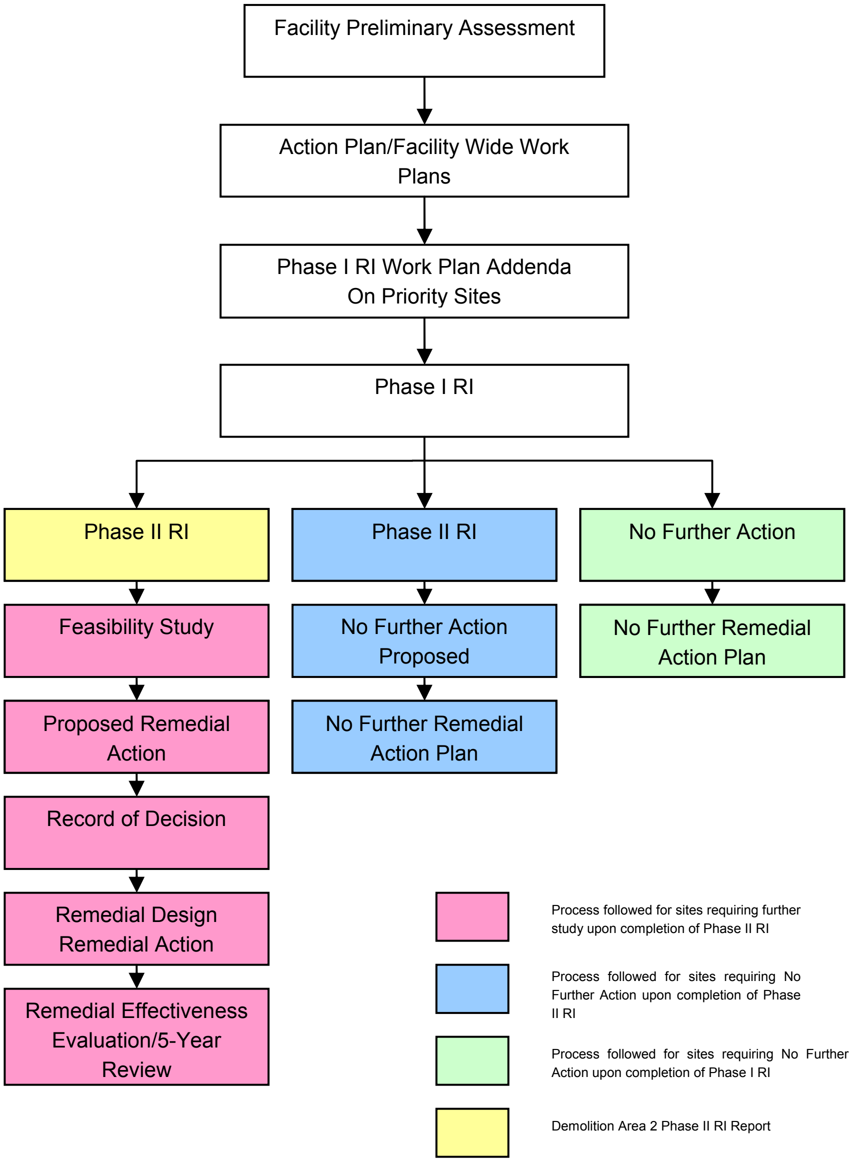


Figure 1-3. RVAAP CERCLA Approach

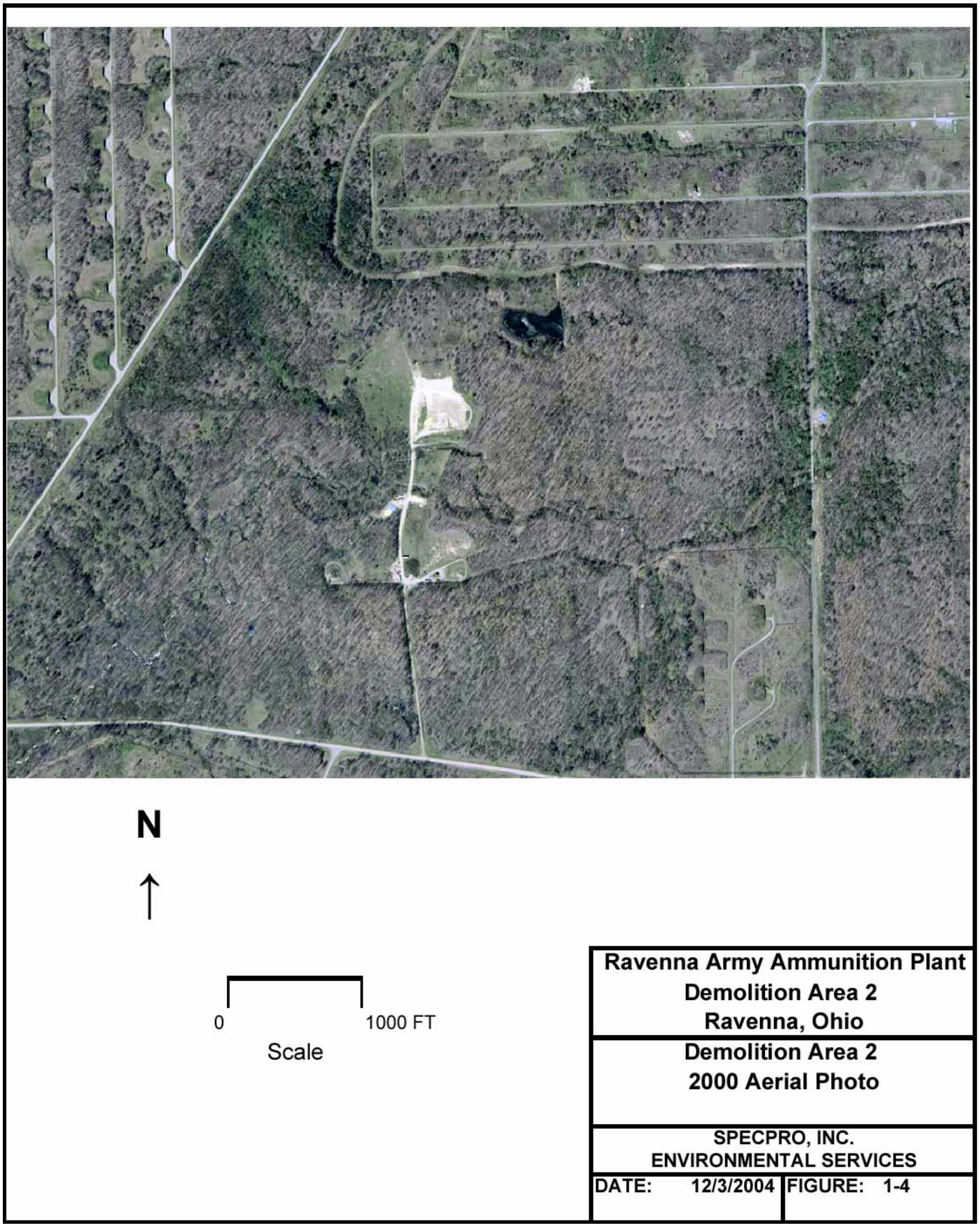


Figure 1-4. Open Demolition Area #2 Aerial Photograph Circa 2000

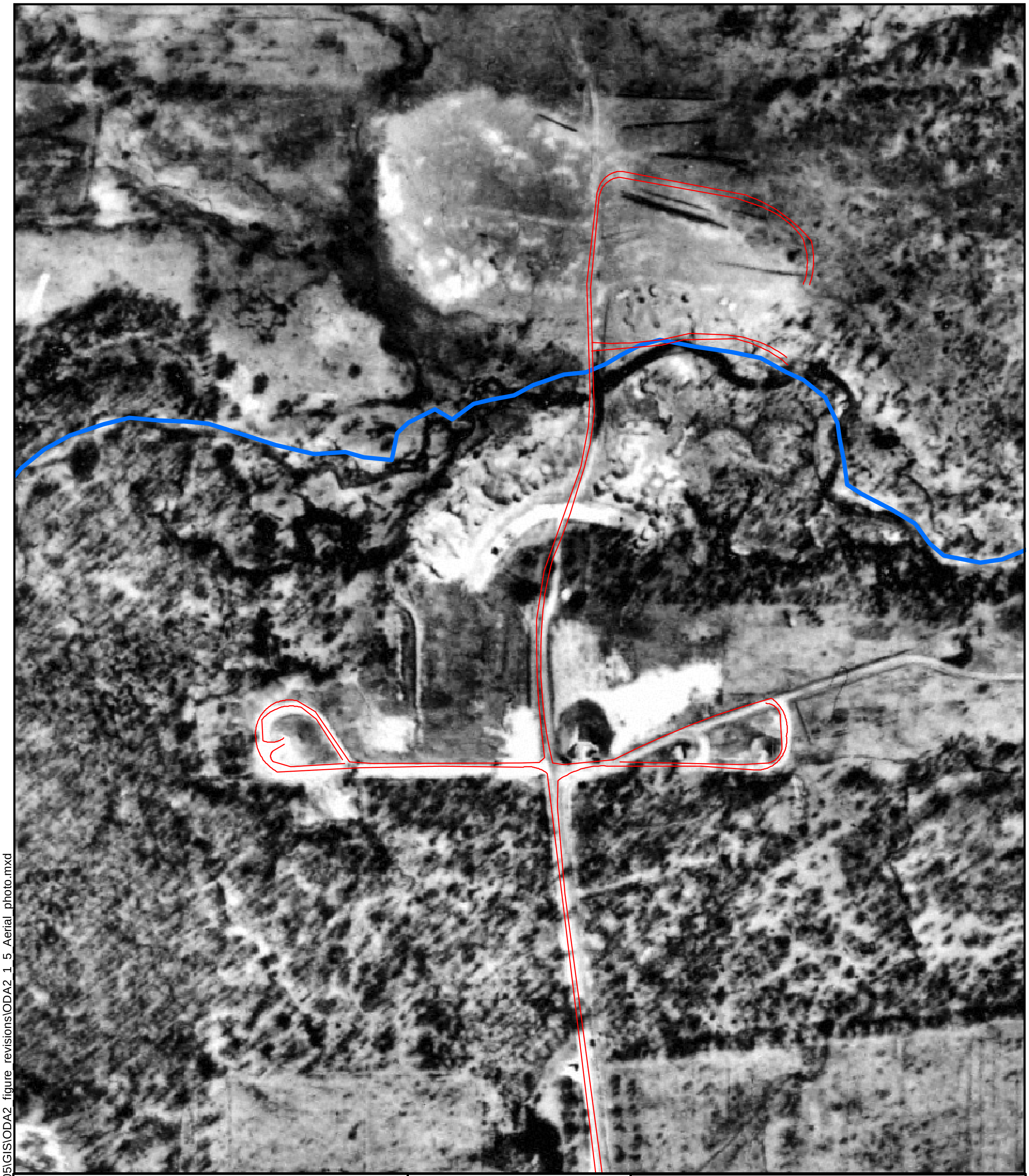


Figure 1-5:
Aerial Photograph of Demolition Activity South of Sand Creek

Legend

🟥	Road
🟦	Sand Creek

Drawn By: HRA

Date: 2005/September/15

Z:\PUBLIC\RVAAP PBC 2005\GIS\ODA2 figure revisions\ODA2 1 5 Aerial photo.mxd

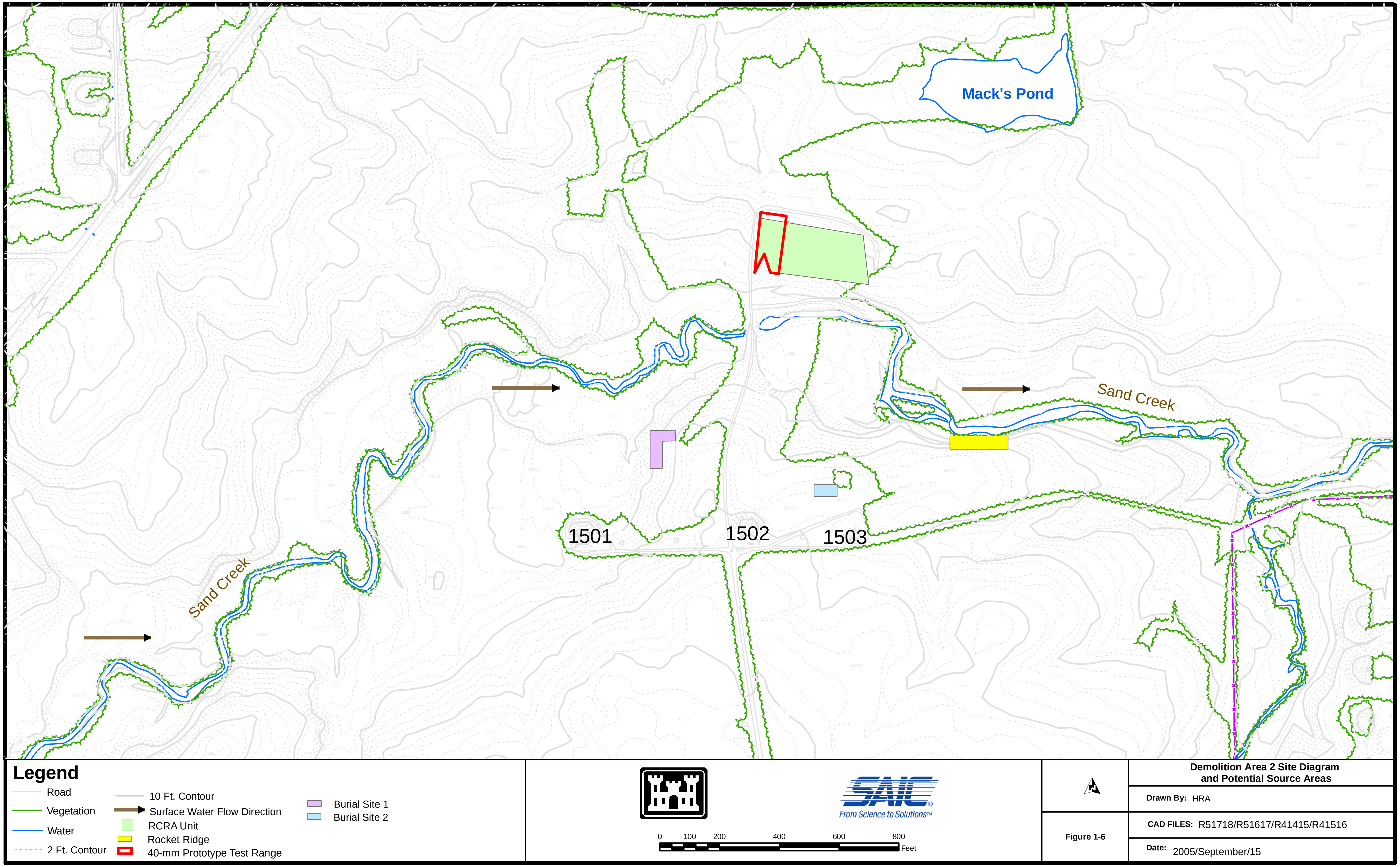


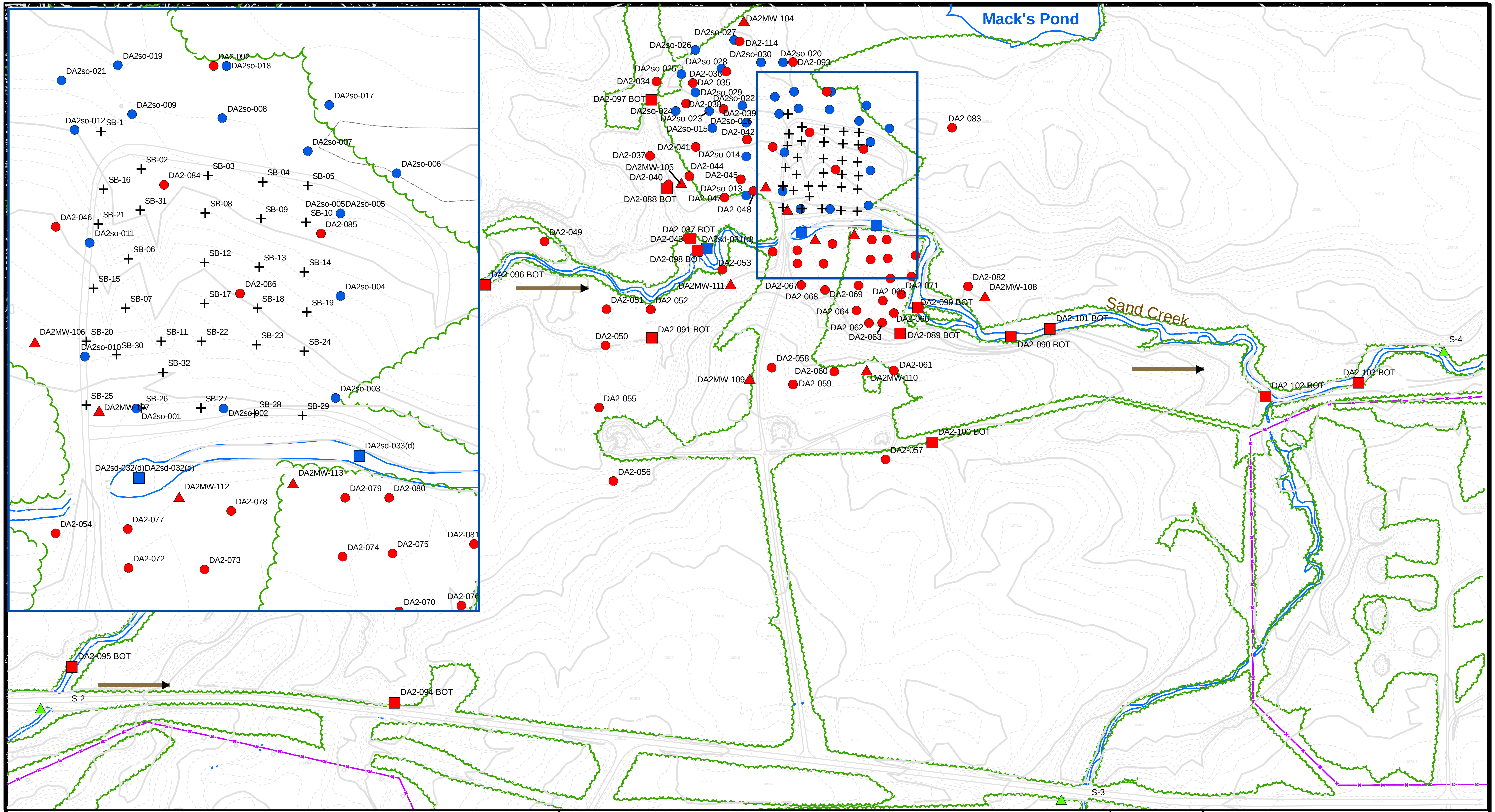
Figure 1-6

Demolition Area 2 Site Diagram and Potential Source Areas

Drawn By: HRA

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/September/15



Legend

	Road		10 Ft. Contour	🟦	Phase I Sediment Sample Location
	Vegetation	→	Surface Water Flow Direction	●	Phase I Soil Sample Location
	Water	▲	Facility-Wide Biological and Water Quality Study Surface Water Sample Estimated Location	▲	Phase II Monitor Well
	2 Ft. Contour	+	1998 RCRA Closure Sample Location	🟥	Phase II Sediment/Surface Water Sample Location
				●	Phase II Soil Sample Location

From Science to Solutions™

0 100 200 400 600 800 Feet

Figure 1-7

ODA2 All Sample Locations

Drawn By: HRA

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/September/15

2.0 ENVIRONMENTAL SETTING

This Section describes the physical characteristics of ODA2 and the surrounding environment that are factors in understanding potential contaminant transport pathways, receptors, and exposure scenarios for human health and ecological risks. The geology, hydrology, climate, and ecological characteristics of RVAAP were originally presented in Section 3.0 of the *Phase I Remedial Investigation Report for High-Priority Areas of Concern at RVAAP* (USACE 1998a). The preliminary SCM for ODA2 presented at the end of this section is refined and updated in Section 8 based on site-specific data from the Phase II RI and local and regional information.

2.1 RVAAP/RTLS PHYSIOGRAPHIC SETTING

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

2.2 SURFACE FEATURES AND SITE TOPOGRAPHY

ODA2 is situated in the central portion of the RVAAP/RTLS facility (Figure 1-2). The AOC is characterized by gently to steeply sloping topography on a weathered shale bedrock surface. Topography of ODA2 was mapped by the USACE in 1998 on a 0.6-meter (2-foot) contour interval, with an accuracy of 0.006 meter (0.02 feet), from aerial photographs taken in 1997. This survey is the basis for the topographic features presented in the figures in this Phase II RI report. Elevations across the AOC vary from approximately 309 to 326 meters (1,017 to 1,071 feet) above mean sea level (amsl).

Cultural features at ODA2 consist mainly of gravel access roads and three above-ground explosive storage bunkers. Surface soil in much of the AOC was highly disturbed during the detonation, disposal, and MEC clearance activities that have occurred at the site.

Within the ODA2 AOC, the 2.5-acre RCRA unit is sparsely vegetated with native grasses due to the recent MEC clearance project and subsequent reseeding. Adjacent portions of the AOC historically used for detonation or disposal are characterized by scrub vegetation and immature hardwoods. Areas to the east, west, and south of the detonation/disposal areas are characterized by mature hardwood forest. Wetland areas are found along the Sand Creek drainage channel to the east and west of the historically active portions of the AOC.

2.3 SOILS AND GEOLOGY

2.3.1 Regional Geology

The regional geology at RVAAP/RTLS consists of horizontal to gently dipping bedrock strata of Mississippian and Pennsylvanian age overlain by varying thicknesses of unconsolidated glacial deposits. The bedrock and unconsolidated geology at RVAAP/RTLS and geology specific to ODA2 are presented in the following subsections.

2.3.1.1 *Soils and Glacial Deposits*

Bedrock at RVAAP/RTLS is overlain by deposits of the Wisconsin-aged Lavery Till in the western portion of the facility and the younger Hiram Till and associated outwash deposits in the eastern portion of the facility (Figure 2-1). Unconsolidated glacial deposits vary considerably in their character and thickness across RVAAP/RTLS, from zero in some of the eastern portion of the facility to an estimated 46 meters (150 feet) in the south-central portion.

Thin coverings of glacial materials have been completely removed as a consequence of human activities at locations such as Ramsdell Quarry, and bedrock is present at or near the ground surface in many locations, such as at Load Line 1 and Load Line 2. Where these glacial materials are still present, their distribution and character indicate their origin is ground moraine. These tills consist of laterally discontinuous assemblages of yellow-brown, brown, and gray silty clays to clayey silts, with sand and rock fragments. Deposits from bodies of glacial-age standing water may also have been encountered, in the form of >15-meter (50-foot) -thick deposits of uniform light gray silt (USACE 2001b).

Soils at RVAAP/RTLS are generally derived from the Wisconsin-age silty clay glacial till. Distributions of soil types are discussed and mapped in the Soil Survey of Portage County, Ohio (USDA 1978). Much of the native soil at RVAAP/RTLS was reworked or removed during construction activities in operational areas of the installation.

According to the Portage County soil survey, the major soil types found in the high-priority AOCs are silt or clay loams with permeabilities ranging from 6.0×10^{-7} to 1.4×10^{-3} centimeters/second.

2.3.1.2 *Bedrock Stratigraphy*

Bedrock occurrence at RVAAP/RTLS consists of Mississippian and Pennsylvanian Age sedimentary rocks that lie stratigraphically beneath the glacial deposits of the Kent and Hiram Tills (Figure 2-2). The oldest bedrock that outcrops within the facility is the Cuyahoga Group of Mississippian Age. The Cuyahoga outcrops in the far northeastern corner of the facility, and generally consists of blue-gray silty shale with interbedded sandstone (Figure 2-3). The remainder of the facility is underlain by bedrock associated with the Pottsville Formation of Pennsylvanian Age. The Sharon Member of the Pennsylvanian Pottsville Formation unconformably overlies the eroded Cuyahoga Formation throughout the eastern half of RVAAP/RTLS. The Sharon Member consists of two units:

sandstone/conglomerate and shale. The Sharon Conglomerate unit of the Sharon Member is highly porous, permeable, cross-bedded, and frequently fractured and weathered. The Sharon Shale unit is a light to dark-gray fissile shale, which has been eroded in many locations. The Connoquenessing Sandstone Member of the Pottsville Formation unconformably overlies the Sharon Member and is a medium- to coarse-grained gray-white sandstone. The Mercer Member of the Pottsville Formation overlies the Connoquenessing and consists of silty to carbonaceous shale. The Homewood Member of the Pottsville Formation unconformably overlies the Mercer Member and consists of coarse-grained cross-bedded sandstones. The Connoquenessing, Mercer, and Homewood Members are present only in the western half of RVAAP/RTLS. The regional dip of the Pottsville Formation strata is between 1.5 and 3 meters (5 to 10 feet) per mile to the south.

2.3.2 Geologic Setting of ODA2

Subsurface characterization at ODA2 during the Phase I and II RIs was limited to the unconsolidated zone. The most thorough characterization was performed by continuous sampling during the drilling of monitoring well borings. Core holes into bedrock were not drilled during the Phase II RI. Several monitoring well borings did penetrate the uppermost portion of the bedrock interval; therefore, a minimal amount of data exists for depth to bedrock and bedrock stratigraphy at the AOC.

2.3.2.1 Soils

At ODA2, soils of the Mahoning/Ellsworth series are dominant to the North of Sand Creek, and soils of the Wadsworth/Ellsworth series are dominant to the South of Sand Creek. Orrville silt loams are prominent along Sand Creek. The Mahoning series soils are typified by poorly drained soil formed in silty clay loam or clay loam glacial till where bedrock is generally greater than 1.8 meters (6 feet). Runoff is typically medium to rapid, and the soil is seasonally wet. Permeabilities typically range from 1.52 to 5.08 centimeters (0.6 to 2.0 inches) per hour.

Much of ODA2 has been significantly disturbed down to a depth of at least 4 ft or greater because of the use of ODA2 for munitions demolition and the associated digging of numerous trenches and pits.

Monitoring well borings provide the generalized geologic characteristics noted below for the unconsolidated zone (from shallow to deep stratigraphic zones). A generalized geologic cross section for the AOC from north to south is provided in Figure 2-4.

At depths beginning at about 0.1 meter (0.33 feet), based on soil sampling and boring data, unconsolidated deposits consist primarily of a brown to yellowish-brown silty clay to clayey silt. This interval typically has a firm to hard consistency, low plasticity, and is dry to moist. In some borings, a gradual color change to olive or gray, increasing clay content, and the presence of mottling was noted.

Fine- to medium-grained sand layers containing some gravel were found to be interspersed within silty clay or clay layers in nearly all of the monitoring well borings as follows:

- 2.99 to 6.64 meters (9.8 to 21.8 feet) in DA2mw-104;

- 1.37 to 4.27 meters (4.5 to 14 feet) in DA2mw-105;
- 2.44 to 2.59 meters (8.0 to 8.5 feet) in DA2mw-106;
- 2.59 to 3.66 meters (8.5 to 12 feet) in DA2mw-107;
- 0.40 to 0.61 meters (1.3 to 2.0 feet) in DA2mw-108;
- 5.24 to 5.33 meters (17.2 to 17.7 feet) in DA2mw-109;
- 0.30 to 0.46 meters (1 to 1.5 feet) in DA2mw-111;
- 1.22 to 3.35 meters (4 to 11 feet) in DA2mw-112; and
- 0.82 to 3.51 meters (2.7 to 11.5 feet) in DA2mw-113.

2.3.2.2 Bedrock Geology

Borings associated with DA2mw-106, DA2mw-107, DA2mw-108, DA2mw-111, DA2mw-112, and DA2mw-113 encountered weathered shale bedrock. Bedrock was observed to be dark gray, fissile shale consistent with the lithology of the Sharon Shale.

2.4 HYDROLOGY

2.4.1 Regional Hydrogeology

Sand and gravel aquifers are present in the buried-valley and outwash deposits in Portage County as described in the *Phase I Remedial Investigation Report for High-Priority Areas of Concern at RVAAP* (USACE 1998a). Generally these saturated zones are too thin and localized to provide large quantities of water for industrial or public water supplies; however, yields are sufficient for residential water supplies. Lateral continuity of these aquifers is not known. Recharge of these units comes from surface water infiltration of precipitation and surface streams. Specific groundwater recharge and discharge areas at RVAAP/RTLS have not been delineated.

2.4.1.1 Unconsolidated Sediment

The thickness of the unconsolidated interval at RVAAP/RTLS ranges from thin to absent in the eastern and northeastern portion of RVAAP/RTLS to an estimated 45 meters (150 feet) in the central portion of the installation. The groundwater table occurs within the unconsolidated zone in many areas of the installation. Because of the very heterogeneous nature of the unconsolidated glacial materials, groundwater flow patterns are difficult to determine with a high degree of accuracy. Vertical recharge from precipitation likely occurs via infiltration along root zones and desiccation cracks and partings within the soil column. Laterally, most groundwater flow likely occurs along preferential pathways (e.g., sand seams, channel deposits, or other stratigraphic discontinuities) having higher permeabilities than surrounding clay or silt-rich materials.

2.4.1.2 Bedrock Hydrogeology

The sandstone facies of the Sharon Member, and in particular the Sharon Conglomerate, were the primary sources of groundwater during RVAAP's active phase, although some wells were completed in the Sharon Shale. Past studies of the Sharon Conglomerate indicate that the highest yields come from the quartzite pebble conglomerate facies and from jointed and fractured zones. Where it is present, the overlying Sharon Shale acts as a relatively impermeable confining layer for the sandstone. Monitoring wells completed in the Sharon Sandstone at Load Line 1 in 1999 typically had hydraulic conductivities of 2.35 x 10^{-5} to 7.3 x 10^{-4} centimeters/second (USACE 2001b). Hydraulic conductivities in wells completed in the Sharon Shale generally are much lower than those in the sandstone.

2.4.1.3 Surface Water System

The entire RVAAP/RTLS facility is situated within the Ohio River Basin, with the West Branch of the Mahoning River representing the major surface stream in the area. This stream flows adjacent to the western end of the facility, generally from north to south, before flowing into the M.J. Kirwan Reservoir that is located to the south of State Route 5. The West Branch flows out of the reservoir along the southern facility boundary before joining the Mahoning River east of RVAAP/RTLS.

The western and northern portions of RVAAP/RTLS display low hills and dendritic surface drainage. The eastern and southern portions are characterized by an undulating to moderately level surface, with less dissection by surface drainage. The facility is marked with marshy areas and flowing and intermittent streams, with headwaters located in the higher regions of the site. Three primary watercourses drain RVAAP/RTLS: the South Fork of Eagle Creek, Sand Creek, and Hinkley Creek.

Sand Creek, with a drainage area of 36 square kilometers (13.9 square miles), flows generally northeast to its confluence with the South Fork of Eagle Creek. In turn, the South Fork of Eagle Creek then continues in a northerly direction for 7 kilometers (2.7 miles) to its confluence with Eagle Creek. The drainage area of the South Fork of Eagle Creek is 67.9 square kilometers (26.2 square miles), including the area drained by Sand Creek. Hinkley Creek, with a drainage area of 28.5 square kilometers (11.0 square miles), flows in a southerly direction through the installation to its confluence with the West Branch of the Mahoning River south of the facility.

Approximately 50 ponds are scattered throughout the installation. Many were built within natural drainageways to function as settling ponds or basins for process effluent and runoff. Others are natural glacial depressions or result from beaver activity. All water bodies at RVAAP/RTLS support an abundance of aquatic vegetation and are well stocked with fish. None of the ponds within the installation are used as water supply sources. Storm water runoff is controlled primarily by natural drainage.

2.4.2 ODA2 Hydrologic/Hydrogeologic Setting

All wells at ODA2 were screened within unconsolidated glacial sediments, at the soil/rock interface, or in the case of MW108, weathered shale. Potentiometric surface maps of groundwater at ODA2 are provided in Figures 2-5 and 2-6. The maps were constructed using static water level data from 10 monitoring wells installed during the Phase II RI, 4 monitoring wells previously installed near the RCRA portion of the AOC, and 2 monitoring wells installed as part of the Winklepeck Burning

Grounds RI. In general, the potentiometric surface is a subdued replica of the site topography. Groundwater flow at the site is generally towards Sand Creek. Differences in the potentiometric surface in Figures 2-5 and 2-6 are due to seasonal variances.

Results of slug tests performed at the 10 monitoring wells during December 2002 reveal low to moderate hydraulic conductivities in the unconsolidated sediments. Hydraulic conductivity ranged from 3.79 x 10^{-7} centimeters/second to 6.53 x 10^{-4} centimeters/second (Table 2-1). Hydraulic conductivity tests were also conducted in the laboratory on 0.6-meter (2-foot) Shelby tube samples collected within the screened interval at wells DA2MW-104, DA2MW-107, DA2MW-109, DA2MW-110, and DA2MW-111. Results ranged from 8.14 x 10^{-8} centimeters/second to 1.15 x 10^{-5} centimeters/second, orders of magnitude less than the slug test results. Slug test results are representative of the entire screened interval for the monitoring wells, while laboratory results are representative of the specific 0.6-meter (2-foot) interval sampled. Therefore, any local heterogeneities that affect hydraulic conductivity within the screened interval, such as sand lenses, may not be present in the Shelby tube samples.

Surface water drains from north to south towards Sand Creek in the northern portion of the AOC, and from south to north towards Sand Creek in the southern portion of the AOC. The primary surface water conveyance across the AOC is Sand Creek, which flows across the center of the site from west to east (see Figure 1-5). The primary north-south drainage feature within the AOC is a drainage pathway that originates near the southeastern border of the Winklepeck Burning Grounds and flows south to intersect with Sand Creek. Stream flow in this drainageway is intermittent and is driven primarily by storm events. Flow in Sand Creek is perennial.

2.5 CLIMATE

RVAAP/RTLS has a humid continental climate characterized by warm, humid summers and cold winters. Precipitation varies widely through the year. The driest month is, on average, February, and the wettest month is July. Data from the National Weather Service compiled over the past 47 years indicate that the average rainfall for the area is 0.98 meter (38.72 inches) annually. The average snowfall is 1.08 meters (42.4 inches) annually. Severe weather, in the form of thunder and hail in summer and snowstorms in winter, is common. Tornadoes are infrequent in Portage County. The Phase II RI field work was primarily conducted during July through September. Climate conditions for the year included above-normal temperatures and precipitation values slightly above normal.

Table 2-1. Hydraulic Conductivity Estimates ODA2 Phase II RI

Monitoring Well ID No.	Screened Interval	Total Depth	Lithology in Screened Interval	Slug Test K (cm/sec)	Laboratory K (cm/sec)	Depth of Shelby Interval
DA2MW104	19.37’-29.37’	30’	Unconsolidated Sediments (clayey silt, silt, sand)	Slug In: 1.47×10^{-5} Slug Out: 1.24×10^{-4}	3.83×10^{-7}	24.0’ – 26.0’
DA2MW105	8.3’-13.3’	14’	Unconsolidated Sediments (sand with gravel)	Slug In: 1.3×10^{-5} Slug Out: 6.53×10^{-4}	N/A	
DA2MW106	8.3’-15.3’	16’	Unconsolidated Sediments (sand, clay/weathered shale)	Slug In: 3.79×10^{-7} Slug Out: 3.79×10^{-4}	N/A	
DA2MW107	8.8’-13.8’	15’	Unconsolidated Sediments (sand, gravel, clay)	Slug In: 1.5×10^{-4} Slug Out: 1.56×10^{-4}	1.16×10^{-5} 1.73×10^{-7}	10.0’ – 12.0’ 12.0’ – 14.0’
DA2MW108	8.8’-13.8’	15’	Weathered Shale	Slug In: 2.69×10^{-5} Slug Out: 1.18×10^{-5}	N/A	
DA2MW109	11.3’-21.3’	24’	Unconsolidated Sediments (silty clay, sand, gravel)	Slug In: 2.17×10^{-6} Slug Out: 3.23×10^{-6}	6.35×10^{-8} 8.14×10^{-8}	20’ – 22’ 22’ – 24’
DA2MW110	9.3’-19.3’	20’	Unconsolidated Sediments (silty clay with gravel)	Slug In: 7.66×10^{-7} Slug Out: 3.79×10^{-6}	4.74×10^{-8} 1.69×10^{-7}	12’ – 14’ 14’ – 16’
DA2MW111	7.1’-12.1’	12.6’	Clay/Weathered Shale	Slug In: 6.36×10^{-6} Slug Out: 5.79×10^{-6}	3.12×10^{-8}	6’ – 8’
DA2MW112	8.8’-13.8’	15’	Unconsolidated Sediments (sand with gravel)	Slug In: 7.53×10^{-5} Slug Out: 6.06×10^{-4}	N/A	
DA2MW113	8.3’-13.3’	14’	Unconsolidated Sediments (sand with gravel)	Slug In: 6.01×10^{-4} Slug Out: 5.19×10^{-4}	N/A	

2.6 POTENTIAL RECEPTORS

2.6.1 Human Receptors

RVAAP is a 1,481 acre portion of the 21,419 acre RTLS of the OHARNG. The OHARNG is currently accountable for 19,938 acres of the installation. RVAAP/RTLS is located in northeastern Ohio approximately 37 km (23 miles) east-northeast of Akron and 48.3 kilometers (30 miles) west-northwest of Youngstown. RVAAP/RTLS occupies east-central Portage County and southwestern Trumbull County. U.S. Census Bureau population estimates for 2001 indicate that the populations of Portage and Trumbull counties are 152,743 and 223,982, respectively. Population centers closest to RVAAP/RTLS are Ravenna, with a population of 12,100, and Newton Falls, with a population of 4,866. Approximately 55 percent of Portage County, in which the majority of RVAAP/RTLS is located, consists of either woodland or farm acreage. The installation is surrounded by several other communities: Windham on the north, Garrettsville 9.6 kilometers (6 miles) to the northwest, Charlestown to the southwest, and Wayland 4.8 kilometers (3 miles) southeast. The Michael J. Kirwan Reservoir (also known as West Branch Reservoir) is the closest major recreational area and is adjacent to the western half of RVAAP/RTLS south of State Route 5.

The RVAAP/RTLS facility is located in a rural area, is not accessible to the general public, and is not near any major industrial or developed areas. The facility is currently fenced and patrolled by security personnel. Army and full-time operating contractor staff (i.e., security and site operation/maintenance) are located onsite. Additional subcontractor staff is onsite for varying periods of time, to complete specific environmental, demolition, or decommissioning projects. Training activities under the OHARNG involve an average of 4,500 personnel during the course of a month, who are onsite for periods of three days (inactive duty or weekend training) to two weeks (annual training).

ODA2 is located in the central portion of RVAAP/RTLS and is not currently used for OHARNG training activities. Groundskeeping activities are limited to infrequent mowing and brush clearing along the perimeter areas outside of the AOC boundary fence. Expected future land use for ODA2 is as an active demolition area and training area for the OHARNG.

2.6.2 Ecological Receptors

The dominant types of vegetative cover at RVAAP/RTLS, including portions of ODA2 and its immediate surroundings, are forests and old fields of various ages. More than 75 percent of RVAAP/RTLS is now in forest. Most of the old field cover is the result of earlier agricultural practices that left these sites with poor topsoil, which limits forest regeneration. Several thousand acres of agricultural fields were planted in trees during the 1950s and 1960s, but these plantings were not successful in areas with poor topsoil. Some fields, leased for cattle grazing during the same time period, were delayed in their reversion to forest. A few fields have been periodically mowed, maintaining them as old field. ODA2 is covered with newly seeded grass and scrub within the former detonation/disposal areas with the remainder of the AOC with forested and wetland area.

From one-half to two-thirds (4,406 to 6,070 hectares [10,000 to 15,000 acres]) of RVAAP/RTLS's land area meets the regulatory definition of jurisdictional wetland. Wetland areas at RVAAP/RTLS include seasonally saturated wetlands, wet fields, and forested wetlands. Most of these wetlands exist because of poorly drained and hydric soils. Beaver impoundments contribute to wetland diversification in some parts of the site. A forested wetland area occurs in the western and eastern portions of the AOC, along the Sand Creek drainage channel.

The flora and fauna at RVAAP/RTLS are varied and widespread. No federal threatened or endangered or candidate threatened or endangered species have been observed on RVAAP/RTLS. A list of state endangered, state threatened or potentially threatened, and state special interest species confirmed to be on RVAAP/RTLS is provided in Table 7-2 (Morgan 2000). Additionally, five rare plant communities/significant natural areas have been identified on RVAAP/RTLS, including the northern woods, Wadsworth Glen, Group 3 woods, B&O Wye Road area, and South Patrol Road swamp forest.

Restricted land use and sound forest management practices have preserved and enabled large forest tracts to mature. Habitat conversion at RVAAP/RTLS, unlike most other habitat conversions occurring nationwide, has been toward restoration of the forests that covered the area prior to its being cleared for agriculture. The reversion of these agricultural fields to mature forest provides a diverse habitat from old field through several successional stages. Overall, the trend toward forest cover enhances the area for use by both plant and animal forest species. Future IRP activities will require consideration of these species to ensure that detrimental effects on threatened or endangered RVAAP/RTLS flora and fauna do not occur; this will be discussed in the ERA (Section 7.0). There are no federal, state, or local parks or protected areas on RVAAP/RTLS property.

2.7 PRELIMINARY SITE CONCEPTUAL MODEL

The facility-wide hydrogeologic SCM for RVAAP, presented in the Facility Wide SAP, is applicable to ODA2 for this Phase II RI, based on current knowledge. The SCM for RVAAP, operational information, analytical data collected during historical environmental investigations, and applicable data collected during previous investigations at ODA2 have been used to refine the SCM specific to the project area as outlined below.

2.7.1 Soil

Based on characterization data to date, contaminated soil within and adjacent to former demolition pits and suspected burial areas are potential secondary sources of contamination in sediment, surface water, and groundwater. Contaminants may be released from soil and migrate in storm runoff either in dissolved phase or adsorbed to particulates and/or colloids. Further characterization of suspected areas of soil contamination was conducted to define contaminant nature and extent and to provide sufficient data for remedial alternatives analysis in a subsequent feasibility study. Subsurface soil characterization was also necessary to determine if leaching processes may be a potential mechanism for contaminant migration to groundwater. The Phase I RI and other historical sampling did not characterize all of the suspected former demolition pits and burial areas. Thus, those areas not previously characterized were specifically targeted for biased sampling in the Phase II RI.

2.7.2 Sediment

Sediment within ditches and tributaries represents a receptor media for contaminants eroded or leached from soil and transported by storm runoff. In addition, sediment may function as a transport mechanism considering that contaminants adsorbed to particulates may be mobilized by surface water flow. Operational data suggest that the ditches in the vicinity of former demolition pits and suspected burial areas represent the most likely locations where contaminants may have accumulated through erosional transport.

Site characteristics and available field data show that the primary surface water and sediment exit pathways for the ODA2 AOC follow unnamed ditches and tributaries that ultimately feed into Sand Creek. For the portion of the AOC that is located south of Sand Creek, drainage flows to the north and east; for the portion of the AOC that is located north of Sand Creek, drainage flows to the south and east. Considering the available data and the SCM, both confirmed and additional suspected source areas, as well as the exit pathways, were specifically targeted for biased sediment sampling. Previous sediment sampling data show evidence of contamination in the vicinity of former suspected burial areas adjacent to Sand Creek.

2.7.3 Surface Water

Surface water represents the likely primary mechanism for mobilization and transport of contamination within and off of ODA2. Most chemical transport via surface water is presumed to occur along the ditches within the AOC and is primarily episodic and related to storm events that produce flushing of the surface water system and mobilization of contaminated soil and sediment through erosion.

2.7.4 Groundwater

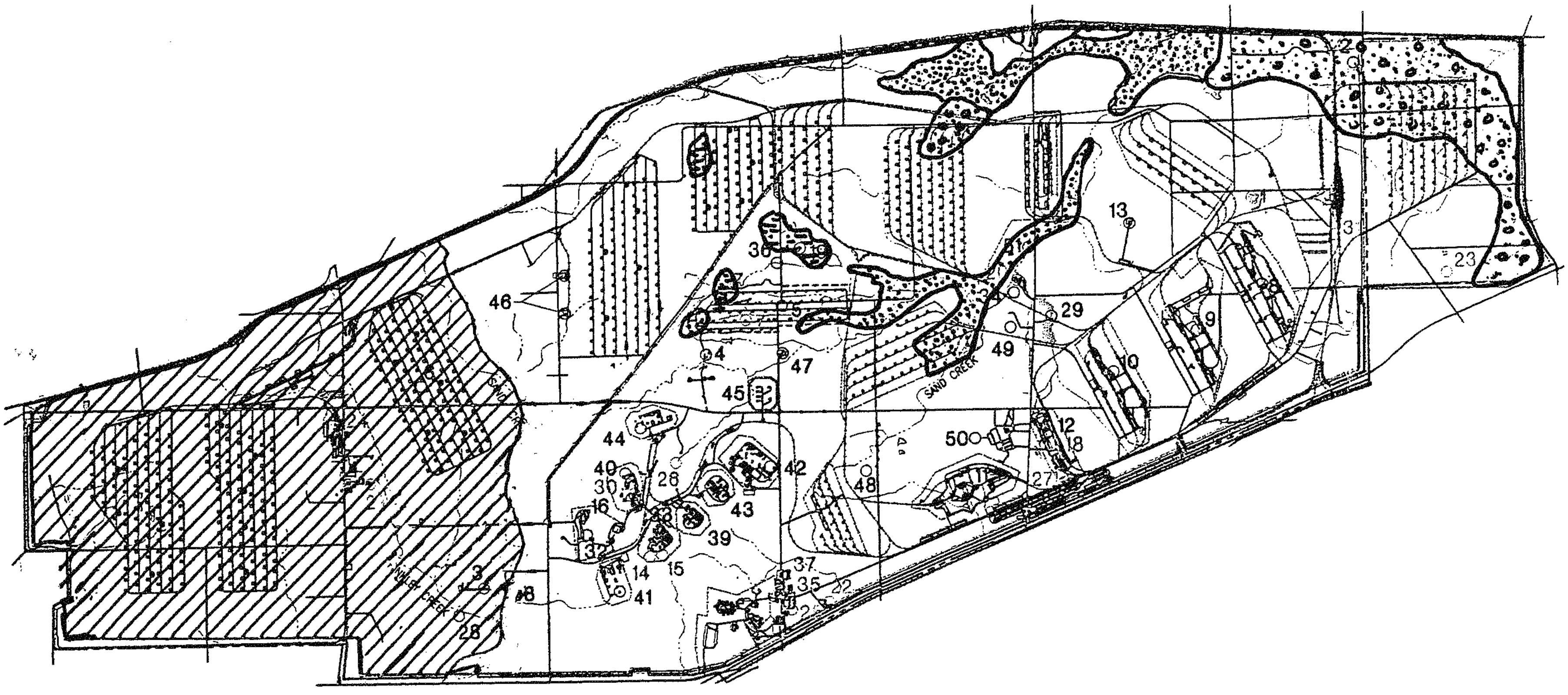
No hydrogeological and analytical data exist for groundwater for the portion of ODA2 that lies south of Sand Creek. Hydrogeologic and analytical data for the portion of ODA2 that includes the RCRA unit has been gathered since the 1992 installation of four groundwater monitoring wells at that site. Quarterly measurement of groundwater levels indicate that the groundwater flow within that area generally follows topography and flows in a general south and east direction toward Sand Creek. For the purposes of DQO development and investigation planning, the SCM presumes that the general groundwater flow patterns south of Sand Creek at ODA2 would also mimic the site topography and surface water drainage patterns, following a north and east direction toward Sand Creek.

Analytical evidence for groundwater contamination by SRCs identified in source area soil (i.e., explosives and metals) is indicated in the groundwater monitoring wells located around the RCRA unit north of Sand Creek. Since 1992, explosives have been subsequently detected in all four wells, and metals exceeding site-wide background criteria were detected in wells DET-2 and DET-4 in 2000. Potential source area SRCs identified to date have low mobility in groundwater. However, previous sampling data from wells around the RCRA unit indicates that the potential exists for groundwater contamination at this AOC.

Groundwater characterization efforts included the installation of monitoring wells in a configuration designed to provide data on general hydrogeologic characteristics and groundwater flow patterns. Wells were installed in the vicinity of known and suspected source areas to evaluate whether contaminants are leaching to groundwater. Monitoring wells were also placed in close proximity to Sand Creek to determine whether groundwater flow and potential contaminant transport into Sand Creek and off of the AOC is occurring.

2.8 CURRENT SITE CONDITIONS

The current potential for human exposure to potential contaminants migrating from the site is mitigated by inactivity at the site, the absence of permanent residents, and the low population density on adjacent private properties. Substantial disruption of ecological terrestrial habitat was observed at the site because of demolition activities. Outside of the recently remediated RCRA unit, no evidence of substantial ecological stress was observed during the field investigation.



Adapted from White, 1987.

- ▨ Recent Alluvium
- ☐ Hiram Till – Ground Moraine
- ▤ Hiram Till – End Moraine
- ▨ Lavery Till - Ground Moraine
- ▣ Outwash Sand and Gravel

OHIO STATE PLANE (NAD83)

0 2000 4000 8000

SCALE: 1" = 4000'

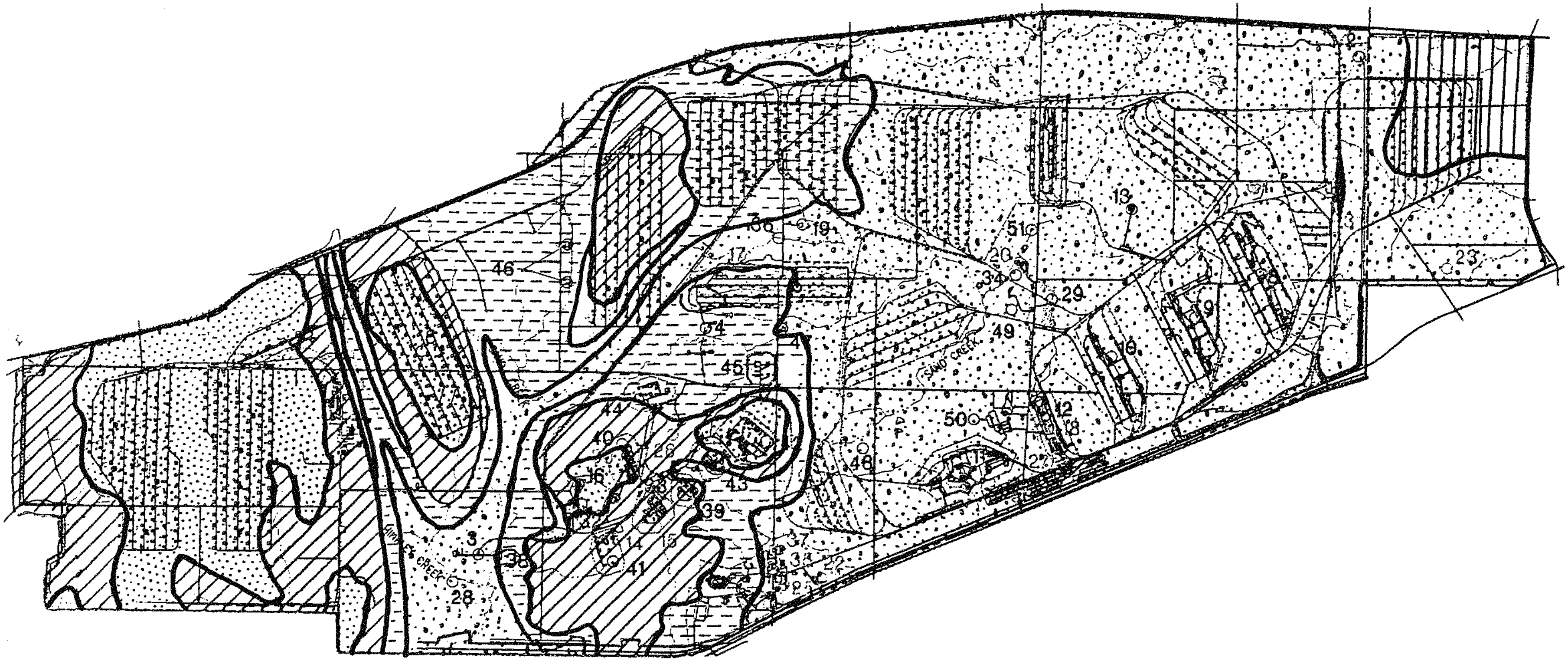
Ravenna Army Ammunition Plant
Demolition Area 2
Ravenna, Ohio

Glacial Geology
of RVAAP

SPECPRO, INC.
ENVIRONMENTAL SERVICES

DATE: 2/16/2005
Revised: 5/11/05

FIGURE: 2-1



Adapted from USATHAMA, 1978.

░ Homewood Sandstone Member

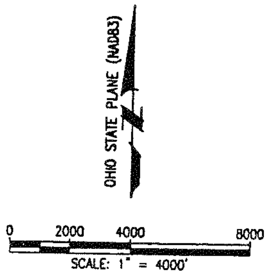
▨ Mercer Member

░ Connoquenessing Sandstone Member

▤ Sharon Member, Shale Unit

⁘ Sharon Member, Conglomerate Unit

▥ Cuyahoga Group



Ravenna Army Ammunition Plant
Demolition Area 2
Ravenna, Ohio

Bedrock Geology
of RVAAP

SPECPRO, INC.
ENVIRONMENTAL SERVICES

DATE: 2/16/2005 **Revised: 5/11/05**	**FIGURE: 2-2**

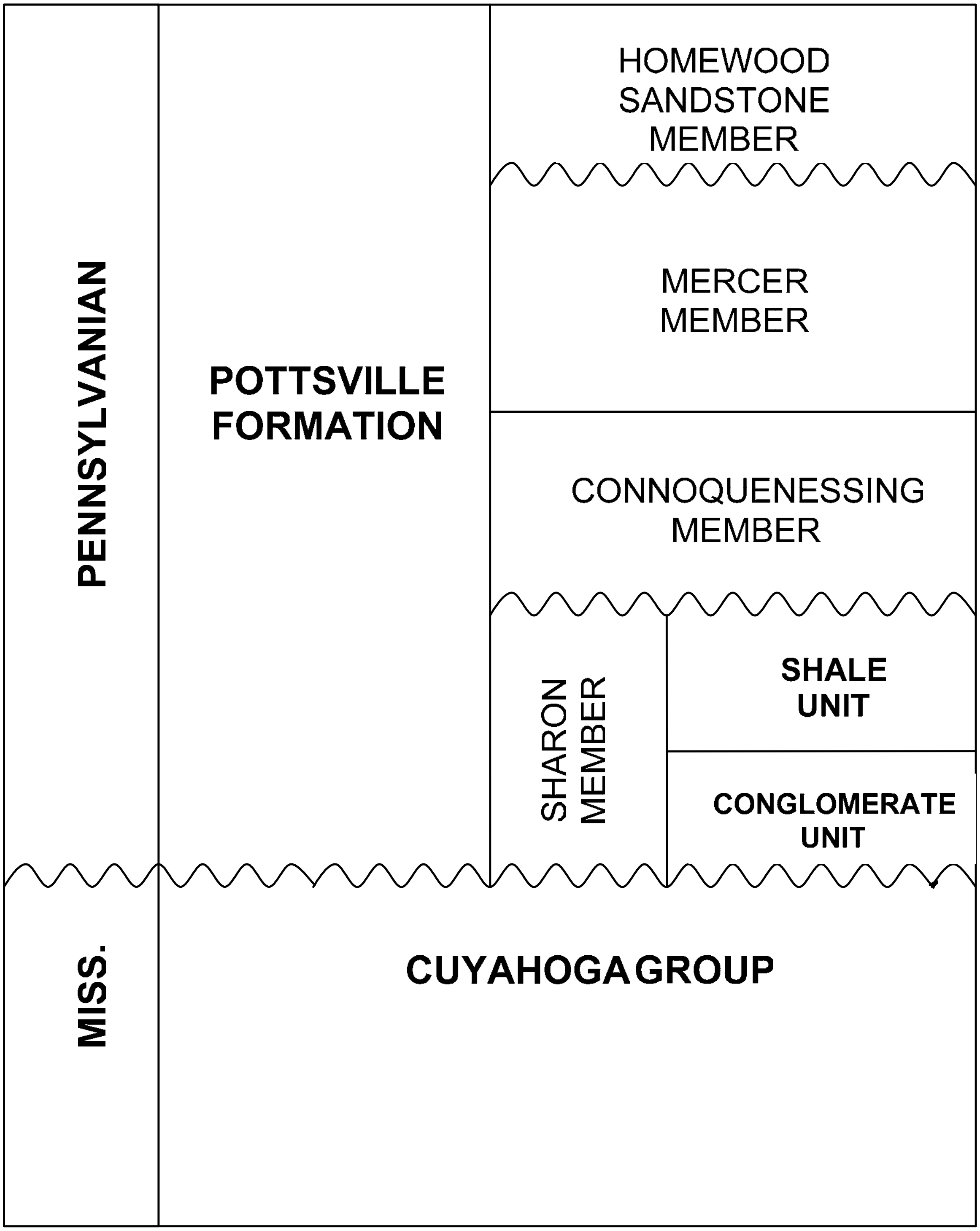
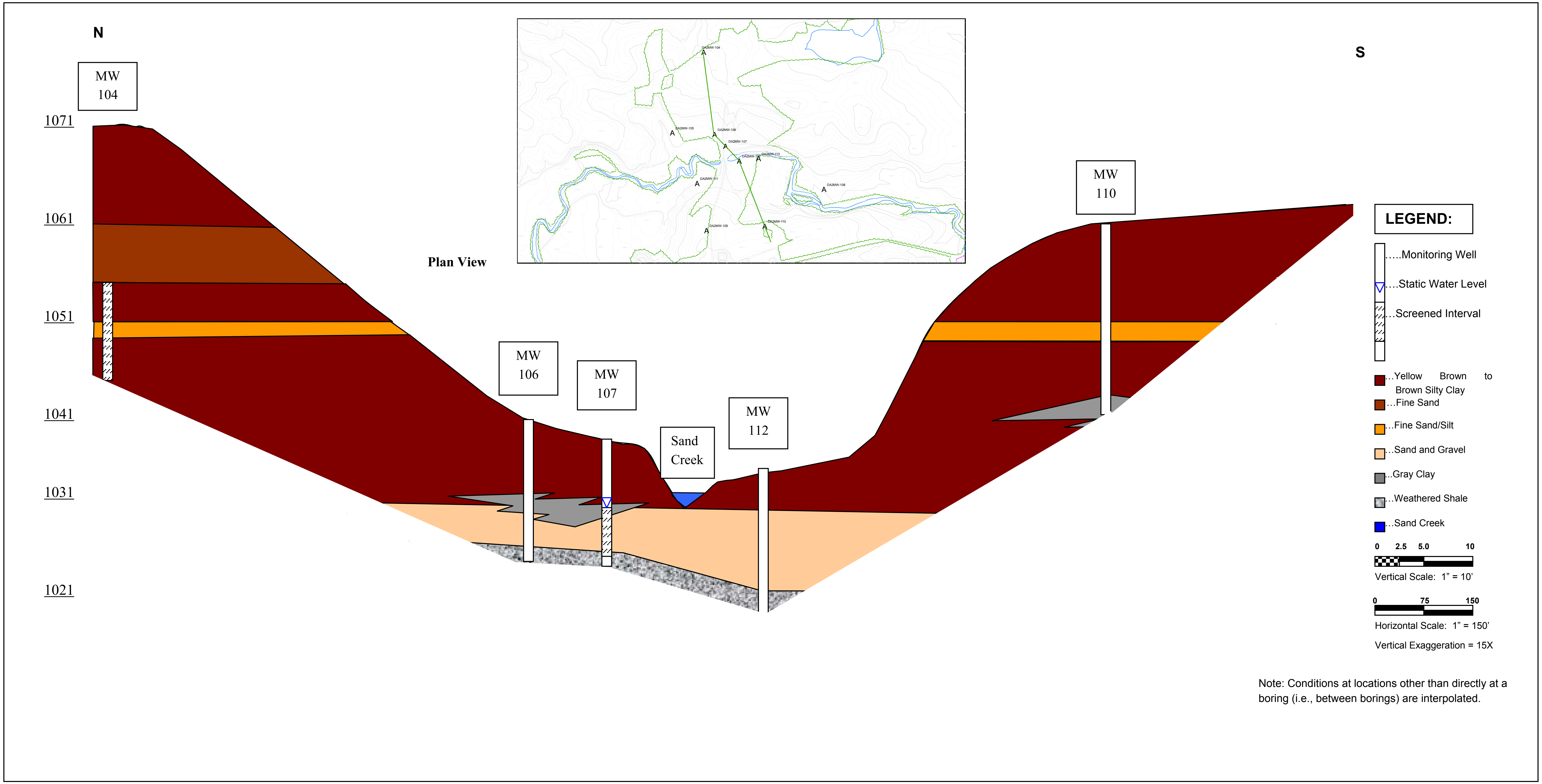


Figure 2-3. Ravenna Army Ammunition Plant Bedrock Stratigraphy (Adapted from Winslow, J.D., and White, G.W., 1966)



Note: Conditions at locations other than directly at a boring (i.e., between borings) are interpolated.

Figure 2-4 Geologic Cross-section of ODA2

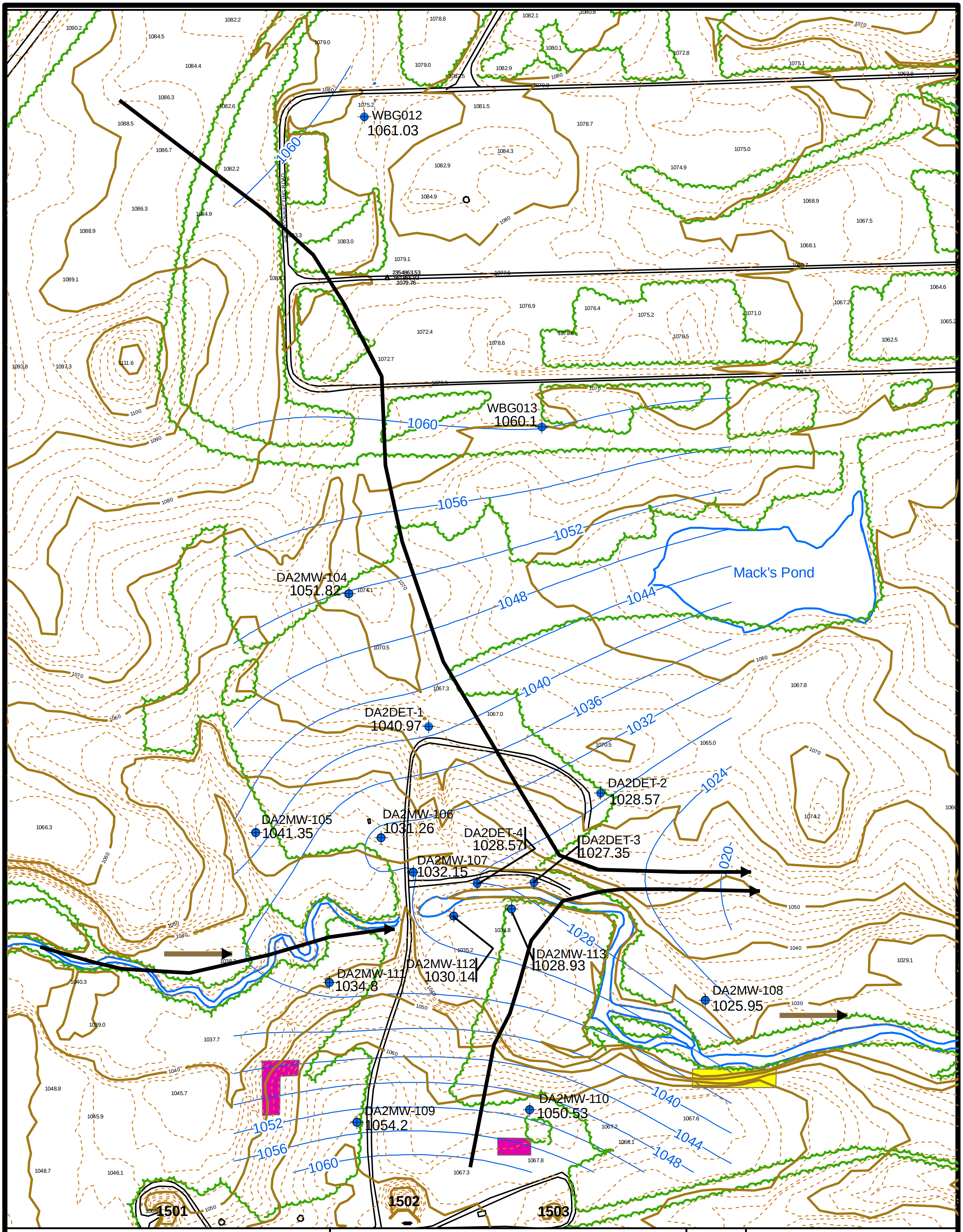


Figure 2-5 Groundwater Contour Map of ODA2 08/27/02

Note:Groundwater contours represent general groundwater flow directions based upon available water level data from site monitoring wells

SAIC
From Science to Solutions

LEGEND
- Roads
- Railroads
- Vegetation
- Water
- Fence
- 2' Contour
- 10' Contour
- Groundwater Flow Direction
- Stream Flow Direction
- Groundwater Contour (CI= 4 ft)
- 🟥 Burial Sites
- 🟨 Sand Creek Disposal

0 50 100 200 300 400
Feet

Drawn By: DAC

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/June/06

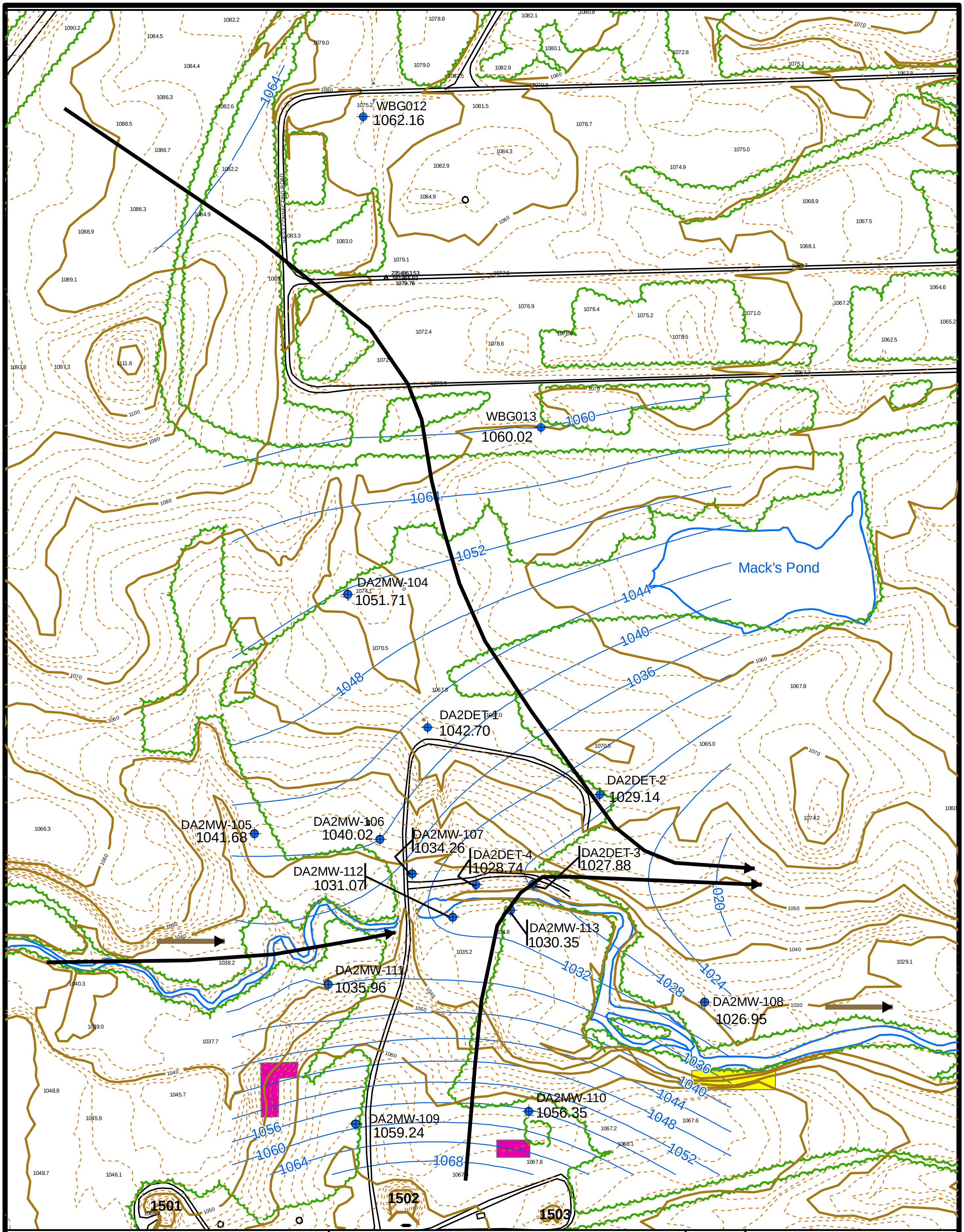


Figure 2-6 Groundwater Contour Map of ODA2 04/03/03

Note:Groundwater contours represent general groundwater flow directions based upon available water level data from site monitoring wells

SAIC
From Science to Solutions

LEGEND

Roads
Railroads
Vegetation
Water
Fence
2' Contour
10' Contour
Groundwater Flow Direction
Stream Flow Direction
Groundwater Contour (CI=4 ft)
Burial Sites
Sand Creek Disposal

0 50 100 200 300 400 Feet

Drawn By: DAC

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/June/06

3.0 STUDY AREA INVESTIGATION

The scope of the Phase II RI field effort at ODA2 included sampling of surface and subsurface soils, sediment, surface water, and groundwater. This section presents information on locations of and rationale for samples collected during the field effort and provides a synopsis of the sampling methods employed during the investigation. Specific notation is made where site conditions required a departure from planned activities in the Phase II RI Work Plan and SAP Addenda (USACE 2002). Information regarding standard field decontamination procedures, sample container types, preservation techniques, sample labeling, chain-of-custody, and packaging and shipping requirements implemented during the field investigation may be found in the Facility Wide SAP (USACE 2001a) and the Phase II RI Work Plan and SAP Addenda.

3.1 SOIL AND VADOSE ZONE CHARACTERIZATION

Soil samples for chemical analyses were collected from a total of 56 stations located throughout ODA2. Figure 3-1 illustrates the locations for surface soil and subsurface soil sampling. Table 3-1 provides a detailed listing of the soil samples collected during the Phase II RI field effort. Surface and subsurface soil samples were collected at all of the stations. Soil sampling logs are presented in Appendix C.

Samples for geotechnical analyses were collected from 5 stations (monitoring well boring locations). Shelby tube samples were collected from depths ranging from 2.3 to 7.3 meters (7.5 to 24.0 feet) within the planned monitoring (screened) interval at these stations. Shelby tube samples were planned for each of the ten monitoring well boring locations; however, only five were obtained as five of the locations encountered bedrock prior to the planned screened intervals.

3.1.1 Rationale

Soil samples were collected primarily at former detonation and disposal areas that were thought to represent potential source areas for contamination. Sampling locations were selected on the basis of operational records, project DQOs, and analytical results from the Phase I RI to characterize contaminant nature and extent. Table 3-1 describes the rationale for the final placement of individual sampling locations for soil within ODA2.

Data from soil samples collected during the Phase II RI at ODA2 were obtained to identify areas contaminated as a result of historical site operations and to determine the vertical and horizontal extent of identified contamination. Soil sampling data were also obtained to evaluate the potential for contaminant migration via leaching or erosion from surface soil sources to receptor media such as sediment and surface water, using numerical models and qualitative methods (See Section 5). The results of the soil sample analyses were also used to quantify risks to human and ecological receptors that may be exposed to soil (See Sections 6 and 7).

Table 3-1. Soil Sample List and Rationales, ODA2 Phase II RI

Area Description	Station ID	Sample Station Rationale	Sample ID	Depth (feet)	Sample Collected (Yes/No)	Comments
North of Sand Creek, West of Demolition Road	DA2-034	Potential source area	DA2SS-034-0649-SO	0-1	Yes	
	DA2-034	Potential source area	DA2SO-034-0650-SO	1-1.5	Yes	
	DA2-035	Potential source area	DA2SS-035-0651-SO	0-1	Yes	
	DA2-035	Potential source area	DA2SO-035-0652-SO	1-3	Yes	
	DA2-036	Potential source area	DA2SS-036-0653-SO	0-1	Yes	
	DA2-036	Potential source area	DA2SO-036-0654-SO	1-3	Yes	
	DA2-037	Potential source area	DA2SS-037-0655-SO	0-1	Yes	
	DA2-037	Potential source area	DA2SO-037-0656-SO	1-1.5	Yes	
	DA2-038	Potential source area	DA2SS-038-0657-SO	0-1	Yes	
	DA2-038	Potential source area	DA2SO-038-0658-SO	1-3	Yes	
	DA2-039	Potential source area	DA2SS-039-0659-SO	0-1	Yes	
	DA2-039	Potential source area	DA2SO-039-0660-SO	1-3	Yes	
	DA2-040	Potential source area	DA2SS-040-0661-SO	0-1	Yes	
	DA2-040	Potential source area	DA2SO-040-0662-SO	1-3	Yes	
	DA2-041	Potential source area	DA2SS-041-0663-SO	0-1	Yes	
	DA2-041	Potential source area	DA2SO-041-0664-SO	1-3	Yes	
	DA2-042	Potential source area	DA2SS-042-0665-SO	0-1	Yes	
	DA2-042	Potential source area	DA2SO-042-0666-SO	1-3	Yes	
	DA2-043	Potential source area	DA2SS-043-0667-SO	0-1	Yes	
	DA2-043	Potential source area	DA2SO-043-0668-SO	1-3	Yes	
	DA2-044	Potential source area	DA2SS-044-0669-SO	0-1	Yes	
	DA2-044	Potential source area	DA2SO-044-0670-SO	1-2.67	Yes	
	DA2-045	Potential source area	DA2SS-045-0671-SO	0-1	Yes	
	DA2-045	Potential source area	DA2SO-045-0672-SO	1-3	Yes	

Table 3-1. Soil Sample List and Rationales, ODA2 Phase II RI (continued)

Area Description	Station ID	Sample Station Rationale	Sample ID	Depth (feet)	Sample Collected (Yes/No)	Comments
North of Sand Creek, West of Demolition Road (continued)	DA2-046	Potential source area	DA2SS-046-0673-SO	0-1	Yes	
	DA2-046	Potential source area	DA2SO-046-0674-SO	1-3	Yes	
	DA2-047	Potential source area	DA2SS-047-0675-SO	0-1	Yes	
	DA2-047	Potential source area	DA2SO-047-0676-SO	1-3	Yes	
	DA2-048	Potential source area	DA2SS-048-0677-SO	0-1	Yes	
	DA2-048	Potential source area	DA2SO-048-0678-SO	1-2.9	Yes	
	DA2-049	Determine presence/absence of contamination	DA2SS-049-0679-SO	0-1	Yes	
	DA2-049	Determine presence/absence of contamination	DA2SO-049-0680-SO	1-3	Yes	
South of Sand Creek, West of Demolition Road	DA2-050	Potential source area	DA2SS-050-0681-SO	0-1	Yes	
	DA2-050	Potential source area	DA2SO-050-0682-SO	1-3	Yes	
	DA2-051	Potential source area	DA2SS-051-0683-SO	0-1	Yes	
	DA2-051	Potential source area	DA2SO-051-0684-SO	1-3	Yes	
	DA2-052	Potential source area	DA2SS-052-0685-SO	0-1	Yes	
	DA2-052	Potential source area	DA2SO-052-0686-SO	1-3	Yes	
	DA2-053	Potential source area	DA2SS-053-0687-SO	0-1	Yes	
	DA2-053	Potential source area	DA2SO-053-0688-SO	1-3	Yes	
	DA2-054	Potential source area	DA2SS-054-0689-SO	0-1	Yes	
	DA2-054	Potential source area	DA2SO-054-0690-SO	1-3	Yes	
	DA2-055	Potential source area	DA2SS-055-0691-SO	0-1	Yes	
	DA2-055	Potential source area	DA2SO-055-0692-SO	1-3	Yes	
	DA2-056	Determine presence/absence of contamination	DA2SS-056-0693-SO	0-1	Yes	
	DA2-056	Determine presence/absence of contamination	DA2SO-056-0694-SO	1-3	Yes	

Table 3-1. Soil Sample List and Rationales, ODA2 Phase II RI (continued)

Area Description	Station ID	Sample Station Rationale	Sample ID	Depth (feet)	Sample Collected (Yes/No)	Comments
South of Sand Creek, East of Demolition Road	DA2-057	Determine presence/absence of contamination	DA2SS-057-0695-SO	0-1	Yes	
	DA2-057	Determine presence/absence of contamination	DA2SO-057-0696-SO	1-3	Yes	
	DA2-058	Potential source area	DA2SS-058-0697-SO	0-1	Yes	
	DA2-058	Potential source area	DA2SO-058-0698-SO	1-3	Yes	
	DA2-059	Potential source area	DA2SS-059-0699-SO	0-1	Yes	
	DA2-059	Potential source area	DA2SO-059-0700-SO	1-3	Yes	
	DA2-060	Potential source area	DA2SS-060-0701-SO	0-1	Yes	
	DA2-060	Potential source area	DA2SO-060-0702-SO	1-3	Yes	
	DA2-061	Potential source area	DA2SS-061-0703-SO	0-1	Yes	
	DA2-061	Potential source area	DA2SO-061-0704-SO	1-3	Yes	
	DA2-062	Potential source area	DA2SS-062-0705-SO	0-1	Yes	
	DA2-062	Potential source area	DA2SO-062-0706-SO	1-3	Yes	
	DA2-063	Potential source area	DA2SS-063-0707-SO	0-1	Yes	
	DA2-063	Potential source area	DA2SO-063-0708-SO	1-3	Yes	
	DA2-064	Potential source area	DA2SS-064-0709-SO	0-1	Yes	
	DA2-064	Potential source area	DA2SO-064-0710-SO	1-3	Yes	
	DA2-065	Potential source area	DA2SS-065-0711-SO	0-1	Yes	
	DA2-065	Potential source area	DA2SO-065-0712-SO	1-3	Yes	
	DA2-066	Potential source area	DA2SS-066-0713-SO	0-1	Yes	
	DA2-066	Potential source area	DA2SO-066-0714-SO	1-3	Yes	
	DA2-067	Potential source area	DA2SS-067-0715-SO	0-1	Yes	
	DA2-067	Potential source area	DA2SO-067-0716-SO	1-1.5	Yes	
	DA2-068	Potential source area	DA2SS-068-0717-SO	0-1	Yes	
	DA2-068	Potential source area	DA2SO-068-0718-SO	1-3	Yes	

Table 3-1. Soil Sample List and Rationales, ODA2 Phase II RI (continued)

Area Description	Station ID	Sample Station Rationale	Sample ID	Depth (feet)	Sample Collected (Yes/No)	Comments
South of Sand Creek, East of Demolition Road (continued)	DA2-069	Potential source area	DA2SS-069-0719-SO	0-1	Yes	
	DA2-069	Potential source area	DA2SO-069-0720-SO	1-3	Yes	
	DA2-070	Potential source area	DA2SS-070-0721-SO	0-1	Yes	
	DA2-070	Potential source area	DA2SO-070-0722-SO	1-2	Yes	
	DA2-071	Potential source area	DA2SS-071-0723-SO	0-1	Yes	
	DA2-071	Potential source area	DA2SO-071-0724-SO	1-3	Yes	
	DA2-072	Potential source area	DA2SS-072-0725-SO	0-1	Yes	
	DA2-072	Potential source area	DA2SO-072-0726-SO	1-3	Yes	
	DA2-073	Potential source area	DA2SS-073-0727-SO	0-1	Yes	
	DA2-073	Potential source area	DA2SO-073-0728-SO	1-3	Yes	
	DA2-074	Potential source area	DA2SS-074-0729-SO	0-1	Yes	
	DA2-074	Potential source area	DA2SO-074-0730-SO	1-3	Yes	
	DA2-075	Potential source area	DA2SS-075-0731-SO	0-1	Yes	
	DA2-075	Potential source area	DA2SO-075-0732-SO	1-3	Yes	
	DA2-076	Potential source area	DA2SS-076-0733-SO	0-1	Yes	
	DA2-076	Potential source area	DA2SO-076-0734-SO	1-2.8	Yes	
	DA2-077	Potential source area	DA2SS-077-0735-SO	0-1	Yes	
	DA2-077	Potential source area	DA2SO-077-0736-SO	1-3	Yes	
	DA2-078	Potential source area	DA2SS-078-0737-SO	0-1	Yes	
	DA2-078	Potential source area	DA2SO-078-0738-SO	1-3	Yes	
	DA2-079	Potential source area	DA2SS-079-0739-SO	0-1	Yes	
	DA2-079	Potential source area	DA2SO-079-0740-SO	1-3	Yes	
	DA2-080	Potential source area	DA2SS-080-0741-SO	0-1	Yes	
	DA2-080	Potential source area	DA2SO-080-0742-SO	1-3	Yes	
	DA2-081	Potential source area	DA2SS-081-0743-SO	0-1	Yes	
	DA2-081	Potential source area	DA2SO-081-0744-SO	1-3	Yes	

Table 3-1. Soil Sample List and Rationales, ODA2 Phase II RI (continued)

Area Description	Station ID	Sample Station Rationale	Sample ID	Depth (feet)	Sample Collected (Yes/No)	Comments
North of Sand Creek	DA2-082	Determine presence/absence of contamination	DA2SS-082-0745-SO	0-1	Yes	
	DA2-082	Determine presence/absence of contamination	DA2SO-082-0746-SO	1-3	Yes	
	DA2-083	Determine presence/absence of contamination	DA2SS-083-0747-SO	0-1	Yes	
	DA2-083	Determine presence/absence of contamination	DA2SO-083-0748-SO	1-3	Yes	
	DA2-084	Potential source area contamination	DA2SS-084-0749-SO	0-1	Yes	
	DA2-084	Potential source area contamination	DA2SO-084-0750-SO	1-3	Yes	
	DA2-085	Potential source area contamination	DA2SS-085-0751-SO	0-1	Yes	
	DA2-085	Potential source area contamination	DA2SO-085-0752-SO	1-3	Yes	
	DA2-086	Potential source area contamination	DA2SS-086-0753-SO	0-1	Yes	
	DA2-086	Potential source area contamination	DA2SO-086-0754-SO	1-3	Yes	
	DA2-092	Potential source area contamination	DA2SS-092-0765-SO	0-1	Yes	Contingency sample
	DA2-092	Potential source area contamination	DA2SO-092-0766-SO	1-3	Yes	Contingency sample
	DA2-093	Potential source area contamination	DA2SS-093-0767-SO	0-1	Yes	Contingency sample

Table 3-1. Soil Sample List and Rationales, ODA2 Phase II RI (continued)

Area Description	Station ID	Sample Station Rationale	Sample ID	Depth (feet)	Sample Collected (Yes/No)	Comments
North of Sand Creek (continued)	DA2-093	Potential source area contamination	DA2SO-093-0768-SO	1-3	Yes	Contingency sample
	DA2-114	Potential source area contamination	DA2SO-114-0870-SO	0-1	Yes	
	DA2-114	Potential source area contamination	DA2SO-114-0871-SO	1-3	Yes	
Soil Borings & Shelby Tube Samples	DA2-104	Potential source area contamination	DA2MW-104-0807-SO	0-2	Yes	

Surface soil samples were collected from 53 sampling stations located throughout the ODA2 AOC as planned in the Phase II RI SAP Addendum (Table 3-1). Corresponding subsurface samples were also planned at these locations and were collected as planned. In addition, three contingency surface/subsurface soil sampling stations were collected north of Sand Creek.

3.1.2 Surface and Subsurface Soil Field Sampling Methods

3.1.2.1 Surface Soil and Dry Sediment

A decontaminated bucket hand auger was used to collect surface soil samples at each station. The target depth interval for surface soil samples was 0 to 0.3 meter (0 to 1 foot). Where analyses for explosives and propellant compounds were specified, composite samples were collected. Because of the physical characteristics of these explosives and propellant compounds (e.g., flakes, particles, and pellets) and the nature of demolition operations, the distribution of these types of compounds can be erratic and highly variable. Composite sampling has been shown to reduce statistical sampling error in surface soil at sites with a history of explosives contamination in surface soil (Jenkins et al. 1996) and to increase the likelihood of capturing detectable levels of explosives compounds over a given area. Composite sampling data are considered acceptable to the Ohio EPA for use in risk assessment where concentrations are expected to vary spatially.

To collect composite samples for surface soil and dry sediment, three borings were hand augured in an equilateral triangle pattern measuring about 0.9 meter (3 feet) on a side. Equal portions of soil from the three subsamples were placed into a large, decontaminated stainless steel bowl and homogenized, and then the samples for explosives and propellant compounds analyses were placed into sample containers and were submitted to the fixed-base laboratory for analysis. Samples for analyses of other contaminants (e.g., inorganics, SVOCs, VOCs, etc.) were collected as described for discrete samples from a boring placed in the approximate center of the triangle formed by the three subsamples. Soil for VOC analyses, if required at that station, was placed directly into sample jars from the auger bucket. The remaining soil was placed into a stainless steel bowl and homogenized. Samples for inorganic constituents (metals and cyanide), SVOCs, and other volatile constituents were collected from the homogenized soil mixture.

Field descriptions and classifications for the soil samples were performed and the results recorded in the project logbooks in accordance with Section 4.4.2.3 of the Facility Wide SAP, as specified in the Phase II RI Work Plan and SAP Addenda, with the exception that headspace gases were not screened in the field for organic vapors. Organic vapor measurements were made in the breathing zone during sampling and the results recorded in the field logbooks.

Following collection of the sample, excess soil was designated as IDW and placed in a lined roll-off container that was staged at Building 1502. IDW practices for all media are discussed in Appendix D. Hand-auger borings were backfilled to the ground surface with dry bentonite chips.

3.1.2.2 Subsurface Soil Sampling Methods

To collect subsurface samples for chemical analyses, a decontaminated auger bucket was used to deepen the surface soil boring over the required depth interval. At locations where composite sampling was performed for explosives and propellant compounds analysis, the subsurface sample was obtained by deepening the surface soil boring in the center of the equilateral triangle.

Soil from the subsurface interval was placed into a stainless steel pan or bowl and homogenized, and representative aliquots were placed into the appropriate sample containers. All VOC samples were collected as discrete aliquots from the middle of the interval without homogenization. All samples were submitted to the fixed-base laboratory for analysis.

Field descriptions and classification of the soils were performed and the results recorded in the project logbooks in accordance with Section 4.4.2.3 of the Facility Wide SAP, as specified in the Phase II RI Work Plan and SAP Addenda, with the exception that headspace gases were not screened in the field for organic vapors. Organic vapor measurements were made in the breathing zone during sampling and at the top of the boring and recorded in the field logbooks.

Following collection of the samples, excess soil was designated as IDW and placed in a lined, labeled roll-off container that was staged at Building 1502. IDW practices for all media are discussed in Appendix D. Hand-auger borings were backfilled to the ground surface with dry bentonite chips.

3.2 SEDIMENT CHARACTERIZATION

3.2.1 Rationale

Sediment samples were collected from a total of 15 stations located within ODA2 (Table 3-2; Figure 3-2). Data from sediment samples collected within ODA2 were obtained to identify areas of contaminant accumulation and evaluate potential contaminant migration via erosional processes from surface soil sources. Samples were collected from within surface drainage channels to evaluate potential contaminant migration to and accumulation within Sand Creek. The analytical results for sediment samples collected from surface drainage features were used to quantify risks to human and ecological receptors that may be exposed to sediment (see Sections 6 and 7). All inorganic sediment samples were collected from the uppermost 15 centimeters (6 inches) below any loose material or vegetative matter. A synopsis of sediment sampling activities for chemical analyses is provided below. Departures from the planned sampling efforts due to site conditions (i.e., refusal) and the addition of contingency samples are specifically noted.

1 **Table 3-2. Sediment and Surface Water Sample List and Rationales, ODA2 Phase II RI**

Area Description	Station	Sample Station Rationale	Sample ID	Depth (ft)	Sample Collected (Yes/No)	Comments
Unnamed tributary, north of Sand Creek	DA2-087	Erosional transport and accumulation of contamination	DA2SS-087-0755-SD	0 to 0.5	Yes	Contingency sample
	DA2-087	Erosional transport and accumulation of contamination	DA2SO-087-0756-SO	N/A	No	Subsurface interval not collected
Unnamed tributary, north of Sand Creek	DA2-088	Erosional transport and accumulation of contamination	DA2SS-088-0757-SD	0 to 0.5	Yes	Contingency sample
	DA2-088	Erosional transport and accumulation of contamination	DA2SO-088-0758-SO	N/A	No	Subsurface interval not collected
Overflow area, East of Demo Rd. on Sand Creek	DA2-089	Determine presence/absence of contamination	DA2SS-089-0759-SD	0 to 0.5	Yes	Contingency sample
	DA2-089	Determine presence/absence of contamination	DA2SO-089-0760-SO	N/A	No	Subsurface interval not collected
	DA2-090	Determine presence/absence of contamination	DA2SS-090-0761-SD	0 to 0.5	Yes	Contingency sample
	DA2-090	Determine presence/absence of contamination	DA2SO-090-0762-SO	N/A	No	Subsurface interval not collected
South of Sand Creek, west of Demo Rd.	DA2-091	Determine presence/absence of contamination	DA2SS-091-0763-SD	0 to 0.5	Yes	Contingency sample
	DA2-091	Determine presence/absence of contamination	DA2SO-091-0764-SO	N/A	No	Subsurface interval not collected
Drainageway from Load Line 11 area	DA2-094	Determine presence/absence of contamination	DA2sd-094-0769-SD	0 to 0.5	Yes	

1

Table 3-2. Sediment and Surface Water Sample List and Rationales, ODA2 Phase II RI (continued)

Area Description	Station	Sample Station Rationale	Sample ID	Depth (ft)	Sample Collected (Yes/No)	Comments
Upstream station	DA2-095	Determine presence/absence of contamination	DA2sd-095-0770-SD	0 to 0.5	Yes	
Upstream station	DA2-096	Determine presence/absence of contamination	DA2sd-096-0771-SD	0 to 0.5	Yes	
Drainage pathway to Sand Creek	DA2-097	Erosional transport and accumulation of contamination	DA2sd-097-0772-SD	0 to 0.5	Yes	
	DA2-098	Erosional transport and accumulation of contamination	DA2sd-098-0773-SD	0 to 0.5	Yes	
Downstream station	DA2-099	Erosional transport and accumulation of contamination	DA2sd-099-0774-SD	0 to 0.5	Yes	
Drainage pathway near Building 1503	DA2-100	Erosional transport and accumulation of contamination	DA2sd-100-0775-SD	0 to 0.5	Yes	
Downstream stations	DA2-101	Erosional transport and accumulation of contamination	DA2sd-101-0776-SD	0 to 0.5	Yes	
	DA2-102	Off-AOC contaminant transport	DA2sd-102-0777-SD	0 to 0.5	Yes	
	DA2-103	Off-AOC contaminant transport	DA2sd-103-0778-SD	0 to 0.5	Yes	

Table 3-2. Sediment and Surface Water Sample List and Rationales, ODA2 Phase II RI (continued)

Area Description	Station	Sample Station Rationale	Sample ID	Depth (ft)	Sample Collected (Yes/No)	Comments
Surface Water - Upstream station	DA2-095	Ambient	DA2sw-095-0779-SW	0 to 0.5	Yes	
	DA2-095	Ambient	DA2sw-095-0780-SW	0 to 0.5	Yes	
	DA2-095	Ambient	DA2sw-095-0781-SW	0 to 0.5	Yes	
	DA2-095	Ambient	DA2sw-095-0782-SW	0 to 0.5	Yes	
Downstream stations	DA2-099	Off-AOC contaminant transport	DA2sw-099-0783-SW	0 to 0.5	Yes	
	DA2-099	Off-AOC contaminant transport	DA2sw-099-0784-SW	0 to 0.5	Yes	
	DA2-099	Off-AOC contaminant transport	DA2sw-099-0785-SW	0 to 0.5	Yes	
	DA2-099	Off-AOC contaminant transport	DA2sw-099-0786-SW	0 to 0.5	Yes	
	DA2-102	Off-AOC contaminant transport	DA2sw-102-0787-SW	0 to 0.5	Yes	
	DA2-102	Off-AOC contaminant transport	DA2sw-102-0788-SW	0 to 0.5	Yes	
	DA2-102	Off-AOC contaminant transport	DA2sw-102-0789-SW	0 to 0.5	Yes	
	DA2-102	Off-AOC contaminant transport	DA2sw-102-0790-SW	0 to 0.5	Yes	

Sediment samples within the AOC were collected as planned from suspected contaminant accumulation areas near known or suspected source areas at five planned and five contingency locations including: (1) the main drainage ditch north of Sand Creek that runs north-south on the western portion of the AOC; (2) a small drainage ditch south of Sand Creek directly west of suspected burial sites 1; (3) in wet areas near Sand Creek directly north of suspected burial site 2; (4) in Sand Creek directly north of the suspected Sand Creek disposal site; and (5) a ditch draining the area directly east of Building 1503.

Sediment samples from 2 locations in Sand Creek downstream of the AOC were collected as planned from: (1) the AOC surface water exit point directly upstream of the confluence of Sand Creek with a tributary draining the western portion of the Wet Storage Area and; and (2) from a station east of the AOC exit point along Sand Creek.

Sediment samples were collected as planned at three upstream locations: (1) in Sand Creek near Newton Falls Road; (2) in Sand Creek near the western edge of the AOC; and (3) in a drainage pathway south and west of the AOC that drains the eastern portion of Load Line 11 and flows northward to Sand Creek.

3.2.2 Sediment Field Sampling Methods

Dry sediment samples from ditch lines and low-lying areas were collected using the hand bucket auger method as described for surface soil samples in Section 3.1.2.1. Subaqueous sediment samples were collected with a decontaminated stainless steel trowel or scoop using the methods described in Section 4.5.2.1.2 of the Facility Wide SAP, as referenced by the Phase II RI Work Plan and SAP Addenda, given that those sampling stations had less than about 30 centimeters (1.0 foot) of water. The trowel was used to manually obtain sediment material to a depth of 15 centimeters (6 inches) below ground surface (bgs). Extracted material was placed into a stainless steel bowl. At sampling locations where VOC samples were to be collected, the VOC containers were immediately filled with the first materials obtained. Sample containers for the remaining nonvolatile analytes were then filled. Loose material and debris samples were also collected from the top of the sediment layer using the stainless steel trowel/scoop method.

Field description of the sediment samples was performed and the results recorded in the project logbooks in accordance with Section 4.4.2.3 of the Facility Wide SAP as specified in the Phase II RI Work Plan and SAP Addenda. Headspace gases were not screened in the field for organic vapors. Organic vapor measurements made in the breathing zone during sampling were recorded in the field logbooks. Sediment sampling logs are presented in Appendix E.

3.3 SURFACE WATER CHARACTERIZATION

3.3.1 Rationale

Surface water samples were collected because this medium represents the primary contaminant transport pathway off of the AOC (either as dissolved phase or adsorbed to particulates/sediment that are mobilized by flow). The data obtained were used to evaluate ambient water quality entering the AOC and to assess potential impacts from other potential source areas (i.e., Load Line 11, Wet Storage Area).

Co-located surface water samples were planned at three stream sediment sampling locations (Table 3-2; Figure 3-2). Surface water samples that were collected included four temporally distinct sets of samples from two locations in Sand Creek downstream of the former detonation area and from one location in Sand Creek upstream of the AOC.

3.3.2 Surface Water Field Sampling Methods

All surface water samples were collected directly into sample containers as referenced in the Phase II RI Work Plan and SAP Addenda (USACE 2002). Filtered samples were not collected. The sample container was submerged, with the cap in place, into the surface water. Then the container was slowly and continuously filled using the cap to regulate the rate of sample entry into the container. Surface water samples were collected prior to sediment samples at co-located sites also in an attempt to minimize the effects of sediment turbidity on surface water quality. Surface water sample collection was initiated at the sampling point furthest downstream in the channel, proceeding to upstream sampling locations, to minimize the effects of sediment turbidity on water sample quality.

Field measurements were taken during sampling including pH, conductivity, dissolved oxygen content, and temperature. These measurements were performed in accordance with procedures in Section 4.3.3 of the Facility Wide SAP as referenced by the Phase II RI Work Plan and SAP Addenda. All field measurements were recorded in the sampling logbooks. Surface water sampling logs are contained in Appendix E.

3.4 GROUNDWATER CHARACTERIZATION

3.4.1 Rationale

The rationale for the installation and sampling of groundwater monitoring wells during the Phase II RI at ODA2 was to identify whether contaminants were present in groundwater at the AOC, determine the directions of groundwater flow and potential contaminant transport, quantify groundwater flow rates to the extent possible, and determine whether any contamination was potentially migrating off of the AOC.

Because the groundwater system at the AOC had not been fully characterized during previous investigations, groundwater monitoring wells were installed at various locations throughout the AOC (Figure 3-2) to determine whether any off-AOC transport of contaminants was occurring. A total of 10 monitoring wells were completed for the Phase II RI. Table 3-3 provides the rationale for placing wells in the selected locations. The placement of the wells maximizes the potential to identify contaminated groundwater resulting from leaching at known and suspected source areas (i.e., former detonation and disposal areas).

3.4.2 Monitoring Well Installation Methods

All monitoring well installation activities were conducted according to the Facility Wide SAP and the ODA2 Phase II RI Work Plan and SAP Addenda. Monitoring wells were installed using hollow-stem auger drilling methods under the direct supervision of a qualified geologist. An 11-centimeter (4.25-inch) inside-diameter, hollow-stem auger was used to advance the borehole through unconsolidated and weathered bedrock materials. Soil samples were collected continuously from the surface to refusal or the planned borehole termination depth using a split-spoon sampler. Soil sampling was conducted during well drilling for description of soil stratigraphy and geotechnical analyses. Samples for chemical analysis were also collected from the 0-0.6 meter and 0.6-1.2 meter (0-2 foot and 2-4 foot) intervals of each well boring. All wells were completed in the unconsolidated zone. The borings for well stations DA2-107, -108, -110, -111, -112, and -113 encountered weathered shale bedrock. A borehole log, including stratigraphic information, was entered in the project logbooks for each monitoring well boring. The monitoring well boring logs are provided in Appendix B.

Organic vapors were monitored from soil and rock cuttings at each borehole using an organic vapor analyzer (OVA); however, samples for headspace readings were not collected. In addition, the breathing zone was continuously monitored for evidence of organic chemicals. All readings were recorded in the project logbooks.

Following drilling of the boreholes to the appropriate depths, monitoring wells were constructed from pre-cleaned 5-centimeter (2-inch) schedule 40 polyvinyl chloride (PVC) pipes. Well screens were commercially fabricated with slot widths of 0.125 centimeter (0.005 inch) or 0.025 centimeter (0.01 inch). The monitoring wells were constructed using either a 1.5-meter (5-foot), 2.1-meter (7 foot) or 3-meter (10-foot) screens. The original specification for this project was to install 10-ft screens at all monitoring well locations. Screen lengths less than 10 feet were used at several locations and are documented in the ODA2 Work Plan and monitoring well logs (Appendix B). The well casing and screens were assembled and lowered into the open borehole. Following placement of the well casing and screen, a pre-washed filter pack, consisting of Global Supply No. 7 sand, was placed from the bottom of the borehole to approximately 0.6 meter (2 feet) above the top of the well screen in each well. A 0.6-meter (2-foot) or 0.9-meter (3-foot) bentonite pellet annular seal was then poured into the borehole on top of the filter pack.

Table 3-3. Groundwater Sample List and Rationale, ODA2 Phase II RI

Area Description	Station	Sample Station Rationale	Sample ID	Sample Collected (Yes/No)	Comments
North of Sand Creek	DA2-104	AOC boundary location	DA2MW-107-0791-GW	Yes	
	DA2-104	AOC boundary location	DA2MW -107-0791-GF	Yes	
	DA2-105	Source area characterization	DA2MW -108-0792-GW	Yes	
	DA2-105	Source area characterization	DA2MW -108-0792-GF	Yes	
	DA2-106	Source area characterization	DA2MW -109-0793-GW	Yes	
	DA2-106	Source area characterization	DA2MW -109-0793-GF	Yes	
	DA2-107	Source area characterization	DA2MW -110-0794-GW	Yes	
	DA2-107	Source area characterization	DA2MW-110-0794-GF	Yes	
	DA2-108	AOC boundary location	DA2MW-111-0795-GW	Yes	
	DA2-108	AOC boundary location	DA2MW-111-0795-GF	Yes	
South of Sand Creek	DA2-109	AOC boundary location	DA2MW-112-0796-GW	Yes	
	DA2-109	AOC boundary location	DA2MW-112-0796-GF	Yes	
	DA2-110	Source area characterization	DA2MW-113-0797-GW	Yes	
	DA2-110	Source area characterization	DA2MW-113-0797-GF	Yes	
	DA2-111	Source area characterization	DA2MW-114-0798-GW	Yes	Actual location differed from planned due to drill rig accessibility limitations.
	DA2-111	Source area characterization	DA2MW-114-0798-GF	Yes	
	DA2-112	Source area characterization	DA2MW-115-0799-GW	Yes	
	DA2-112	Source area characterization	DA2MW-115-0799-GF	Yes	
	DA2-113	Source area characterization	DA2MW-116-0800-GW	Yes	
	DA2-113	Source area characterization	DA2MW-116-0800-GF	Yes	
RCRA Area Existing Wells	DET-1	Source area characterization	DA2MW-DET1-0801-GW	Yes	
	DET-1	Source area characterization	DA2MW-DET1-0801-GF	Yes	
	DET-2	Source area characterization	DA2MW-DET2-0802-GW	Yes	
	DET-2	Source area characterization	DA2MW-DET2-0802-GF	Yes	
	DET-3	Source area characterization	DA2MW-DET3-0803-GW	Yes	
	DET-3	Source area characterization	DA2MW-DET3-0803-GF	Yes	
	DET-4	Source area characterization	DA2MW-DET4-0804-GW	Yes	
	DET-4	Source area characterization	DA2MW-DET4-0804-GF	Yes	

Table 3-3. Groundwater Sample List and Rationale, ODA2 Phase II RI (continued)

Area Description	Station	Sample Station Rationale	Sample ID	Sample Collected (Yes/No)	Comments
Winklepeck Burning Grounds Existing Wells	WBG-012	AOC boundary location	WBGMW-012-0805-GW	Yes	
	WBG-012	AOC boundary location	WBGMW-012-0805-GF	Yes	
	WBG-013	AOC boundary location	WBGMW-013-0806-GW	Yes	
	WBG-013	AOC boundary location	WBGMW-013-0806-GF	Yes	

For monitoring well completion, a grout mixture consisting of Type I Portland cement and 5 percent bentonite was placed from the top of the annular seal to the ground surface, followed by the placement of a protective steel surface casing with locking cover and construction of a mortar collar and cement pad. Four steel posts were installed around each well and painted. Monitoring well installation procedures are provided in Section 4.3.2 of the Facility Wide SAP (USACE 2001a). Well diagrams provided in Appendix B summarize the construction details for the monitoring wells installed during the Phase II RI at ODA2, including depths, screened intervals, and groundwater elevations. This information is summarized in Table 3-4.

Table 3-4. Groundwater Monitoring Well Summary

Monitoring Well ID No.	Top of Casing Elevation (feet amsl)	Ground Elevation (feet amsl)	Total Monitoring Well Depth (feet btoc)	Monitoring Well Depth (feet bgs)	Screened Interval (feet bgs)	Lithology in Screened Interval
DA2MW-104	1073.89	1070.82	29.57	26.5	16.5’-26.3’	Unconsolidated Sediments (clayey silt, silt, sand)
DA2MW-105	1045.34	1042.66	16.18	13.5	8.3’-13.3’	Unconsolidated Sediments (sand with gravel)
DA2MW-106	1043.79	1041.19	18.1	15.5	8.3’-15.3’	Unconsolidated Sediments (sand, clay/weathered shale)
DA2MW-107	1041.63	1039.18	16.45	14.0	8.8’-13.8’	Soil/Rock Interface
DA2MW-108	1032.36	1029.92	16.94	14.5	9.3’-14.3’	Weathered Shale
DA2MW-109	1071.29	1068.66	24.13	21.5	11.3’-21.3’	Unconsolidated Sediments (silty clay, sand, gravel)
DA2MW-110	1063.78	1061.39	21.89	19.5	9.3’-19.3’	Unconsolidated Sediments (silty clay with gravel)
DA2MW-111	1042.12	1039.63	14.79	12.3	7.1’-12.1’	Clay/Weathered Shale
DA2MW-112	1037.44	1034.87	16.57	14.0	8.8’-13.8’	Soil/Rock Interface
DA2MW-113	1037.11	1034.51	16.1	13.5	8.3’-13.3’	Soil/Rock Interface

btoc - below top of casing

Once the wells were completely installed, the well's location and elevation were surveyed by a licensed surveyor. The monitoring well's location and elevations are provided in the well logs in Appendix C. A report of the survey is provided in Appendix F.

3.4.3 Well Development Methods

At least 48 hours after completion, each monitoring well was developed so that representative groundwater samples could be collected. Well development was accomplished by purging at least five well volumes of groundwater, using a submersible pump or a bailer, until the development water was visually clear (where possible) and sediment thickness in the well was less than 3.0 centimeters (0.1 foot).

Previously installed monitoring wells DET-1, DET-2, DET-3, DET-4, WBG-012, and WBG-013 were sampled during this investigation. These wells were checked for siltation prior to sampling by measuring the depth to the bottom of the well and comparing them to the reported well construction depths. No redevelopment was completed, as redevelopment was not in the scope of this investigation. The reported construction depths in the 2001 facility-wide well inspection records were used to determine the degree of siltation (i.e., 2002 field measurement of total depth versus reported constructed depths):

Monitoring Well	Recorded Total Depth (2002 well purge records)	Reported Construction Depth	Siltation (ft)	Siltation (%)
DET-1	38.48	40.5	2.02	20%
DET-2	41.86	40	0	0%
DET-3	16	16	0	0%
DET-4	13.69	16	2.31	23%
WBG-012	31.61	32.61	1	10%
WBG-013	24.13	24.6	0.47	5%

A comparison to the reported construction depths to the total recorded depth measured in the field in 2002 indicate DET-1, and DET-4 have sufficient siltation (e.g., >20% of the screened interval) to merit re-development prior to any future sampling event. Excessive siltation may limit the hydraulic connection between the well screen and the groundwater zone, thus potentially impacting the representativeness of the groundwater sample.

Well development records were included in the project logbooks and are provided in Appendix G.

3.4.4 Groundwater Field Sampling Methods

Following development of the wells, groundwater samples were collected. The procedure for sampling groundwater is described in Sections 4.3.4 and 4.3.5 of the Facility Wide SAP. Before sampling, the monitoring wells were purged until readings of pH, conductivity, dissolved oxygen, and water temperature reached equilibrium. Groundwater samples were collected using a bailer.

Monitoring wells DA2MW-106, DA2MW-109, DA2MW-110, and DA2MW-111 were purged dry and allowed to recover 12 to 24 hours prior to sampling. General groundwater quality indicator parameters (pH, specific conductance, dissolved oxygen, temperature, and turbidity) were monitored during the sampling procedure and are presented in Appendix G. All monitoring wells were purged until temperature, pH, dissolved oxygen, and specific conductivity readings stabilized. All groundwater samples were analyzed for explosives, propellants, target analyte list (TAL) metals (filtered only), cyanide, VOCs, SVOCs, and pesticides/polychlorinated biphenyls (PCBs). Groundwater samples analyzed for dissolved metals were filtered using a disposable filter with 0.45-µm pores. The results of groundwater sampling at ODA2 are discussed in detail in Section 4.6. The groundwater sampling logs are contained in Appendix G. The laboratory analytical data are presented in Appendix H.

3.4.5 In Situ Permeability Testing

Slug tests were performed at all monitoring wells to determine the hydraulic conductivity of the geologic materials surrounding each well screen. Slug tests followed the provisions of the Phase II RI Work Plan and SAP Addenda. These analyses calculate horizontal hydraulic conductivities in the screened interval of each well. Both falling-head and rising-head tests were conducted in order to obtain comparative results and validate the test results. Falling-head tests were performed by inserting a PVC cylinder into the well and monitoring the return (drop) of the potentiometric surface to the pretest static water level over time. Rising-head tests were performed by reversing the process (e.g., the slug was removed, and the rise in water level was monitored). The tests were performed after each well had fully recovered from groundwater sampling, using pressure transducers for water level measurements and automated data collection. The slug was designed to displace approximately 0.3 meter (1 foot) of water.

Water level measurements were recorded using a pre-programmed logarithmic time interval. Water levels were monitored for a period of 6 hours or until the well re-equilibrated to 90 percent of the pretest water level. The data were evaluated using the updated Bouwer and Rice method (Bouwer 1989, Butler 1998). Compensation for water levels within the screened interval is included in this evaluation method. The results of the slug tests performed in December 2002 are presented in Appendix I and are discussed in Section 2.

3.5 ANALYTICAL PROGRAM OVERVIEW

3.5.1 Geotechnical Analyses

Soil samples collected using the bucket hand-auger method are classified as disturbed samples. Disturbed sediment samples (e.g., collected using manual methods) were visually classified in the field and submitted for Unified Soil Classification System (USCS) classification, grain size distribution, and total organic carbon (TOC) by chemical analysis. The results of the geotechnical evaluation for sediment samples are discussed in Section 4 and included in Appendix A.

In addition to disturbed samples, Shelby tubes were used to collect two undisturbed samples where possible from monitoring well locations. Two Shelby tube samples from within the screened interval (variable depths) were planned for each monitoring well boring. Shelby tube samples were collected from the following stations: DA2-104, -107, -109, -110, and -111. The Shelby tube samples were analyzed for a comprehensive suite of parameters to evaluate site hydrogeologic characteristics and to obtain data for potential future evaluation of natural attenuation. Geotechnical analytical parameters for undisturbed samples included TOC, moisture content, grain size distribution, USCS, Atterberg limits, hydraulic conductivity, hydrometer analysis, specific gravity, bulk density, porosity, and pH.

3.5.2 Laboratory Analyses

All analytical procedures were completed in accordance with applicable professional standards, USEPA requirements, government regulations and guidelines, USACE Louisville District analytical quality assurance (QA) guidelines, and specific project goals and requirements. The sampling and analysis program conducted during the Phase II RI for ODA2 involved the collection and analysis of surface soil, subsurface soil, sediment, surface water, and groundwater. Specified samples were analyzed by an independent qualifty control (QC) split analytical laboratory under contract with the USACE Louisville District.

Samples collected during the investigation were analyzed by GPL Laboratories, Gaithersburg, MD, a USACE Center of Excellence certified laboratory. The specified QC split samples collected for soil, sediment, surface water, and groundwater were analyzed by USACE-contracted laboratory, Severn Trent Laboratories, located in North Canton, Ohio. Laboratories supporting this work have statements of qualifications including organizational structures, QA manuals, and standard operating procedures, which are available upon request.

Samples were collected and analyzed according to the Facility Wide SAP and the ODA2 Phase II RI Work Plan and SAP Addendum. Prepared in accordance with USACE and Ohio EPA guidance, the Facility Wide SAP and associated addenda outline the organization, objectives, intended data uses, and QA/QC activities to achieve the desired DQOs and maintain the defensibility of the data. Project DQOs were established in accordance with USEPA Region 5 guidance. Requirements for sample collection, handling, analysis criteria, target analytes, laboratory criteria, and data validation criteria for the Phase II RI are consistent with USEPA requirements for National Priorities List (NPL) sites. DQOs for this project included analytical precision, accuracy, representativeness, completeness, comparability, and sensitivity for the measurement data. Appendix J presents an assessment of those objectives as they apply to the analytical program.

Strict adherence to the requirements set forth in the Facility Wide SAP and project addenda was required of the analytical laboratory so that conditions adverse to quality would not arise. The laboratory was required to perform all analyses in compliance with USEPA SW-846 (USEPA 1990a), *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols*. SW-846 chemical analytical procedures were followed for the analyses of metals, VOCs, SVOCs, pesticides, PCBs, explosives, propellants, and cyanide. Laboratories were required to comply with all methods as written; recommendations were considered requirements.

QA/QC samples for this project included field blanks, trip blanks, QA field duplicates, laboratory method blanks, laboratory control samples, laboratory duplicates, matrix spike/matrix spike duplicate (MS/MSD) samples, and QC field split samples (submitted to the independent USACE-contracted laboratory). An excess number, relative to the original specifications of the ODA2 Phase II RI SAP Addendum, of certain QA/QC samples (field duplicates and QC field splits) was collected and analyzed during the Phase II RI (refer to Appendices J and K). Field blanks, consisting of potable water used in the decontamination process, equipment rinsate blanks, and trip blanks were submitted for analysis along with field duplicate samples to provide a means to assess the quality of the data resulting from the field sampling program. Field blank samples were analyzed to determine procedural contamination at the site that may contribute to sample contamination. Equipment rinsate blanks were used to assess the adequacy of the equipment decontamination processes for soil sample collection. Trip blanks were used to assess the potential for contamination of samples caused by contaminant migration during sample shipment and storage. Field duplicate samples were analyzed to determine sample heterogeneity and sampling methodology reproducibility. Laboratory method blanks and laboratory control samples were employed to determine the accuracy and precision of the analytical method as implemented by the laboratory. Matrix spikes provided information about the effect of the sample matrix on the measurement methodology. Laboratory sample duplicates and MS/MSDs assisted in determining the analytical reproducibility and precision of the analysis for the samples of interest. The QC field split samples provide independent verification of the accuracy and precision of the principal analytical laboratory. Evaluation of these QC measures and of their contribution to documenting the project data quality is provided in Appendix K, Data Quality Summary Report (DQSR).

SpecPro, Inc. is the custodian of the project file and will maintain the contents of the file for this investigation, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, correspondence, and chain-of-custody forms. These files will remain in a secure area under the custody of the SpecPro, Inc. Program Manager until they are transferred to the USACE Louisville District and RVAAP. Analytical data reports from GPL Laboratories have been forwarded to the USACE Louisville District laboratory data validation contractor (Lab Data Consultants, Inc.) for validation review and QA comparison. GPL will retain all original raw data information (both hard copy and electronic) in a secure area under the custody of the laboratory project manager.

3.5.3 Data Review, Validation, and Quality Assessment

Samples were properly packaged for shipment and dispatched to GPL Laboratories for analysis. A separate signed custody record with sample numbers and locations listed was enclosed with each shipment. When transferring the possession of samples, the individuals who relinquished and received the samples signed, dated, and noted the time on the record. All shipments were in compliance with applicable Department of Transportation regulations for environmental samples.

Data were produced, reviewed, and reported by the laboratory in accordance with specifications outlined in the ODA2 Phase II RI Quality Assurance Project Plan (QAPP) Addendum, the USACE Louisville District analytical QA guidelines, and the laboratory's QA manual. Laboratory reports included documentation verifying analytical holding time compliance.

GPL Laboratories performed in-house analytical data reduction under the direction of the laboratory project manager and QA officer. These individuals were responsible for assessing data quality and informing SpecPro of any data that are considered “unacceptable” or that require caution on the part of the data user in terms of its reliability. Data were reduced, reviewed, and reported as described in the laboratory QA manual and standard operating procedures. Data reduction, review, and reporting by the laboratory were conducted as follows:

- Raw data produced by the analyst were turned over to the respective area supervisor.
- The area supervisor reviewed the data for attainment of QC criteria as outlined in the established methods and for overall reasonableness.
- Upon acceptance of the raw data by the area supervisor, a report was generated and sent to the laboratory project manager.
- The laboratory project manager completed a thorough review of all reports.
- The laboratory project manager executed the final reports.

Data were then delivered to SpecPro for data verification. GPL Laboratories prepared and retained full analytical and QC documentation for the project in both paper copy and electronic storage media (e.g., magnetic tape), as directed by the analytical methodologies employed. GPL Laboratories provided the following information to SpecPro in each analytical data package submitted:

- Cover sheets listing the samples included in the report and narrative comments describing problems encountered in analysis;

- Tabulated results of inorganic and organic compounds identified and quantified; and,

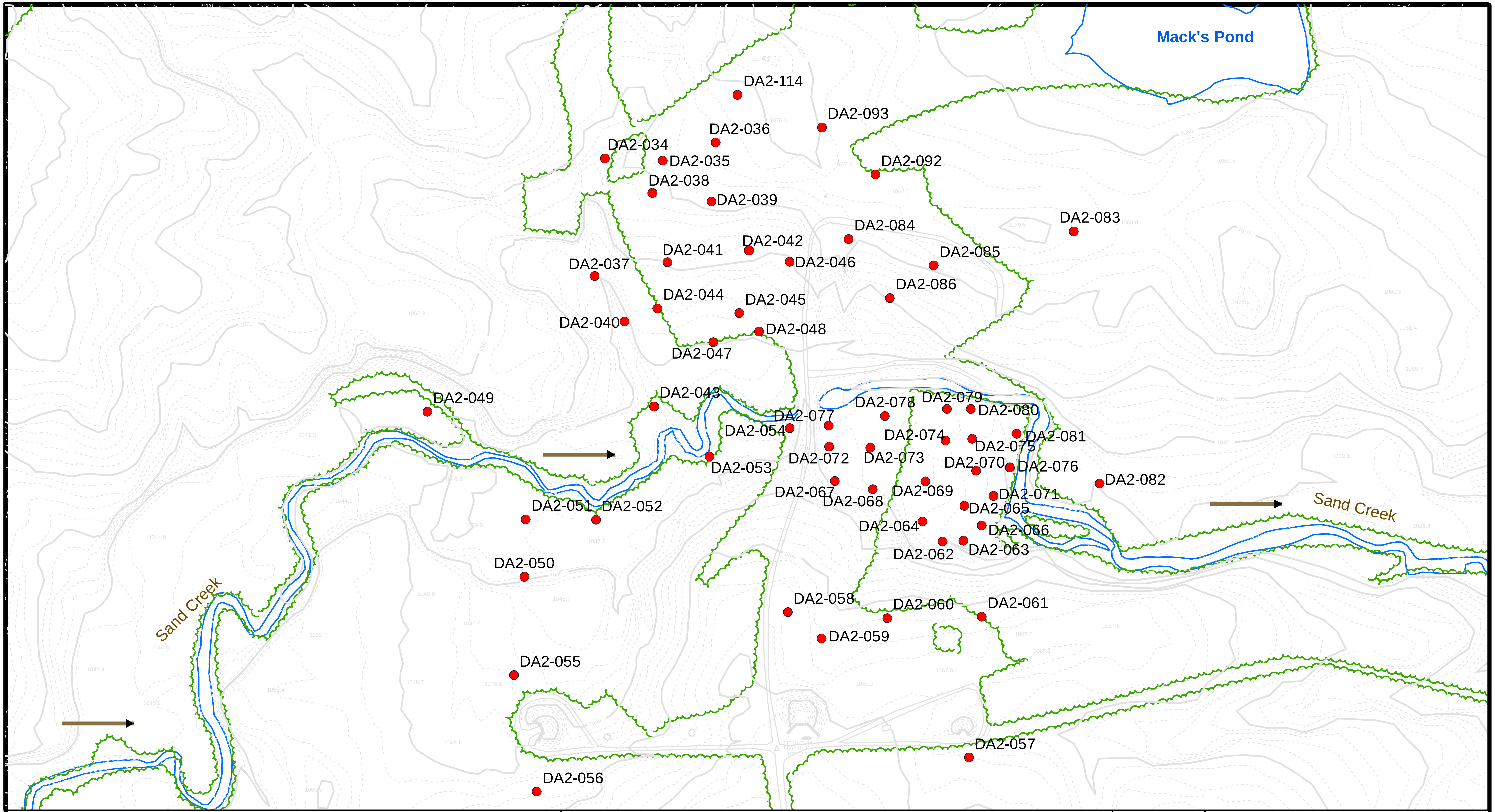
- Analytical results for QC sample spikes, sample duplicates, initial and continuing calibration verifications of standards and blanks, method blanks, and laboratory control sample information.

A systematic process for data verification was performed by SpecPro to ensure that the precision and accuracy of the analytical data were adequate for their intended use. This verification also attempted to minimize the potential of using false positive or false negative results in the decision-making process (i.e., to ensure accurate identification of detected versus non-detected compounds). This approach was consistent with DQOs for the project and with the analytical methods, and was appropriate for determining contaminants of concern and calculating risk. Analytical data were verified through the review process outlined in the SAP and are presented in Appendix H. Following data verification, all data packages were forwarded to the USACE independent data validation contractor.

Independent data validation was performed by Lab Data Consultants, Inc. under a separate task with the USACE Louisville District. This review constituted comprehensive validation of 10 percent of the primary data set, comprehensive validation of the QA split sample data set, and a comparison of primary sample, field duplicate sample, and field QA split sample information.

3.6 ORDANANCE AND EXPLOSIVES AVOIDANCE AND FIELD RECONNAISSANCE

Ordnance and explosives (OE) avoidance subcontractor support staff were present during all field operations. The OE Team Leader led an initial safety briefing on OE to train all field personnel to recognize and stay away from propellants and OE. Daily tailgate safety briefings included reminders regarding OE avoidance. Site visitors were briefed on OE avoidance before they were allowed access to the AOC. Prior to beginning sampling activities, access routes into areas from which samples were to be collected were assessed for potential OE using visual surveys and hand-held magnetometers. The OE Team Leader, USACE technical representative, and SpecPro project manager located proposed sampling stations and monitoring wells within the AOC using pin flags or wooden stakes marked with the sample station identification number. The pin flag or stake was placed at a point approved by the OE technician. An OE technician remained with the sampling crews as work progressed. At stations where subsurface soil samples were to be collected from 0.3 to 0.9 meter (1 to 3 feet) bgs, a magnetometer was lowered into the borehole to screen for subsurface magnetic anomalies at the top of the subsurface interval. For monitoring well borings, OE technicians screened the locations by hand auguring to a minimum depth of at least 0.6 meters (2 feet) or original undisturbed native soil or bedrock encounter, whichever was greater. The OE technician remained onsite as drilling was performed to visually examine drill cuttings for any unusual materials indicative of potential OE. Appendix L presents the UXO Survey Report.



Legend

Road	10 Ft. Contour
Vegetation	Surface Water Flow Direction
Water	● Surface and Subsurface Soil Sample Location - Please see Table 3-1 for sample depths
2 Ft. Contour	

From Science to Solutions™

0 100 200 400 600 800 Feet

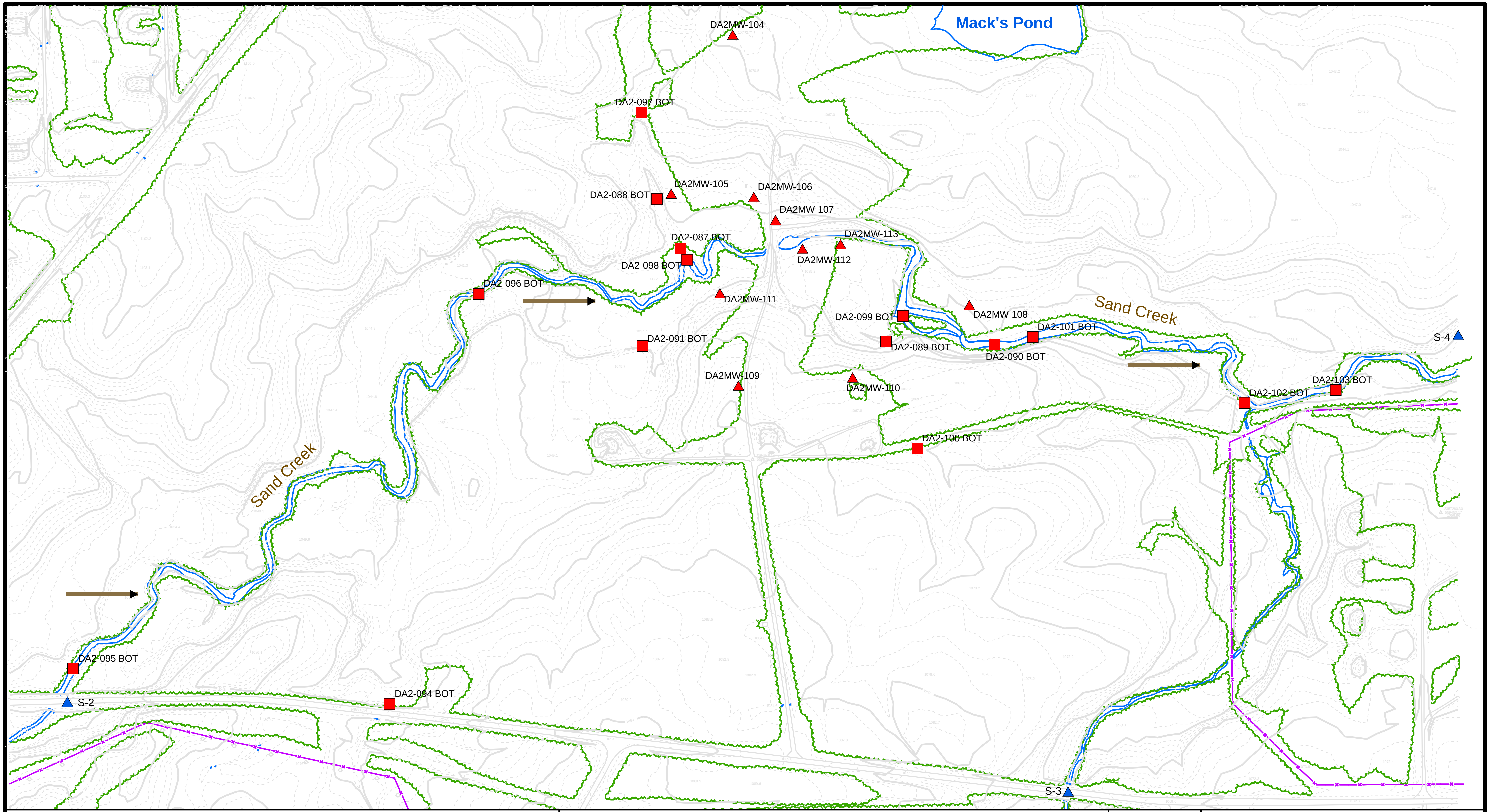
Figure 3-1

Surface and Subsurface Soil Sample Location Map

Drawn By: HRA

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/September/15



Legend

- Road
- Vegetation
- Water
- 2 Ft. Contour
- 10 Ft. Contour
- Surface Water Flow Direction
- ▲ Monitor Well
- ■ Sediment/Surface Water Sample Location
- ▲ Facility-Wide Biological and Water Quality Study Surface Water Sample Estimated Location

From Science to Solutions™

0 100 200 400 600 800 Feet

Figure 3-2

Sediment, Surface Water, and Groundwater Sample Location Map

Drawn By: HRA

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/September/15

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents results of the Phase II RI data screening to identify contaminants indicative of AOC operations. Constituents that are deemed to be related to AOC operations are classified as SRCs. These SRCs are then evaluated to determine their occurrence and distribution in environmental media at ODA2. Section 4.1 presents the statistical methods and screening criteria used to reduce and display data and to distinguish naturally occurring constituents from SRCs indicative of historical site operations. Sections 4.2 through 4.6 present the nature and extent of identified SRCs by environmental media (surface soil, subsurface soil, sediment, surface water, and groundwater). A summary of the results of the ordnance and explosives avoidance activities is presented in Section 4.8. Section 4.9 provides a summary of the results of the contaminant nature and extent evaluation.

4.1 DATA EVALUATION METHODS

The evaluation of ODA2 Phase II RI analytical data for each environmental medium involved four general steps: (1) defining background concentrations, (2) defining data aggregates, (3) performing data reduction and screening, and (4) presenting data.

4.1.1 Site Chemical Background

Chemicals occur naturally in soil, sediment, surface water, and groundwater. The natural levels (background) of chemicals must be known in order to determine whether the concentrations measured at ODA2 are higher than would be expected if the detonation/disposal operations had not occurred. Facility wide background for inorganic constituents in soil, sediment, surface water, and groundwater were developed as part of a previous Phase II RI conducted at the Winklepeck Burning Grounds at RVAAP (USACE 2001c). Although some organic compounds also occur under ambient conditions (i.e., some polycyclic aromatic hydrocarbons [PAHs]), the organic compounds of primary concern (e.g., explosives) are man-made, and, therefore, comparison to background is not relevant.

In the facility wide background study, background was calculated for each inorganic constituent detected for each environmental medium of interest. The background is the 95 percent upper tolerance limit (UTL) of the 95th percentile of the distribution of background concentrations. This means that if a sample is taken from an area with concentrations of inorganics that are not elevated above background, the measured concentration will be below background 95 percent of the time. If a measured concentration is above background, it is likely that it comes from an area with concentrations above background.

Background were set to zero for inorganics that were not detected in the facility wide background samples. For metals that were not detected in the background samples, any detected result from ODA2 was considered to be above background. RVAAP facility wide background for each medium are listed in Table 4-1.

Table 4-1. RVAAP Facility Wide Background

Analyte	Surface Soil mg/kg	Subsurface Soil mg/kg	Sediment mg/kg	Surface Water ug/L	Groundwater Bedrock Zone Filtered ug/L	Groundwater Bedrock Zone Unfiltered ug/L	Groundwater Unconsolidated Zone Filtered ug/L	Groundwater Unconsolidated Unfiltered ug/L
Cyanide	0	0	0	0	0	0	0	0
Aluminum	17700	19500	13900	3370	0	9410	0	0
Antimony	0.96	0.96	0	0	0	0	0	0
Arsenic	15.4	19.8	19.5	3.2	0	19.1	11.7	11.7
Barium	88.4	124	123	47.5	256	241	82.1	82.1
Beryllium	0.88	0.88	0.38	0	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0
Calcium	15800	35500	5510	41400	53100	48200	115000	115,000
Chromium	17.4	27.2	18.1	0	0	19.5	7.3	7.3
Cobalt	10.4	23.2	9.1	0	0	0	0	0
Copper	17.7	32.3	27.6	7.9	0	17	0	0
Iron	23100	35200	28200	2560	1430	21500	279	279
Lead	26.1	19.1	27.4	0	0	23	0	0
Magnesium	3030	8790	2760	10800	15000	13700	43300	43,300
Manganese	1450	3030	1950	391	1340	1260	1020	1,020
Mercury	0.036	0.044	0.059	0	0	0	0	0
Nickel	21.1	60.7	17.7	0	83.4	85.3	0	0
Potassium	927	3350	1950	3170	5770	6060	2890	2,890
Selenium	104	105	107	0	0	0	0	0
Silver	0	0	0	0	0	0	0	0
Sodium	123	145	112	21300	51400	49700	45700	45,700
Thallium	0	0.91	0.89	0	0	0	0	0
Vanadium	31.1	37.6	26.1	0	0	15.5	0	0
Zinc	61.8	93.3	532	42	52.3	193	60.9	60.9

4.1.2 Definition of Aggregates

The ODA2 Phase II RI data were grouped (aggregated) in two ways for evaluation of contaminant nature and extent, the HHBRA, and the screening SERA. The initial aggregation of data is by environmental media (soil, sediment, surface water, and groundwater) to facilitate evaluation of contaminant nature and extent and site risks. Data for the soil medium was further aggregated on the basis of depth for consistency with the HHBRA and USEPA RAG: surface soil from 0 to 0.3 meter (0 to 1 foot) and subsurface soil greater than a depth of 0.3 meter (1 foot). Soil samples collected from 0 to 2 feet in the monitoring well borings were composited and submitted for analysis as surface soil samples.

For each of the media aggregates, an evaluation was conducted to determine if further aggregation was warranted on the basis of site characteristics, historical operations, ecological habitat, and potential future remedial strategy and land use (spatial aggregates). For surface and subsurface soil, the geographic area of ODA2 was separated into two aggregates:

- Area A – area north of Sand Creek; and
- Area B – southern floodplain downgradient of the Sand Creek Disposal Area (Rocket Ridge).

For surface water samples, ODA2 was separated into two aggregates:

- Upstream of suspected source areas; and
- Downstream of suspected source areas.

For sediment samples, ODA2 was separated into four aggregates:

- Upstream of suspected source areas;
- Downstream of suspected source areas;
- North of Sand Creek; and
- South of Sand Creek.

For this Phase II RI, the groundwater medium was not subdivided into spatial aggregates. All of the monitoring wells installed during the RI monitor the water table interval, and all wells were screened within the unconsolidated zone. Accordingly, no technical basis existed for aggregation at this point in the CERCLA process.

4.1.3 Data Reduction and Screening

4.1.3.1 Data Reduction

More than 175 environmental soil, sediment, surface water, groundwater, and field QC samples were collected with approximately 17,026 discrete laboratory analyses (i.e., analytes) being obtained, reviewed, and integrated into this RI. These totals do not include field measurements and field descriptions. Analytical results were reported by the laboratory in electronic format and loaded into a database. As discussed in Section 3.6, verification of data was performed to ensure that all requested data were received and complete. Data use qualifiers were assigned to each result based on the laboratory QA review and verification criteria. Results were qualified as follows:

- "U" not detected at the indicated concentration;
- "UJ" not detected, reporting limit estimated
- "J" analyte present but at an estimated concentration less than the reporting limit
- "R" result not usable
- "=" analyte present and concentration accurate.

Phase II data were rejected as detailed in Appendix K; however, the project completeness goal of 90 percent was met (92.8 percent) and the rejected data did not negatively impact the project objectives.

A complete discussion of the results of the verification process is contained in the data quality assessment (Appendix K). Independent validation of 10 percent of the Phase II RI data and 100 percent of the USACE QA laboratory data was performed by a third-party subcontractor to the USACE Louisville District.

The data reduction process employed to identify SRCs involved first calculating data summary statistics. Site data were extracted from the database such that QC splits and field duplicates were excluded from the screening data sets. Rejected results were excluded from the screening process. All analytes having at least one detected value were included in the data reduction process. Summary statistics calculated for each data aggregate (Tables 4-2, 4-5, 4-7, 4-9, and 4-11 presented at the end of this section) included the minimum, maximum, and average (mean) detected values and the proportion of detected results to the total number of samples collected. Nondetected results meeting contract-required detection limits were set to one-half of the reported detection limit during calculation of the mean result for each compound. Nondetected results with elevated detection limits (more than five times the contract-required detection limit) were excluded from the summary statistics in order not to skew the calculation of mean values.

Following data reduction, the data were screened to identify SRCs using the processes outlined in the following sections. SRCs and the concentrations above background for each aggregate are presented in Tables 4-3, 4-6, 4-8, 4-10, and 4-12 at the end of this section. Additional screening of identified SRCs was conducted as part of the fate and transport evaluation to identify contaminant migration chemicals of potential concern (CMCOPCs) and as part of the risk assessments to identify human health and ecological COPCs (see Sections 6.0 and 7.0).

4.1.3.2 Frequency of Detection Screen

For sample aggregates containing more than 20 samples, a frequency of detection criterion was applied to identify SRCs. Inorganic constituents, VOCs, SVOCs, pesticides, and PCBs with a frequency of detection greater than or equal to 5 percent (e.g., 1 in 20 samples) were identified as SRCs. If the frequency of detection for one of these classes of analytes was less than 5 percent, a weight of evidence approach was used to determine if the chemical was an SRC. The weight of evidence approach involved examining the magnitude and locations of the detected results. If no clustering within a particular area was noted and concentrations were not substantially elevated relative to the detection limits, the detected results were considered spurious, and the compound was eliminated as an SRC. If an aggregate had a sample population of less than 20 samples, all detected constituents were carried forward to the facility wide background and essential human nutrient screening steps.

All detected explosives and propellants were considered to be SRCs regardless of the frequency of detection and thus were subjected to the risk evaluation (Section 5.0). However, appropriate qualification is made in the assessment of occurrence and distribution for explosives and propellants having a frequency of detection less than 5 percent.

4.1.3.3 Facility Wide Background Screen

For each inorganic constituent passing the frequency of detection screen, concentrations were compared against facility wide background developed as part of the Phase II RI for the Winklepeck Burning Grounds (USACE 2001c). For inorganic constituents, if the maximum detected concentration of an analyte exceeded its respective background, it was considered to be an SRC. In the event a constituent was not detected in the background data set, the background was set to zero, and any detected result for that constituent was considered above background. This conservative process ensured that detected constituents were not eliminated as SRCs simply because they were not detected in the background data set. All detected organic compounds were considered to be above background because these classes of compounds do not occur naturally.

4.1.3.4 Essential Nutrients Screen

Chemicals that are considered to be essential nutrients (calcium, chloride, iodine, iron, magnesium, potassium, phosphorus, and sodium) are an integral part of the food supply and are often added to foods as supplements. Thus, these constituents are not generally addressed as SRCs in the contaminant nature and extent evaluation and the HHBRA (USEPA 1989a and 1996b) unless they are grossly elevated relative to background. The essential nutrient screen is not applied for the SERA. For the ODA2 Phase II RI, analyses were conducted for calcium, iron, magnesium, potassium, and sodium. These five constituents were eliminated as SRCs in all environmental media for the nature and extent evaluation and HHBRA.

4.1.4 Data Presentation

Data summary statistics and screening results for SRCs in each data aggregate are presented in Tables 4-2, 4-5, 4-7, 4-9, and 4-11 at the end of this section. SRCs and the concentrations detected above background for each aggregate are presented in Tables 4-3, 4-6, 4-8, 4-10, and 4-12 at the end of this section. Analytical results for classes of SRCs (e.g., explosive compounds, inorganics, or VOCs) are presented in data summary tables for each medium and spatial aggregate whenever a sufficient number of detected values occurred to merit such tables. Where few detected values for a class of SRCs occurred, the values are addressed in the text of the section. Complete analytical results, including all nondetected results, are contained in Appendix H. Each table in Appendix H presents the results for each sampling station for a specific medium aggregate (e.g., surface soil, subsurface soil, sediment) and class of analytes.

In the sections addressing the nature and extent of contamination for each medium, analytical results for selected SRCs are presented on maps to depict spatial distribution. To compile the data for these figures, the number of SRCs was tallied for each sample location. It was noted that this resulted in a bell-shaped distribution curve. This distribution curve is represented on the figures by a symbol showing sample locations that had no, low, medium, or high numbers of SRCs relative to the other sample locations. The cut-off values for the SRCs discussed below were chosen based on a visual inspection of the tally results.

4.1.5 Use of Data from Previous Investigations

Data generated from previous investigations at ODA2 were used qualitatively to support the evaluation of contaminant nature and extent. However, only Phase II RI data were used quantitatively for fate and transport and risk assessments. The data obtained during previous investigations were not used quantitatively in the Phase II RI because recent MEC clearance and site grading activities resulted in significant soil disturbance in the area that these samples were taken. Accordingly, the data do not accurately represent current conditions at the AOC. Vegetation removal and site grading activities also resulted in increased erosion potential and sediment loading to AOC surface drainage features; therefore, previous data for sediment media also likely do not represent current conditions. Surface water represents a transient medium, and previous data, if sufficient data exist, may be used to examine trends over time but also do not to represent current conditions. Previous data are summarized qualitatively for each of the media investigated under this Phase II RI and may be used to generally identify source areas and support the evaluation of occurrence and distribution of contamination related to historical operations.

4.2 SURFACE SOIL

4.2.1 Summary of Previous Data

In 1983, a total of ten surface soil samples were taken within the "horseshoe" bermed area. The samples were analyzed for EP toxicity (arsenic, barium, cadmium, chromium, mercury, lead, selenium, and silver) and explosives. Analyses indicated that explosives were present in all ten samples; EP toxicity analysis showed detectable amounts of heavy metals in four samples (barium in one sample; lead in three). One of the samples exceeded the EP toxicity level for lead; all other results were below EP toxicity levels (USAEHA 1984). In 1992, 11 surface soil samples were collected and analyzed for explosives, RCRA metals, and nitrate-nitrates, phosphorus, and TKN. Soil sample analysis indicated the presence of explosives in seven of the 11 samples, and the presence of arsenic, barium, cadmium, mercury, lead, nitrate-nitrates, phosphorus, and TKN above background in several of the samples (USAEHA 1992). In 1998, as part of a RCRA Closure Field Investigation Report, 32 surface locations were sampled within and around the RCRA unit at ODA2. Metals exceeding Phase I background were indicated in several of the samples; explosives were present in five of the samples; and the propellant nitrocellulose was detected in two surface soil samples. The Phase I sampling at ODA2 included 30 surface soil locations. Contamination of surface soil by explosive compounds and inorganic analytes was identified during the Phase I investigation. Explosive compounds were identified in five surface soil samples. Inorganic analytes were detected above Phase I site-wide background in surface soil samples: aluminum, arsenic, barium, cadmium, chromium, lead, magnesium, mercury, nickel, potassium, selenium, sodium, thallium, and zinc. No contamination from VOCs or SVOCs was indicated in the samples analyzed during the Phase I investigation. In 2000, a total of eight surface soil samples were taken at three suspected disposal/burial sites within ODA2 – Burial Site #1, Burial Site #2 and Sand Creek. Explosives were detected in the surface soil at Burial Site #2, and metals above Phase I site-wide background were found in surface soils at all three areas.

4.2.2 Phase II RI Data

4.2.2.1 *Explosives and Propellants*

Nine explosive/propellant compounds were detected at least once in surface soil samples collected during the Phase II RI. Table 4-2 presents a summary of analytical results for all detected explosive/propellant compounds. Table 4-3 presents the SRCs and the concentrations above background for surface soil samples. Complete laboratory results for explosive/propellant testing in surface soil is presented in Appendix H, Table H-1. Of the detected compounds, Tetryl was the most widespread, occurring in 24 percent (16 of 66) of the surface soil samples. The remaining explosive/propellant compounds detected were 2,4-Dinitrotoluene (2 of 144 samples), 1,3,5-Trinitrobenzene (1 of 64 samples), 2-Amino-4,6-Dinitrotoluene (4 of 66 samples), 4-Amino-2,6-Dinitrotoluene (4 of 66 samples), Nitroglycerin (2 of 66 samples), 2,4,6-

Trinitrotoluene (6 of 66 samples), high melting explosive (HMX) (2 of 66 samples), and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (1 of 66 samples). The distribution of detected explosives and propellants in surface soil in ODA2 is shown in Figure 4-1 and described in the following sections.

North of Sand Creek

The following explosive and propellant compounds were detected in surface soil samples collected north of Sand Creek:

- 1,3,5-Trinitrobenzene detected in DA2-044 (86 µg/kg);
- 2,4,6-Trinitrotoluene detected in DA2-038 (3200 µg/kg), -039 (68 µg/kg), and –045 (87 µg/kg);
- 2,4-DNTdetected in DA2-037 (210 µg/kg);
- 2-Amino-4,6-Dinitrotoluene detected in DA2-045 (65 µg/kg);
- 4-Amino-2,6-Dinitrotoluene detected in DA2-045 (56 µg/kg);
- Nitroglycerine detected in DA2-045 (7200 µg/kg);
- RDX detected in DA2-114 (150 µg/kg); and
- Tetryl was detected in DA2-035 (810 µg/kg), -038 (590 µg/kg), -039 (18000 µg/kg), -040 (120 µg/kg), -044 (4200 µg/kg), -048 (3400 µg/kg), and –093 (1300 µg/kg).

South of Sand Creek

The following explosive and propellant compounds were detected in surface soil samples collected south of Sand Creek:

- 2,4,6-Trinitrotoluene detected in DA2-053 (150 µg/kg), -072 (2100 µg/kg), and –111 (110 µg/kg);
- 2,4-DNTdetected in DA2–112 (130 µg/kg);
- 2-Amino-4,6-Dinitrotoluene detected in DA2-053 (260 µg/kg), -072 (87 µg/kg), and –111 (390 µg/kg);
- 4-Amino-2,6-Dinitrotoluene detected in DA2-053 (180 µg/kg), -072 (140 µg/kg), and –111 (250 µg/kg);
- HMX detected in DA2-067 (580 µg/kg) and –068 (120 µg/kg);
- Nitroglycerine detected in DA2-053 (31000 µg/kg); and
- Tetryl was detected in DA2-053, (200 µg/kg), -058 (480 µg/kg), -065 (240 µg/kg), -068 (520 µg/kg), -072 (710 µg/kg), -073 (560 µg/kg), -074 (2300 µg/kg), -077 (820 µg/kg), and -078 (2300 µg/kg).

The highest number of explosive/propellant compounds in a sample were detected at sampling station DA2-053 in the southern floodplain, with five reported.

4.2.2.2 Inorganic Constituents

A total of 25 inorganic compounds were detected at least once in surface soil samples collected during the Phase II RI, 18 of which were identified as SRCs and carried forward to the risk screening process (Sections 6.0 and 7.0). Seven of the detected constituents were eliminated as potential surface soil SRCs because they were either considered essential nutrients (calcium, iron, magnesium, sodium, and potassium) or less than 5% of the samples were detected (antimony and silver). The maximum detected concentrations for aluminum, antimony, barium, beryllium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, vanadium, and zinc exceeded their respective background and were retained as SRCs. Cadmium, hexavalent chromium, nitrate/nitrites, and sulfides were also retained as SRCs because the backgrounds for the constituents were set to zero.

For those metals retained as SRCs in surface soil, cadmium, copper, and zinc were the most pervasive. These four metals were detected above background in over 85% of the samples analyzed. As mentioned above, hexavalent chromium, which does not have an established site background, was detected in two samples. SRCs and concentrations above background for surface soil samples are presented in Table 4-3. The number of SRCs was tallied for each sample location. It was noted that this resulted in a bell-shaped distribution curve. This distribution curve is represented on the following figures by a symbol showing sample locations that had no, low, medium, or high numbers of SRCs relative to the other sample locations. The cut-off values for the relatively high number of SRCs discussed below were chosen based on a visual inspection of the tally results. Complete laboratory results for inorganics in surface soil is presented in Appendix H, Table H-2. Surface soil sampling stations are shown in Figure 3-1 and the distribution of detected inorganics in the surface soil samples is shown in Figure 4-2.

North of Sand Creek

While inorganics were detected in surface soil samples throughout the AOC, the following locations north of Sand Creek had eight or more SRC inorganics detected above background as follows:

- DA2-036 – aluminum, cadmium, chromium, copper, nickel, sulfide, vanadium, and zinc;
- DA2-039 – arsenic, cadmium, hexavalent chromium, cobalt, copper, mercury, nickel, nitrate/nitrite, sulfide, and zinc;
- DA2-42 – arsenic, barium, beryllium, cadmium, cobalt, copper, lead, mercury, nickel, and zinc;
- DA2-44 – barium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, and zinc;
- DA2-045 and DA2-046 – arsenic, barium, cadmium, copper, lead, mercury, nickel, and zinc;
- DA2-084 – arsenic, barium, cadmium, copper, lead, mercury, nickel, and zinc;

- DA2-086 – arsenic, barium, cadmium, copper, lead, mercury, nickel, sulfide, and zinc; and
- DA2-104 – arsenic, cadmium, chromium, cobalt, copper, nickel, sulfide, and zinc.

South of Sand Creek

The following locations south of Sand Creek had eight or more SRC metals detected above background as follows:

- DA2-054 – barium, cadmium, copper, lead, mercury, nitrate/nitrite, sulfide, and zinc;
- DA2-068 – beryllium, cadmium, chromium, copper, lead, mercury, selenium, and zinc; and
- DA2-077 – barium, cadmium, hexavalent chromium, copper, lead, mercury, sulfide, silver, and zinc.

The highest concentrations for the inorganic SRCs above background in the surface soil samples are as follows:

North of Sand Creek

- Aluminum – 23400 mg/kg at DA2-036;
- Arsenic – 19.9 mg/kg at DA2-048 and DA2-084;
- Beryllium – 1.5 mg/kg at DA2-042;
- Cadmium – 9.5 mg/kg at DA2-046;
- Chromium – 31.7 mg/kg at DA2-036;
- Hexavalent chromium – 8 mg/kg at DA2-039;
- Cobalt – 14.2 mg/kg at DA2-093;
- Copper – 168 mg/kg at DA2-107;
- Lead – 117 mg/kg at DA2-107;
- Manganese – 1570 mg/kg at DA2-093;
- Mercury – 0.41 mg/kg at DA2-035;
- Nickel – 31.2 mg/kg at DA2-046;
- Nitrate/Nitrite – 5.1 mg/kg at DA2-039;
- Selenium – 1.5 mg/kg at DA2-044;
- Vanadium – 38 mg/kg at DA2-036; and
- Zinc – 557 mg/kg at DA2-107.

South of Sand Creek

- Aluminum – 17900 mg/kg at DA2-110;
- Arsenic – 16.7 mg/kg at DA2-055;
- Beryllium – 0.98 mg/kg at DA2-068;
- Cadmium – 3.8 mg/kg at DA2-077;

- Chromium – 60.8 mg/kg at DA2-068;
- Hexavalent chromium – 28 mg/kg at DA2-077 ;
- Cobalt – 24.6 mg/kg at DA2-057;
- Copper – 1210 mg/kg at DA2-067;
- Lead – 218 mg/kg at DA2-069;
- Manganese – 2140 mg/kg at DA2-057;
- Mercury – 9.9 mg/kg at DA2-077;
- Nickel – 28.8 mg/kg at DA2-074;
- Nitrate/Nitrite – 4 mg/kg at DA2-054;
- Selenium – 1.9 mg/kg at DA2-109;
- Silver – 0.32 mg/kg at DA2-070; and
- Zinc – 492 mg/kg at DA2-077.

4.2.2.3 SVOCs, VOCs, and Pesticides and PCBs

Appendix H, Table H-4 lists the laboratory results for SVOCs, VOCs, pesticides, and PCBs in surface soil samples. Table 4-2 presents a summary of analytical results for all detected SVOC, VOC, pesticide, and PCB compounds in surface soil. Table 4-3 presents the SRCs and concentrations above background for surface soil samples.

Semivolatile Organic Compounds

A total of 66 SVOCs were analyzed for in seven surface soil samples collected from ODA2 during the Phase II RI. Of these, only three SVOCs were detected, and these were detected in three samples. Bis(2-ethylhexyl)phthalate was detected at sample stations DA2-054, DA2-086, and DA2-104. Di-n-butyl phthalate was detected at sample stations DA2-054 and DA2-104. N-nitrosodiphenylamine was detected at sample station DA2-054.

Volatile Organic Compounds

A total of 37 VOCs were analyzed for in seven surface soil samples collected during the Phase II RI. Methylene chloride was detected in three of the samples. 2-Butanone, acetone, and toluene were each detected in one sample.

Pesticides and PCBs

A total of 22 pesticides and seven PCB compounds (Aroclors) were analyzed for in eight surface soil samples collected from ODA2. No PCB compounds were detected in these samples. 4,4-DDD was detected in one sample.

4.2.3 Summary

Based on the evaluation of the occurrence and distribution of contaminants in surface soil, SRCs are generally found in two areas of the AOC; the floodplain south of Sand Creek, and north of Sand Creek. The following observations can be made concerning SRCs in surface soil:

- Explosives and propellants are found at the highest concentration at sample locations DA2-053 (south of Sand Creek) and DA2-045 (north of Sand Creek). Explosives and propellants are found at 11 sampling locations south of Sand Creek, mostly in the floodplain adjacent to Sand Creek. The limits of explosives and propellant occurrences have been delineated in the floodplain south of Sand Creek. Adequate amounts of samples with non-detections of explosive and propellant occurrences encompass the AOC. Explosives and propellants are found at 10 sampling locations north of Sand Creek, mostly to the north and west. Additional sampling may be required in this area to further delineate the nature and extent of explosive and propellant occurrences to the north of Sand Creek. The explosive and propellant occurrences to the north of Sand Creek are surrounded by a few samples that did not have detections of explosives and propellants. However, additional sampling may be necessary to further delineate extent of explosives and propellants at the perimeter.

- Metals exceeding background are found at surface soil sample locations throughout the AOC. The area north of Sand Creek has eight surface soil sampling locations that have eight or more SRCs above background. These sample locations are generally centrally located in the AOC north of Sand Creek. The area south of Sand Creek has three surface soil sampling locations that have eight or more SRCs above background. These locations south of Sand Creek are in the floodplain adjacent to Sand Creek. The lateral extent of inorganic SRCs in surface soil have not been delineated based on the sampling results.

- SVOCs, VOCs, pesticides, and PCBs are either not detected in surface soil, or detections are limited to low concentrations in a limited number of sample locations.

4.3 SUBSURFACE SOIL

4.3.1 Summary of Previous Data

In 1992, 36 subsurface (to >10 feet in depth) soil samples were collected and analyzed for explosives, metals, and non-metals. Soil sample analysis indicated the presence of explosives in six of the 36 samples, and the presence of arsenic, barium, cadmium, mercury, lead, nitrate-nitrates, phosphorus, and TKN above background in several of the samples (USAEHA 1992). In 1998, as part of a RCRA Closure Field Investigation Report, 29 soil borings to 8 feet in depth or greater (two of these were taken to a depth of 14 feet, and one was taken to a depth of 20 feet) were sampled within and around the RCRA unit at ODA2. Metals exceeding Phase I background were indicated in several of the samples; and explosives were present in five of the samples. The Phase I sampling at ODA2 included subsurface soil sampling of areas north of Sand Creek. Subsurface soil samples were collected from 30 soil locations. Contamination of subsurface soil by explosive compounds and inorganic analytes was identified during the Phase I. Explosive compounds were identified in six subsurface soil samples. Inorganic analytes detected above site-wide background were found in subsurface soil samples as well. Arsenic, barium, cadmium, lead, mercury, sodium, thallium, and zinc were detected above background in subsurface soils. No contamination from VOCs and SVOCs was indicated in the samples analyzed during the Phase I investigation. In 2000, sampling of subsurface soils was conducted at three suspected disposal/burial sites within ODA2 – Burial Site #1, Burial Site #2, and Sand Creek. Soil samples were collected from two locations and three depths (to 4 feet depth) at Burial Sites #1 and #2; and at four locations and three depths (to 4 feet depth) at Sand Creek. Explosives were detected at all locations, and the propellant nitrocellulose was detected at Burial Site #2 and at Sand Creek. Metals above Phase I background were also found in all three areas: antimony, barium, beryllium, cadmium, cobalt, copper and lead at Burial Site #1; arsenic, chromium, copper, magnesium, nickel, and zinc at Burial Site #2; and antimony, barium, cadmium, copper, magnesium, manganese, lead, silver, and zinc at Sand Creek.

4.3.2 Phase II RI Data

4.3.2.1 Geotechnical Results

Eight undisturbed geotechnical samples were collected during the Phase II RI from selected subsurface soil stations and submitted for moisture, Atterberg limits, USCS classification, bulk density, hydraulic conductivity, porosity, pH, specific gravity, and grain-size distribution analyses. Table 4-4 provides a summary of the geotechnical data for subsurface soil collected from monitoring well boreholes at ODA2.

Sieve analyses and USCS classification identified the samples as ranging from lean clay (CL) to poorly graded sand with silty clay and gravel (SP-SC). Moisture content of the samples varied depending on the location, with results ranging from 10 percent (4.3 to 4.9 meters [14-16 feet] bgs at DA2-110) to 20 percent (7.3 to 7.9 meters [24 to 26 feet] bgs at DA2-104), where samples were obtained from the saturated zones of monitoring well borings.

All samples selected for Atterberg limits analyses were identified as having some degree of plasticity, with the exception of the 3.0- to 3.7-meter (10- to 12-foot) bgs depth at DA2-107 and the 7.3- to 7.9-meter (24- to 26-foot) bgs depth at DA2-104.

Hydraulic conductivity values ranged from 8.1×10^{-8} centimeters/second (6.1 to 6.7 meters [20 to 22 feet] bgs at DA2-109) to 1.2×10^{-5} centimeters/second (3.0 to 3.7 meters [10 to 12 feet] bgs at DA2-107).

Porosity values ranged from 0.21 for the poorly graded sand with silty clay and gravel at a depth of 3.0 to 3.7 meters (10 to 12 feet) bgs at station DA2-107 to 0.35 for the silt present at the 7.3 to 7.9 meter (24- to 26-foot) bgs depth at station DA2-104.

Dry bulk density ranged from 110.0 pound/cubic foot (7.3 to 7.9 meters [24 to 26 feet] bgs at DA2-104) to 131.4 pound/cubic foot (3.7 to 4.3 meters [12 to 14 feet] bgs at DA2-110).

TOC was also analyzed in eight of the subsurface soil samples collected for geotechnical analyses. TOC concentrations ranged from 3.65 mg/kg at a depth of 3.0 to 3.7 meters (10 to 12 feet) bgs at station DA2-107 to 11.8 mg/kg in the depth interval 3.7 to 4.3 meters (12 to 14 feet) bgs at station DA2-107.

4.3.2.2 <u>*Explosives and Propellants*</u>

Subsurface soil samples were collected from 66 locations and analyzed for explosives and propellants during the ODA2 Phase II RI. Nine explosive/propellant compounds were detected at least once in subsurface soil at ODA2. Table 4-5 presents summary statistics for all detected explosive and propellant compounds in subsurface soil. SRCs and concentrations above background in subsurface soil samples are presented in Table 4-6. Complete laboratory results for explosives and propellants in subsurface soil are presented in Appendix H, Table H-6. Of the detected compounds, Tetryl and 2,4,6-Trinitrotoluene occurred with the highest frequency, with 10 of the 66 samples having detectable concentrations. The distribution of explosives and propellant compounds in subsurface soil at ODA2 is shown on Figure 4-3. Sampling stations at DA2-045, DA2-067, DA2-086, and DA2-111 contained the highest number of detectable explosives, with five separate compounds being detected at each of these sampling locations.

Evaluation of the explosives/propellant data indicates that the extent of these compounds in subsurface soil is concentrated in the southern floodplain of Sand Creek downgradient of the Sand Creek Disposal Area. These compounds are also detected north of Sand Creek in areas mainly to the north and west of the AOC (Figure 4-3). The occurrence and distribution of explosive/propellant compounds in subsurface soil is discussed in detail below.

North of Sand Creek

The following explosive and propellant compounds were detected at subsurface soil sampling locations north of Sand Creek:

- Tetryl was detected in samples collected from DA2-045, -046, -084, and 086. The highest concentration was detected at DA2-046 (2.1 mg/kg);
- 2,4,6-TNT was detected in samples collected from DA2-035, -044, -045, and -086. The highest concentration was detected in DA2-035 (200 ug/kg);
- RDX was detected in DA2-044 (520 µg/kg) and DA2-082 (100 µg/kg).
- 2,4-DNTwas detected at DA2-107 (58 µg/kg);

- 2-Amino-4,6-Dinitrotoluene was detected at DA2-045, -047, and -086. The highest concentration was detected in DA2-086 (140 µg/kg);
- 4-Amino-2,6-Dinitrotoluene was detected at DA2-045, -047, -053, -067, -086, and -111. The highest concentration was detected at station DA2-067 (110 µg/kg);
- Nitroglycerine was detected at DA2-045 (26 mg/kg); and
- o-Nitrotoluene was detected at station DA2-035 (430 µg/kg).

South of Sand Creek

The following explosive and propellant compounds were detected at subsurface soil sampling locations south of Sand Creek:

- Tetryl was detected in samples collected from DA2-053, -072, -073, -077, -078, and 079. The highest concentration was detected in DA2-079 (4.4 mg/kg).
- 2,4,6-TNT was detected in samples collected from DA2-067, -072, -073, -079, -081, and -111. The highest concentration was detected in DA2-111 (1.3 mg/kg).
- RDX was detected in DA2-072 (410 µg/kg).
- 2,4-DNTwas detected at DA2-067 (62 µg/kg) and DA2-111 (60 µg/kg).
- 2-Amino-4,6-Dinitrotoluene was detected at DA2-053 (230 µg/kg) and DA2-111 (570 µg/kg).
- 4-Amino-2,6-Dinitrotoluene was detected at DA2-053, -067, and -111. The highest concentration was detected at station DA2-067 (430 µg/kg).

4.3.2.3 Inorganic Constituents

A total of 66 subsurface soil samples were collected and analyzed for inorganic elements. In addition, eight subsurface soil samples were analyzed for sulfide, hexavalent chromium, and nitrate/nitrite. A total of 24 inorganics were detected at least once in these samples. Twelve of these inorganics were eliminated as potential SRCs because they are normally considered essential nutrients (calcium, iron, magnesium, potassium, and sodium); the frequency of detection was less than 5 percent (antimony); or there were no detections above background (aluminum, chromium, cobalt, manganese, nickel, and vanadium). The remaining 12 inorganic constituents were classified as SRCs and carried forward to the risk screening (Section 6.0); these constituents are further summarized on Table 4-5. SRCs and concentrations above background are presented in Table 4-6. Complete laboratory results for inorganics in subsurface soil are presented in Appendix H, Table H-7. Of the inorganic SRCs in subsurface soil, cadmium may be considered pervasive across the site (i.e., detected above background in 50 percent or more of the samples). Of the inorganic SRCs detected in the subsurface soil, the following were detected at least once above site background; arsenic, barium, beryllium, cadmium, hexavalent chromium, copper, lead, mercury, nitrate/nitrite, selenium, sulfide, and zinc. The following sample locations have 6 or more inorganic SRCs above background in the subsurface soil:

North of Sand Creek

- DA2-044 – cadmium, copper, lead, mercury, nitrate/nitrite, sulfide, and zinc;
- DA2-045 – barium, cadmium, copper, lead, mercury, and zinc;
- DA2-046 – barium, cadmium, copper, lead, mercury, and zinc;
- DA2-084 – beryllium, cadmium, hexavalent chromium, copper, lead, mercury, sulfide, and zinc; and
- DA2-086 – barium, cadmium, copper, lead, mercury, and zinc.

South of Sand Creek

- DA2-068 – cadmium, hexavalent chromium, copper, lead, mercury, sulfide, and zinc; and
- DA2-074 – cadmium, copper, lead, mercury, sulfide, and zinc.

The highest concentrations for the inorganic SRCs above background in the subsurface soil samples are as follows:

North of Sand Creek

- Arsenic – 32.6 mg/kg at DA2-036;
- Barium – 700 mg/kg at DA2-045;
- Beryllium – 1.2 mg/kg at DA2-084;
- Cadmium – 4.7 mg/kg at DA2-045;
- Hexavalent chromium – 23 mg/kg at DA2-084;
- Copper – 152 mg/kg at DA2-086;
- Lead – 78.6 mg/kg at DA2-107;
- Mercury – 0.24 mg/kg at DA2-046;
- Nitrate/Nitrite – 3.7 mg/kg at DA2-044;
- Sulfide – 1,900 mg/kg at DA2-104; and
- Zinc – 2770 mg/kg at DA2-045.

South of Sand Creek

- Antimony – 2.2 mg/kg at DA2-073;
- Arsenic – 26.4 mg/kg at DA2-055;
- Cadmium – 3.3 mg/kg at DA2-072;
- Hexavalent chromium – 16 mg/kg at DA2-068;
- Copper – 445 mg/kg at DA2-073;
- Lead – 147 mg/kg at DA2-073;
- Mercury – 18.1 mg/kg at DA2-072;
- Nitrate/Nitrite – 2 mg/kg at DA2-059;
- Selenium – 1.7 mg/kg at DA2-059;

- Sulfide – 530 mg/kg at DA2-074; and
- Zinc – 422 mg/kg at DA2-072.

The distribution of detected inorganics above background is shown in Figure 4-4.

4.3.2.4 SVOCs, VOCs, Pesticides and PCBs

Appendix H, Table H-9 lists the laboratory results for SVOCs, VOCs, pesticides, and PCBs in subsurface soil samples. Table 4-5 presents a summary of analytical results for all detected SVOC, VOC, pesticide, and PCB compounds in subsurface soil. Table 4-6 presents the SRCs and concentrations above background for subsurface soil samples.

Semi-Volatile Organic Compounds

A total of 66 SVOC compounds were analyzed in seven subsurface soil samples during the ODA2 Phase II RI. Bis[2ethylhexyl] phthalate was detected at five sampling locations (DA2-044, DA2-059, DA2-074, DA2-084, and DA2-104). Di-n-butyl phthalate was detected at 4 sampling locations (DA2-044, DA2-059, DA2-074, and DA2-084) and n-Nitrosodiphenylamine was detected at one location DA2-084.

Volatile Organic Compounds

A total of 37 VOC compounds were analyzed in seven subsurface soil samples from ODA2. Toluene was detected in one sample at a concentration of 0.007 mg/kg (DA2-068). 2-Butanone was detected in one sample at a concentration of 0.012 mg/kg (DA2-104). Tetrachloroethylene detected in one sample at a concentration of 0.0024 mg/kg (DA2-074). Sources of these VOCs are not known.

Pesticides and PCBs

Seven PCBs (Aroclors) and 22 pesticides were analyzed for in seven subsurface soil samples at ODA2. No PCB compounds or pesticides were detected in the samples.

4.3.3 Summary

Based on the evaluation of the occurrence and distribution of contaminants in subsurface soil at ODA2, the following observations can be made:

- Explosives and propellants are present in subsurface soil at 8 sampling locations north of Sand Creek. 2,4,6-TNT and tetryl are the most common explosives north of Sand Creek, with DA2-045 having the highest number (5) of explosive and propellants detected. South of Sand Creek, explosives and propellants were detected at 11 locations, with DA2-111 having the highest number detected (4). 2,4,6-TNT and tetryl were detected in subsurface soil at six sampling locations south of Sand Creek.

- All subsurface samples had at least one SRC inorganic compound detected above the background for subsurface soil, with the exception of DA2-058 and DA2-083. North of Sand Creek, DA2-044, -045, -046, and -084 had six or more SRCs detected at each sampling location. South of Sand Creek, DA2-068 and -074 has six or more SRCs detected at those sampling locations.

- The VOCs toluene, tetrachloethylene, and 2-Butanone were detected in one of seven subsurface soil samples analyzed for VOCs at ODA2. SVOCs di-n-butyl phthalate, (four detects in seven samples), bis(2-ethyhexyl) phthalate (five detects in seven samples), and n-Nitrosodiphenylamine (one detect in seven samples) were also detected.

- Pesticides and PCBs were not detected in subsurface soil samples.

4.4 SEDIMENT

Sediment samples were collected at depths of 0.0 to 0.2 meter (0 to 0.5 foot) in 15 locations during the Phase II RI to determine the nature and extent of contamination (Figure 3-2). The sampling locations lie within drainage ditches and in Sand Creek. Drainages within ODA2 are typically dry and convey sediment and surface water only during storm events. Sediment samples were analyzed for explosives, propellants, TAL metals, hexavalent chromium, VOCs, SVOCs, PCBs/pesticides, cyanide, sulfide, nitrates, TOC, and grain-size distribution.

The complete analytical results for sediment samples collected at ODA2 are presented by sample station and analyte in Appendix H. Table 4-7 presents the summary statistics and determination of SRCs in sediment. SRCs and the concentrations above background for sediment samples collected for this RI are presented in Table 4-8. Complete laboratory analytical results for sediment are presented in Appendix H, Tables H-11 through H-15. The following sections describe major findings from the Phase I RI, as well as the distribution of explosives, propellants, inorganic, and organic constituents in ODA2 as determined in the Phase II RI.

4.4.1 Summary of Phase I RI Data

In the 1992 Geohydrologic Study, three co-located surface water and sediment samples were collected from Sand Creek, one upstream and two downstream from the RCRA unit and were analyzed for explosives, metals, non-metals, and VOCs. There was no evidence of contamination within the sediment samples.

For the Phase I RI, sediment samples were collected from three locations in Sand Creek and were analyzed for explosives, metals, cyanide, VOCs, SVOCs, PCBs and pesticides. No contamination from explosives, VOCs, SVOCs, PCBs, or pesticides was indicated. Three inorganic analytes were detected above Phase I site-wide background (cadmium, sodium, and thallium) during the Phase I RI.

4.4.2 Phase II RI Data

4.4.2.1 Geotechnical Results

Geotechnical samples were collected from all 17 sediment stations and submitted for grain size distribution and TOC analyses. All of the sediment samples were disturbed (grab) samples. Table 4-4 presents summary results of the geotechnical analyses for sediment. Appendix A contains complete geotechnical laboratory results. The highest TOC concentration (39 milligrams/kilogram) was detected at station DA2-089.

4.4.2.2 Explosives and Propellants

No explosives compounds were detected in any of the sediment samples collected during the Phase II RI. The propellant nitrocellulose was detected in sediment sample DA2-100 (29 mg/kg) located south of Sand Creek.

4.4.2.3 Inorganic Constituents

A total of 22 metals were detected at least once in sediment during the Phase II RI. Five of the detected metals were eliminated as potential SRCs because they were major geochemical constituents normally considered essential elements (calcium, iron, magnesium, potassium, and sodium). Arsenic, manganese, and zinc were eliminated as potential SRCs because the highest detected concentration was below the site background. Hexavalent chromium was detected in only one of 10 samples tested. The distribution of detected inorganics above background in sediment are shown in Figure 4-5. Appendix H, Table H-12 presents analytical results for inorganic compounds in sediment. Inorganic SRCs were detected in the following aggregates.

Upstream (DA2-095 and DA2-096)

Cadmium was detected at 0.13 mg/kg at DA2-095, near were Sand Creek flows into the AOC. Sulfide was detected at DA2-095 at 110 mg/kg. Cadmium was detected at a concentration of 0.1 mg/kg at DA2-096. Sulfide was not detected above background at DA2-096.

North of Sand Creek (DA2-087, -088, and –097)

The sediment samples collected a DA2-097 were the furthest upgradient samples collected north of Sand Creek, followed by DA2-088 and DA2-087. Inorganic SRCs at each sampling location in this aggregate are as follows:

- DA2-097:
    - Barium (317 mg/kg)
    - Beryllium (0.69 mg/kg)
    - Cadmium (2.3 mg/kg)
    - Cobalt (10.5 mg/kg)

    - Copper (60.7 mg/kg)
    - Lead (31.3 mg/kg)
    - Mercury (0.12 mg/kg)
    - Nickel (24.3 mg/kg)
    - Nitrate/Nitrite (4.9 mg/kg)
    - Sulfide (760 mg/kg)

- DA2-088:
    - Beryllium (0.49 mg/kg)
    - Cadmium (0.65 mg/kg)

- DA2-087:
    - Beryllium (0.67 mg/kg)
    - Cadmium (1.2 mg/kg)
    - Copper (29.4 mg/kg)
    - Mercury (0.07 mg/kg)

South of Sand Creek (DA2-094, -091, -089, and –100)

Inorganic SRCs detected in sediment samples collected south of Sand Creek are as follows:

- DA2-094:
    - Beryllium (0.58 mg/kg)
    - Cadmium (0.53 mg/kg)
    - Nickel (20.5 mg/kg)
    - Sulfide (330 mg/kg)

- DA2-091:
    - Beryllium (0.54 mg/kg)
    - Cadmium (1.8 mg/kg)
    - Copper (62.3 mg/kg)
    - Mercury (0.24 mg/kg)

- DA2-089:
    - Beryllium (0.57 mg/kg)
    - Cadmium (1.1 mg/kg)
    - Copper (52.7 mg/kg)
    - Lead (30.8 mg/kg)
    - Mercury (0.37 mg/kg)
    - Nickel (18.2 mg/kg)

- DA2-100:

    - Aluminum (17,300 mg/kg)
    - Barium (148 mg/kg)
    - Beryllium (1.2 mg/kg)
    - Cadmium (0.75 mg/kg)
    - Chromium (19.4 mg/kg)
    - Lead (28.3 mg/kg)
    - Mercury (0.14 mg/kg)
    - Nickel (25.2 mg/kg)
    - Nitrate/Nitrite (9.1 mg/kg)
    - Sulfide (1100 mg/kg)
    - Vanadium (30.9 mg/kg)

Downstream (DA2-098, -099, -090, -101, -102, and –103)

In order from those sediment samples collected furthest upstream to those collected downstream, inorganic SRCs in sediment samples are as follows:

- DA2-098:
    - Cadmium (0.33 mg/kg)
    - Sulfide (340 mg/kg)

- DA2-099:
    - Beryllium (0.42 mg/kg)
    - Cadmium (0.53 mg/kg)
    - Hexavalent chromium (6.1 mg/kg)
    - Mercury (0.12 mg/kg)
    - Nitrate/Nitrite (3.2 mg/kg)
    - Sulfide (1100 mg/kg)

- DA2-090:
    - Cadmium (0.2 mg/kg)

- DA2-101:
    - Beryllium (0.5 mg/kg)
    - Cadmium (0.81 mg/kg)
    - Copper (28.6 mg/kg)
    - Mercury (0.13 mg/kg)
    - Nickel (19.9 mg/kg)
    - Sulfide (150 mg/kg)

- DA2-102:
    - Cadmium (0.19 mg/kg)
    - Nitrate/Nitrite (3.5 mg/kg)

    - Sulfide (130 mg/kg)

- DA2-103:
    - Beryllium (0.52 mg/kg)
    - Cadmium (0.46 mg/kg)
    - Sulfide (75 mg/kg)

4.4.2.4 SVOCs, VOCs, Pesticides, and PCBs

No PCBs were detected in any sediment sample from ODA2. The pesticide Dieldrin was detected in the downstream sample location DA2-103 at a concentration of 0.64 µg/kg. SVOC and VOC SRCs were detected in sediment samples collected at ODA2 as follows:

Upstream

Di-n-butyl phthalate was detected at stations DA2-095 (170 µg/kg) and DA2-096 (84 µg/kg). Fluoranthene was detected in DA2-095 (120 µg/kg).

North of Sand Creek

North of Sand Creek at station DA2-097, di-n-butyl phthalate (200 µg/kg) and bis(2-ethylhexyl) phthalate (32 µg/kg) were detected.

South of Sand Creek

No SVOC or VOC SRCs were detected in sediment samples south of Sand Creek.

Downstream

2-Butanone was detected in DA2-098 (7.9 µg/kg) and DA2-099 (16 µg/kg). Trichloroethane was detected in DA2-101 (3.8 µg/kg). Chloromethane was detected in DA2-103 (4 µg/kg).

4.4.3 Summary of Sediment Results

The interpretation of chemical data obtained from ODA2 sediment is summarized as follows:

- The following inorganic SRCs (with the maximum concentration detected) occur in sediment above background:
    - Aluminum (17,300 mg/kg at DA2-100)
    - Barium (317 mg/kg at DA2-097)
    - Beryllium (1.2 mg/kg at DA2-100)
    - Cadmium (2.3 mg/kg at DA2-097)
    - Chromium (19.4 mg/kg at DA2-100)
    - Hexavalent chromium (6.1 mg/kg at DA2-099)
    - Cobalt (10.5 mg/kg at DA2-097)

  - Copper (62.3 mg/kg at DA2-091)
  - Lead (31.3 mg/kg at DA2-097)
  - Mercury (0.37 mg/kg at DA2-089)
  - Nickel (25.2 mg/kg at DA2-100)
  - Nitrate/Nitrite (9.1 mg/kg at DA2-100)
  - Sulfide (1,100 mg/kg at DA2-099)
  - Vanadium (30.9 mg/kg at DA2-100)

- SRCs in sediment above background that have migrated to the furthest downstream location east of the AOC (station DA2-103) include beryllium and cadmium.

- The sample locations that had the highest concentration of inorganic SRCs in sediment sample are as follows:

  - DA2-089 (downstream floodplain of Sand Creek) – mercury
  - DA2-091 (upstream floodplain south of Sand Creek) – copper
  - DA2-097 (ditch north of Sand Creek) – barium, cadmium, cobalt, and lead
  - DA2-099 (Sand Creek downstream) – hexavalent chromium and sulfide
  - DA2-100 (ditch upgradient of Sand Creek Disposal Area) - beryllium, chromium, nickel, nitrate/nitrite, and vanadium

- Nitrocellulose was detected (29 mg/kg) in the sediment sample collected at DA2-100.

4.5 SURFACE WATER

Surface water samples were collected from three locations at four separate sampling events during the Phase II RI to determine nature and extent of contamination (Figure 3-2). All surface water samples were co-located with sediment samples in Sand Creek (stations DA2-095, DA2-099, and DA2-102 in order from upstream to downstream).

All surface water sample collection and analysis for the Phase II RI was conducted in accordance with the *Final Work Plan and Sampling and Analysis Plan Addenda for the Phase II Remedial Investigation of Demolition Area 2 at the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2002), as described in Section 3.0 of this report. Surface water samples were analyzed for explosives, TAL metals, VOCs, SVOCs, PCBs/pesticides, nitrate, sulfide, and cyanide.

The complete analytical results for surface water samples collected at ODA2 are presented by sampling station and analyte in Appendix H, Tables H-16 through H-20. Table 4-9 presents the summary statistics and determination of SRCs in surface water. Table 4-10 presents the SRCs and the concentrations above background for surface water samples. The following sections describe the distribution of explosives, propellants, inorganic, and organic constituents as determined in the Phase II RI.

4.5.1 Summary of Previous Data

Three co-located surface water and sediment samples were collected from Sand Creek, one upstream and two downstream from the RCRA unit. A grab sample of surface runoff from the RCRA unit to Sand Creek was also taken during a rain event as part of the study. The surface water and runoff samples were analyzed for explosives, metals, non-metals, and VOCs. As part of the surface water investigation, benthic macroinvertebrates were also collected. Surface water and surface runoff samples indicated the presence of explosives, along with levels of lead, copper, iron, zinc, and mercury that exceeded the state ambient water quality criteria for warmwater habitats. Benthic macroinvertebrates were sampled by Hester Dendy and Surber sampling methods in Sand Creek above and below the RCRA unit. Results from the biological data diversity analysis indicated that the RCRA unit was not adversely affecting the macroinvertebrate community.

4.5.2 Phase II RI Data

4.5.2.1 <u>*Explosives and Propellants*</u>

No explosive compounds were detected in surface water samples collected during the Phase II RI. The only propellant compound detected was nitrocellulose, which was detected at all three stations in the September 2002 sampling event.

4.5.2.2 <u>*TAL Metals and Cyanide*</u>

A total of 13 TAL metals were detected at least once in surface water during the Phase II RI. Five of the detected metals were eliminated as potential SRCs because they were major geochemical constituents normally considered essential elements (calcium, iron, potassium, magnesium, and sodium). Barium, manganese, and zinc were eliminated as SRCs because they were not detected above background. Cyanide was not detected in any surface water sample. Nitrate was detected in 9 samples. Aluminum, chromium, nickel, nitrate/nitrite, and sulfide were retained as inorganic SRCs for surface water.

The breakdown of inorganic SRCs detected during the four sampling events are as follows:

- **July 9&10, 2002**: Nitrate/nitrite (0.23 mg/L) was detected above background in the upstream sample collected at DA2-095. Nitrate/Nitrite (0.2 mg/L) and sulfide (2.2 mg/L) were detected above background at the downstream sampling location DA2-099. Nitrate/Nitrite (0.24 mg/L) was detected above background at the furthest downstream sampling location DA2-102.

- **September 9&10, 2002**: Nitrate/nitrite (0.13 mg/L) was detected above background in the upstream sample collected at DA2-095. No inorganic SRCs were detected above background at sampling location DA2-099. Nitrate/nitrite (0.06 mg/L) was detected above background at the furthest downstream sampling location DA2-102.

- **November 26, 2002**: Nitrate/nitrite (0.09 mg/L) was detected above background in the upstream sample collected at DA2-095. Nitrate/nitrite (0.05 mg/L) was detected above background at the downstream sampling location DA2-099. No inorganic SRCs were detected above background at the furthest downstream sampling location DA2-102.

- **April 4, 2003**: Chromium (38.6 ug/L), nickel (14.9 ug/L), and nitrate/nitrite (0.05 mg/L) were detected above background in the upstream sample collected at DA2-095. No inorganic SRCs were detected above background at sampling location DA2-099. Nitrate/nitrite (0.07 mg/L) was detected above background at the furthest downstream sampling location DA2-102.

4.5.2.3 SVOCs, VOCs, and Pesticides/PCBs

One SVOC (bis(2-ethylhexyl) phthalate) was detected in 1 of the 12 surface water samples and two VOCs (carbon disulfide and chloroform) were detected in 3 of the 12 surface water samples collected at ODA2. Chloroform was detected at all three stations for the same sampling events on 11/26/2002. Bis(2-ethylhexyl) phthalate (2.1 ug/L) was detected once on 4/04/03 at DA2-102. Carbon disulfide was detected at DA2-099 on 7/10/2002 (0.66 ug/L), at DA2-102 on 4/04/2003 (1.1 ug/L), and at DA2-102 on 9/09/2002 (1.07 ug/L). No pesticides or PCB compounds were detected in any surface water sample at ODA2.

4.5.3 Summary of Surface Water Results

A summary of analytical results for surface water samples is presented in Table 4-9 and 4-10. The interpretation of SRC data obtained from ODA2 surface water is summarized below:

- **July 9&10, 2000**: Carbon disulfide and sulfide were only detected above background in the downstream location (DA2-099). Nitrate/nitrite was detected above background in all three sampling locations, with the concentration remaining basically unchanged between all three locations.

- **September 9&10, 2002**: Nitrocellulose was detected at all three sample locations. Nitrate/nitrite was detected in the upstream sample (DA2-095) and the furthest downstream sample (DA2-102). Carbon disulfide was detected in the furthest downstream sample (DA2-102).

- **November 26, 2002**: Chloroform was detected above background at all three sampling locations. Nitrate/nitrite was detected above background at DA2-095 and DA2-099.

- **April 4, 2003**: Chromium and nickel were detected above background at DA2-095. Carbon disulfide was only detected at DA2-099. Bis(2-ethylhexyl) phthalate was only detected at DA2-102. Nitrate/nitrite was detected above background at DA2-095 and DA2-102.

4.6 GROUNDWATER

Groundwater samples were collected from 16 wells during the Phase II RI (see Figure 3-2). Wells WBG-012 and WBG-013 are located north of ODA2 in and downgradient of the Winklepeck Burning Grounds. The remaining fourteen wells are located within ODA2, ten installed as part of the Phase II RI, and four previously installed to monitor groundwater at the RCRA unit. All wells within ODA2 were screened within unconsolidated deposits consisting primarily of silts and silty clays. Groundwater flow patterns have been approximated from water level measurements in the wells (see Figure 2-5, 2-6, and 2-7). Groundwater flows, consistent with regional drainage patters, towards Sand Creek. The flow north of Sand Creek is to the south and east; the flow south of Sand Creek is to the north and east.

Unfiltered groundwater samples from each well were analyzed for explosives, propellants, VOCs, SVOCs, PCB/pesticides, cyanide, sulfide, nitrates, and hexavalent chromium. Metals were analyzed for in filtered groundwater samples. The complete analytical results are provided for groundwater by analyte and station in Appendix H, Tables H-21 through 25. Table 4-11 provides the summary statistics and determination of SRCs for groundwater at ODA2. Table 4-12 presents the SRCs and the concentrations above background for groundwater samples. Nature and extent of contamination in groundwater is considered on an AOC-wide basis; therefore, no spatial aggregates have been assigned

4.6.1 Explosives and Propellants

Four separate explosive/propellant compounds were detected in groundwater samples during the Phase II RI. The most frequently detected compound was nitrocellulose, which was reported for all wells. The highest concentration of nitrocellulose, 1,300 micrograms/liter (ug/L), was reported for the monitoring well located at station WBG-012. RDX, 2-Amino-4,6,-dinitrotoluene, and 4-Amino-2,6-dinitrotoluene were detected at well WBG-013. Both of these wells are upgradient of ODA2 and are within or immediately downgradient of WBG and were installed as part of the WBG AOC investigation.

4.6.2 TAL Metals and Cyanide

All groundwater samples were analyzed for TAL metals, cyanide, and nitrate. Five of these metals were eliminated as potential SRCs because they are normally considered essential nutrients (calcium, iron, magnesium, potassium, and sodium). Facility wide background for metals were established prior to the Phase II efforts and only detections above background are discussed below. Relevant exceptions to this are aluminum, cobalt, copper, hexavalent chromium, lead, nickel, nitrate/nitrite, and vanadium, for which background were set to zero and are, therefore, automatically considered SRCs if detected at a frequency greater than 5 percent. The metals most frequently considered as SRCs were nitrate/nitrite (11 detections), aluminum (6 detections), and hexavalent chromium (5 detections), and vanadium (8 detections). Hexavalent chromium and nickel were detected in 7 of the samples. Other metals SRCs in groundwater include arsenic, barium, chromium, cobalt, copper, lead, manganese, nickel, vanadium, and zinc. DA2-104 had the most metals at the maximum concentration detected in the groundwater.

4.6.3 SVOCs, VOCs, and PCBs

Di-n-butyl-phthalate was detected at wells DA2-110 and DA2-113. Carbon Disulfide was detected at wells DA2-107, DA2-108, DET1, DET4, and WBG-012. No pesticides or PCBs were detected in any of the wells sampled.

4.6.4 Summary

The interpretation of chemical data obtained from ODA2 groundwater is summarized as follows:

- Groundwater in all monitoring wells contains site-related metals with the exception of DA2-110, DA2-112, and DA2-DET4. DA2-104 located in the northern portion of the AOC generally has the highest number of inorganic SRCs detected in any well sampled at the AOC.

- Wells WBG-012 and WBG-013 contain explosives and/or propellants and are upgradient of ODA2.

- Di-n-butyl-phthalate was detected at two wells (DA2-110 and DA2-113). Carbon Disulfide was detected at five wells (DA2-107, DA2-108, DET1, DET4, and WBG-012). No pesticides or PCBs were detected in any of the wells sampled.

4.7 OE AVOIDANCE SURVEY SUMMARY

UXO technicians provided OE avoidance training and support during all field operations. The OE avoidance crew cleared all soil, surface water/sediment, and drilling locations. No unexploded ordnance, propellants, or explosives were discovered during field reconnaissance and magnetometer surveys of access routes and proposed sampling or drilling. Various debris and metal scrap was encountered throughout ODA2 during visual and magnetometer surveys. In several instances, subsurface magnetic anomalies resulted in the decision to move pre-planned sampling and well locations to points where no anomalies were observed. Details of the UXO Survey are presented in Appendix L.

4.8 SUMMARY OF CONTAMINANT NATURE AND EXTENT

During the Phase II investigation at ODA2, 175 environmental samples were collected as follows: 66 surface soil samples, 66 subsurface soil samples, 15 sediment samples, 12 surface water samples, and 16 groundwater samples. Limited data gaps in the Phase II data exist; however, it is not anticipated higher concentrations will be detected during any additional sampling conducted to define lateral extent. It is anticipated that any further sampling results from samples collected on the edges of the limit of assessment will be lower than concentrations found in the source area; therefore conducting the risk assessments with the current Phase II RI data set is conservative. Additional data will be assessed as part of the FS. If higher concentrations are detected, the results of the risk assessment will be reevaluated.

The following text provides a summary of the results of the investigation.

4.8.1 Surface Soil

Based on the evaluation of the occurrence and distribution of contaminants in surface soil, SRCs are generally found in two areas of the AOC; the floodplain south of Sand Creek, and north of Sand Creek. The following observations can be made concerning SRCs in surface soil:

- Explosives and propellants are found at the highest concentration at sample locations DA2-053 (south of Sand Creek) and DA2-045 (north of Sand Creek). Explosives and propellants are found at 11 sampling locations south of Sand Creek, mostly in the floodplain adjacent to Sand Creek. These compounds are found at 10 sampling locations north of Sand Creek, mostly to the north and west. However, additional sampling may be necessary to further delineate extent of explosives and propellants at the perimeter.

- Metals exceeding background are found at surface soil sample locations throughout the AOC. The area north of Sand Creek has eight surface soil sampling locations that have eight or more SRCs above background. These sample locations are generally centrally located in the AOC north of Sand Creek. The area south of Sand Creek has three surface soil sampling locations that have eight or more SRCs above background. These locations south of Sand Creek are in the floodplain adjacent to Sand Creek. The lateral extent of inorganic SRCs in surface soil have not been delineated based on the sampling results.

- SVOCs, VOCs, pesticides, and PCBs are either not detected in surface soil, or detections are limited to low concentrations in a limited number of sample locations.

4.8.2 Subsurface Soil

Based on the evaluation of the occurrence and distribution of contaminants in subsurface soil at ODA2, the following observations can be made:

- Explosives and propellants are present in subsurface soil at eight sampling locations north of Sand Creek. 2,4,6-Trinitrotoluene and tetryl are the most common explosive north of Sand Creek, with DA2-045 having the highest number (5) of explosive and propellants detected. South of Sand Creek, explosives and propellants were detected at 11 locations, with DA2-111 having the highest number detected (4). 2,4,6-Trinitrotoluene and tetryl was detected in subsurface soil at six sampling locations south of Sand Creek.

- All subsurface samples had at least one inorganic compound detected above the background for subsurface soil with the exception of DA2-058 and DA2-083. North of Sand Creek, DA2-044, -045, -046, and -084 had six or more SRCs detected at each sampling location. South of Sand Creek, DA2-068 and -074 has six or more SRCs detected at those sampling locations.

- The VOCs toluene, tetrachloethylene, and 2-Butanone were detected in one of seven subsurface soil samples analyzed for VOCs at ODA2. SVOCs di-n-butyl phthalate, (four detects in seven samples), bis(2-ethyhexyl) phthalate (five detects in seven samples), and n-Nitrosodiphenylamine (one detect in seven samples) were also detected.

- Pesticides and PCBs were not detected in subsurface soil samples.

4.8.3 Sediment

The interpretation of chemical data obtained from ODA2 sediment is summarized as follows:

- The following SRCs (with the maximum concentration detected) occur in sediment above background:
  - Aluminum (17,300 mg/kg at DA2-100)
  - Barium (317 mg/kg at DA2-097)
  - Beryllium (1.2 mg/kg at DA2-100)
  - Cadmium (2.3 mg/kg at DA2-097)
  - Chromium (19.4 mg/kg at DA2-100)
  - Hexavalent chromium (6.1 mg/kg at DA2-099)
  - Cobalt (10.5 mg/kg at DA2-097)
  - Copper (62.3 mg/kg at DA2-091)
  - Lead (31.3 mg/kg at DA2-097)
  - Mercury (0.37 mg/kg at DA2-089)
  - Nickel (25.2 mg/kg at DA2-100)
  - Nitrate/Nitrite (9.1 mg/kg at DA2-100)
  - Sulfide (1,100 mg/kg at DA2-099)
  - Vanadium (30.9 mg/kg at DA2-100)

- SRCs in sediment above background that have migrated to the furthest downstream location east of the AOC (station DA2-103) include beryllium and cadmium.

- The sample locations that had the highest concentration of inorganic SRCs in sediment sample are as follows:

    - DA2-089 (downstream floodplain of Sand Creek) – mercury
    - DA2-091 (upstream floodplain south of Sand Creek) – copper
    - DA2-097 (ditch north of Sand Creek) – barium, cadmium, cobalt, and lead
    - DA2-099 (Sand Creek downstream) – hexavalent chromium and sulfide
    - DA2-100 (ditch upgradient of Sand Creek Disposal Area) - beryllium, chromium, nickel, nitrate/nitrite, and vanadium

4.8.4 Surface Water

The interpretation of SRC data obtained from ODA2 surface water is summarized below:

- **July 9&10, 2000**: Carbon disulfide and sulfide were only detected above background in the downstream location (DA2-099). Nitrate/nitrite was detected above background in all three sampling locations, with the concentration remaining basically unchanged between all three locations.

- **September 9&10, 2002**: Nitrocellulose was detected at all three sample locations. Nitrate/nitrite was detected in the upstream sample (DA2-095) and the furthest downstream sample (DA2-102). Carbon disulfide was detected in the furthest downstream sample (DA2-102).

- **November 26, 2002**: Chloroform was detected above background at all three sampling locations. Nitrate/nitrite was detected above background at DA2-095 and DA2-099.

- **April 4, 2003**: Nickel and chromium were detected above background at DA2-095. Carbon disulfide was only detected at DA2-099. Bis(2-ethylhexyl) phthalate was only detected at DA2-102. Nitrate/nitrite was detected above background at DA2-095 and DA2-102.

4.8.5 Groundwater

The interpretation of chemical data obtained from ODA2 groundwater is summarized as follows:

- Groundwater in all monitoring wells contains site-related metals with the exception of DA2-110, DA2-112, and DA2-DET4. DA2-104, located in the northern portion of the AOC, contained the most inorganics at the maximum concentration detected in groundwater.

- Only monitoring wells WBG-012 and WBG-013 (upgradient of ODA2) contain explosives and/or propellants.

- Di-n-butyl-phthalate was detected at two wells (DA2-110 and DA2-113). Carbon Disulfide was detected at five wells (DA2-107, DA2-108, DET1, DET4, and WBG-012).

- No pesticides or PCBs were detected in any of the wells sampled.

4.8.6 Potential Laboratory Contamination

Low concentrations of methylene chloride and acetone were reported in the analytical results summarized above. Low levels of methylene chloride and acetone are often seen as common laboratory contaminants, as these solvents are utilized in the standard operating procedures of the laboratory. The laboratory attempted to reach the lowest possible levels of quantification, and in doing so are detecting concentrations below the required reporting limits. In an effort to mitigate laboratory contamination and achieve their standard reporting limit with little or no laboratory contamination, the analytical laboratory will stress the importance of proper receipt and storage of soil samples separate from organic extractions as well as higher grade reagents and improved cleaning processes after analysis of samples containing elevated concentrations of constituents.

To be conservative, acetone and methylene chloride are carried forward to the COPC screening.

1 **Table 4-2. Summary Statistics and Determination of Site-Related Contaminations in Surface Soil Samples**

Analysis Type	Analyte	Units	Frequency of Detection	Minimum Detect	Average Result[a]	Maximum Detect	Site Background Criteria	Site Related?	Justification
Explosives	1,3,5-Trinitrobenzene	mg/kg	1/ 66	8.60E-02	5.06E-02	8.60E-02		Yes	No Background Data Available
Explosives	2,4,6-Trinitrotoluene	mg/kg	6/ 66	6.80E-02	1.32E-01	3.20E+00		Yes	No Background Data Available
Explosives	2,4-Dinitrotoluene	mg/kg	2/ 66	1.30E-01	5.36E-02	2.10E-01		Yes	No Background Data Available
Explosives	2-Amino-4,6-Dinitrotoluene	mg/kg	4/ 66	6.50E-02	5.91E-02	3.90E-01		Yes	No Background Data Available
Explosives	4-Amino-2,6-Dinitrotoluene	mg/kg	4/ 66	5.60E-02	5.65E-02	2.50E-01		Yes	No Background Data Available
Explosives	HMX	mg/kg	2/ 66	1.20E-01	1.08E-01	5.80E-01		Yes	No Background Data Available
Explosives	Nitroglycerine	mg/kg	2/ 66	7.20E+00	5.43E+00	3.10E+01		Yes	No Background Data Available
Explosives	RDX	mg/kg	1/ 66	1.50E-01	1.01E-01	1.50E-01		Yes	No Background Data Available
Explosives	Tetryl	mg/kg	16/ 66	1.20E-01	6.30E-01	1.80E+01		Yes	No Background Data Available
Inorganics	Aluminum	mg/kg	66/ 66	4.02E+03	1.11E+04	2.34E+04	1.77E+04	Yes	Above Background
Inorganics	Antimony	mg/kg	3/ 66	1.40E+00	2.75E-01	2.20E+00	9.60E-01	No	<= 5% Detects
Inorganics	Arsenic	mg/kg	66/ 66	3.50E+00	1.33E+01	1.99E+01	1.54E+01	Yes	Above Background
Inorganics	Barium	mg/kg	66/ 66	3.10E+01	8.00E+01	1.75E+02	8.84E+01	Yes	Above Background
Inorganics	Beryllium	mg/kg	66/ 66	2.70E-01	5.95E-01	1.50E+00	8.80E-01	Yes	Above Background
Inorganics	Cadmium	mg/kg	64/ 66	1.20E-01	1.21E+00	9.50E+00		Yes	No Background Data Available
Inorganics	Calcium[b]	mg/kg	66/ 66	2.34E+02	2.66E+03	3.41E+04	1.58E+04	No	Essential Element
Inorganics	Chromium	mg/kg	66/ 66	6.80E+00	1.61E+01	6.08E+01	1.74E+01	Yes	Above Background
Inorganics	Chromium, Hexavalent	mg/kg	2/ 7	8.00E+00	6.65E+00	2.80E+01		Yes	No Background Data Available
Inorganics	Cobalt	mg/kg	66/ 66	4.10E+00	8.56E+00	2.46E+01	1.04E+01	Yes	Above Background
Inorganics	Copper	mg/kg	66/ 66	8.30E+00	1.06E+02	1.21E+03	1.77E+01	Yes	Above Background
Inorganics	Iron[b]	mg/kg	66/ 66	1.02E+04	2.41E+04	3.93E+04	2.31E+04	No	Essential Element
Inorganics	Lead	mg/kg	66/ 66	1.21E+01	3.45E+01	2.18E+02	2.61E+01	Yes	Above Background
Inorganics	Magnesium[b]	mg/kg	66/ 66	1.15E+03	2.62E+03	5.34E+03	3.03E+03	No	Essential Element
Inorganics	Manganese	mg/kg	66/ 66	1.15E+02	5.14E+02	2.14E+03	1.45E+03	Yes	Above Background

Table 4-2. Summary Statistics and Determination of Site-Related Contaminations in Surface Soil Samples (continued)

Analysis Type	Analyte	Units	Frequency of Detection	Minimum Detect	Average Result[a]	Maximum Detect	Site Background Criteria	Site Related?	Justification
Inorganics	Mercury	mg/kg	54/ 66	6.00E-02	6.59E-01	9.90E+00	3.60E-02	Yes	Above Background
Inorganics	Nickel	mg/kg	66/ 66	7.60E+00	1.86E+01	3.12E+01	2.11E+01	Yes	Above Background
Inorganics	Nitrate/Nitrite	mg/kg	2/ 7	4.00E+00	1.95E+00	5.10E+00		Yes	No Background Data Available
Inorganics	Potassium[b]	mg/kg	66/ 66	3.99E+02	1.08E+03	2.51E+03	9.27E+02	No	Essential Element
Inorganics	Selenium	mg/kg	7/ 66	8.60E-01	3.71E-01	1.90E+00	1.40E+00	Yes	Above Background
Inorganics	Silver	mg/kg	1/ 66	3.20E-01	4.87E-02	3.20E-01		No	<= 5% Detects
Inorganics	Sodium[b]	mg/kg	8/ 66	6.74E+01	3.57E+01	2.23E+02	1.23E+02	No	Essential Element
Inorganics	Sulfide	mg/kg	7/ 7	5.20E+01	4.63E+02	2.20E+03		Yes	No Background Data Available
Inorganics	Vanadium	mg/kg	66/ 66	7.80E+00	1.85E+01	3.80E+01	3.11E+01	Yes	Above Background
Inorganics	Zinc	mg/kg	66/ 66	4.92E+01	1.40E+02	5.57E+02	6.18E+01	Yes	Above Background
Organic Pesticides	4,4-DDD	mg/kg	1/ 7	2.60E-02	4.52E-03	2.60E-02		Yes	No Background Data Available
Organic-Semivolatiles	bis(2-ethylhexyl) phthalate	mg/kg	3/ 7	2.20E-02	1.32E-01	1.00E-01		Yes	No Background Data Available
Organic-Semivolatiles	di-n-Butyl Phthalate	mg/kg	2/ 7	1.50E-01	2.81E-01	8.60E-01		Yes	No Background Data Available
Organic-Semivolatiles	n-Nitrosodiphenylamine	mg/kg	1/ 7	1.00E-01	1.78E-01	1.00E-01		Yes	No Background Data Available
Organic-Volatiles	2-Butanone	mg/kg	1/ 7	8.90E-03	6.20E-03	8.90E-03		Yes	No Background Data Available
Organic-Volatiles	Acetone	mg/kg	1/ 7	1.90E-02	1.71E-02	1.90E-02		Yes	No Background Data Available
Organic-Volatiles	Tetrachloroethylene	mg/kg	4/ 7	3.70E-03	3.57E-03	4.80E-03		Yes	No Background Data Available
Organic-Volatiles	Toluene	mg/kg	1/ 7	2.00E-03	2.80E-03	2.00E-03		Yes	No Background Data Available

[a] Values less than the detection limit were set to one-half of the reporting limit in calculation of the average.

[b] Eliminated as an SRC based on the essential element screen

Site Background Criteria was determined for the Winlepeck Burning Ground Phase II Remedial Investigation (USACE 2001c)

Table 4-3. SRC in Surface Soil Samples at ODA2

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2mw-104**	**DA2mw-105**	**DA2mw-106**	**DA2mw-107**	**DA2mw-108**	**DA2mw-109**	**DA2mw-110**
Sample ID			**DA2MW-104-0807-SO**	**DA2MW-105-0811-SO**	**DA2MW-106-0815-SO**	**DA2MW-107-0819-SO**	**DA2MW-108-0823-SO**	**DA2MW-109-0827-SO**	**DA2MW-110-0831-SO**
Date			**07/15/2002**	**07/15/2002**	**07/15/2002**	**07/18/2002**	**07/15/2002**	**07/19/2002**	**07/25/2002**
Depth (ft)			**0.0 - 2.0**	**0.0 - 2.0**	**0.0 - 2.0**	**0.0 - 2.0**	**0.0 - 2.0**	**0.0 - 2.0**	**0.0 - 2.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**							
Explosives									
1,3,5-Trinitrobenzene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics									
Aluminum	MG/KG	17700	16600	11600	9790	12200	8150	12900	17900 #
Antimony	MG/KG	0.96	0.24 UN/UN	0.23 UN/UN	0.33 BN/U	1.2 BN/U	0.25 BN/U	0.47 UN/UN	0.23 UN/UN
Arsenic	MG/KG	15.4	16.2 *N/*N#	17.1 *N/*N#	15.3 *N/*N	13.3 N/N	10.6 *N/*N	10	14.4
Barium	MG/KG	88.4	62.7	55.3	102 #	136 #	38.4	68.1	62.8
Beryllium	MG/KG	0.88	0.8 */*	0.48 */*	0.58 */*	1.1 #	0.53 */*	0.62	0.6
Cadmium	MG/KG		0.27 */*#	0.8 */*#	2.1 */*#	2.1 #	0.29 */*#	0.88 #	0.23 #
Calcium	MG/KG	15800	951 */*	978 */*	2220 */*	34100 */*#	234 */*	1600	406
Chromium	MG/KG	17.4	22.1 #	15.9	14.5	14.2	11.7	16.1	19 #
Chromium, Hexavalent	MG/KG		4.4 U/U	NA	NA	NA	NA	NA	NA
Cobalt	MG/KG	10.4	11.9 #	6.9	9.7	7.6	6.4	8.2	7
Copper	MG/KG	17.7	26.2 N/N#	25.8 N/N#	78.7 N/N#	168 */*#	14 N/N	38 #	20.3 #
Iron	MG/KG	23100	32700 #	23100	24400 #	21400	27200 #	35800 #	24200 #
Lead	MG/KG	26.1	15.6	21.5	23.1	117 #	24.9	19.6	14.3
Magnesium	MG/KG	3030	3890 *N/*N#	2530 *N/*N	2810 *N/*N	5340 #	1480 *N/*N	2570	2680
Manganese	MG/KG	1450	272 */*	262 */*	398 */*	822	413 */*	710	115
Mercury	MG/KG	0.036	0.02 U/U	0.06 B/U	0.15 #	0.13 #	0.05 B/U	0.15 #	0.03 B/U
Nickel	MG/KG	21.1	28.1 #	16.1	22.3 #	18.7	14.1	15.6	16.8
Nitrate/Nitrite	MG/KG		1.9 U/U	NA	NA	NA	NA	NA	NA
Potassium	MG/KG	927	1550 N/N#	1030 N/N#	1240 N/N#	1530 N/N#	833 N/N	1100 N/N#	1250 E/E#
Selenium	MG/KG	1.4	0.24 U/U	0.23 U/U	0.2 U/U	0.98 U/U	0.22 B/U	1.9 #	0.55 B/U
Silver	MG/KG		0.06 U/U	0.05 U/U	0.05 U/U	0.23 U/U	0.05 U/U	0.11 U/U	0.06 U/U
Sodium	MG/KG	123	46.1 B/U	24.5 B/U	26.7 B/U	164 B/U	16.8 U/U	41.7 B/U	55.3 B/U
Sulfide	MG/KG		530 #	NA	NA	NA	NA	NA	NA
Vanadium	MG/KG	31.1	26.7	21	16.3	15.6	15.7	21.5	25.3
Zinc	MG/KG	61.8	74.2 #	67.4 #	155 #	557 #	63 #	206 #	55.1
Organic Pesticides									
4,4-DDD	MG/KG		0.0017 U/U	NA	NA	NA	NA	NA	NA
Organic-Semivolatiles									
bis(2-ethylhexyl) phthalate	MG/KG		0.1 J/J	NA	NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		0.15 J/J	NA	NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		0.38 U/U	NA	NA	NA	NA	NA	NA
Organic-Volatiles									
2-Butanone	MG/KG		0.011 U/U	NA	NA	NA	NA	NA	NA
Acetone	MG/KG		0.018 B/U	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		0.0057 U/U	NA	NA	NA	NA	NA	NA
Toluene	MG/KG		0.0057 U/U	NA	NA	NA	NA	NA	NA

Table 4-3. SRC in Surface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2mw-111**	**DA2mw-112**	**DA2mw-113**	**DA2ss-034**	**DA2ss-035**	**DA2ss-036**	**DA2ss-037**
Sample ID			**DA2MW-111-0835-SO**	**DA2MW-112-0839-SO**	**DA2MW-113-0843-SO**	**DA2ss-034-0649-SO**	**DA2ss-035-0651-SO**	**DA2ss-036-0653-SO**	**DA2ss-037-0655-SO**
Date			**07/18/2002**	**07/25/2002**	**07/25/2002**	**07/25/2002**	**07/19/2002**	**07/15/2002**	**08/02/2002**
Depth (ft)			**0.0 - 2.0**	**0.0 - 2.0**	**0.0 - 2.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**							
Explosives									
1,3,5-Trinitrobenzene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		0.11	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.13	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.21
2-Amino-4,6-Dinitrotoluene	MG/KG		0.39	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.25	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.81	0.2 U/U	0.2 U/U
Inorganics									
Aluminum	MG/KG	17700	9070	6640	10100	12300	10700	23400 #	8890
Antimony	MG/KG	0.96	0.25 UN/UN	2.2 N/N#	0.23 UN/UN	1.2 UN/UN	0.22 UN/UN	0.26 UN/UN	0.28 UN/UN
Arsenic	MG/KG	15.4	15.6 N/N#	14.8	13.3	12.2	14.3	13.5 *N/*N	12.2
Barium	MG/KG	88.4	52.8	52.3	68	162 #	70.2	78.2	76.9
Beryllium	MG/KG	0.88	0.48	0.48	0.5	0.62	0.56	0.88 */*	0.55
Cadmium	MG/KG		1.6 #	1 #	1.2 #	0.78 #	2.1 #	0.45 */*#	0.53 #
Calcium	MG/KG	15800	1140 */*	5150	1700	1260	1480	804 */*	1360
Chromium	MG/KG	17.4	12.9	9.8	13.5	16.5	14.5	31.7 #	11.4
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA	4.8 U/U	NA
Cobalt	MG/KG	10.4	8.5	8.3	8.3	11.6 #	10.1	10.4	7.1
Copper	MG/KG	17.7	78.2 */*#	45.9 #	93.6 #	35.9 #	58.5 #	28.9 N/N#	21.8 #
Iron	MG/KG	23100	23400 #	21400	22700	24100 #	25700 #	39300 #	21700 */*
Lead	MG/KG	26.1	21.6	61.3 #	24.7	26.1	20.4	22.2	15.8
Magnesium	MG/KG	3030	2180	1960	2490	3120 #	2760	5260 *N/*N#	1790 N/N
Manganese	MG/KG	1450	418	351	363	1460 #	468	222 */*	516
Mercury	MG/KG	0.036	0.61 #	0.26 #	0.29 #	0.24 #	0.41 #	0.03 B/U	0.06 #
Nickel	MG/KG	21.1	17.6	17.2	18.4	19.6	20.1	31.1 #	15.5
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA	1.6 U/U	NA
Potassium	MG/KG	927	1060 N/N#	870 E/E	1100 N/N#	1280 N/N#	1220 N/N#	2510 N/N#	821 N/N
Selenium	MG/KG	1.4	0.49 B/U	0.51 B/U	0.23 U/U	1.2 U/U	0.86	0.43 B/U	0.28 U/U
Silver	MG/KG		0.06 U/U	0.05 U/U	0.05 U/U	0.29 U/U	0.05 U/U	0.06 U/U	0.07 U/U
Sodium	MG/KG	123	32.9 B/U	71.3	44.6 B/U	100 U/U	50.3 B/U	31.2 B/U	40.3 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA	2200 #	NA
Vanadium	MG/KG	31.1	17	11.6	16.1 N/N	21.2 N/N	17.8	38 #	16.2
Zinc	MG/KG	61.8	133 #	91.5 #	107 #	118 #	113 #	78.9 #	81.2 #
Organic Pesticides									
4,4-DDD	MG/KG		NA	NA	NA	NA	NA	0.0017 U/U	NA
Organic-Semivolatiles									
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA	0.4 U/U	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA	0.4 U/U	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA	0.4 U/U	NA
Organic-Volatiles									
2-Butanone	MG/KG		NA	NA	NA	NA	NA	0.0089 J/J	NA
Acetone	MG/KG		NA	NA	NA	NA	NA	0.065 B/U	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA	0.006 U/U	NA
Toluene	MG/KG		NA	NA	NA	NA	NA	0.006 U/U	NA

Table 4-3. SRC in Surface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2ss-038**	**DA2ss-039**	**DA2ss-040**	**DA2ss-041**	**DA2ss-042**	**DA2ss-043**
Sample ID			**DA2ss-038-0657-SO**	**DA2ss-039-0659-SO**	**DA2ss-040-0661-SO**	**DA2ss-041-0663-SO**	**DA2ss-042-0665-SO**	**DA2ss-043-0667-SO**
Date			**07/25/2002**	**07/15/2002**	**07/25/2002**	**07/25/2002**	**07/15/2002**	**07/26/2002**
Depth (ft)			**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**						
Explosives								
1,3,5-Trinitrobenzene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		3.2 J/J	0.068 J/J	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.59	18	0.12 J/J	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics								
Aluminum	MG/KG	17700	11000	10900	9980	18600 #	11500	12800
Antimony	MG/KG	0.96	0.24 UN/UN	0.37 BN/U	0.21 UN/UN	0.24 UN/UN	0.27 UN/UN	0.22 UN/UN
Arsenic	MG/KG	15.4	16 #	17.8 *N/*N#	16.1 #	12.6	18.5 *N/*N#	14.7
Barium	MG/KG	88.4	68.4	75.3	78.4	87.9	125 #	83.1
Beryllium	MG/KG	0.88	0.57	0.71 */*	0.55	0.72	1.5 */*#	0.64
Cadmium	MG/KG		0.97 #	0.63 */*#	2.4 #	0.45 #	1.4 */*#	1.6 #
Calcium	MG/KG	15800	1420	1430 */*	1350	1600	1910 */*	1990
Chromium	MG/KG	17.4	15.2	15.7	13.7	24.6 #	16.6	16.5
Chromium, Hexavalent	MG/KG		NA	8 #	NA	NA	NA	NA
Cobalt	MG/KG	10.4	9.9	12.5 #	9.3	9.1	11.3 #	9.6
Copper	MG/KG	17.7	58.9 #	34 N/N#	89.4 #	29.8 #	58.7 N/N#	91.1 #
Iron	MG/KG	23100	26200 #	30400 #	25400 #	31900 #	27900 #	25800 #
Lead	MG/KG	26.1	25.9	18.5	34.6 #	15.7	26.9 #	25.7
Magnesium	MG/KG	3030	2710	3070 *N/*N#	2540	4220 #	3160 *N/*N#	3020
Manganese	MG/KG	1450	428	506 */*	503	243	442 */*	588
Mercury	MG/KG	0.036	0.1 #	0.1 #	0.07 #	0.09 #	0.1 #	0.27 #
Nickel	MG/KG	21.1	20.7	26 #	20.6	25 #	24.6 #	22.1 #
Nitrate/Nitrite	MG/KG		NA	5.1 #	NA	NA	NA	NA
Potassium	MG/KG	927	1280 N/N#	1280 N/N#	1110 N/N#	1820 N/N#	1440 N/N#	1160 N/N#
Selenium	MG/KG	1.4	0.24 U/U	0.25 U/U	0.21 U/U	0.32 B/U	0.27 U/U	0.47 B/U
Silver	MG/KG		0.06 U/U	0.06 U/U	0.05 U/U	0.06 U/U	0.06 U/U	0.05 U/U
Sodium	MG/KG	123	31.7 B/U	20.5 U/U	25.8 B/U	41.5 B/U	37 B/U	62.4 B/U
Sulfide	MG/KG		NA	70 #	NA	NA	NA	NA
Vanadium	MG/KG	31.1	18.8 N/N	18.8	19 N/N	30.6 N/N	19.7	21
Zinc	MG/KG	61.8	98.4 #	77.5 #	114 #	117 #	120 #	236 #
Organic Pesticides								
4,4-DDD	MG/KG		NA	0.026 P/P	NA	NA	NA	NA
Organic-Semivolatiles								
bis(2-ethylhexyl) phthalate	MG/KG		NA	0.37 U/U	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	0.37 U/U	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	0.37 U/U	NA	NA	NA	NA
Organic-Volatiles								
2-Butanone	MG/KG		NA	0.011 U/U	NA	NA	NA	NA
Acetone	MG/KG		NA	0.018 B/U	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	0.0055 U/U	NA	NA	NA	NA
Toluene	MG/KG		NA	0.0055 U/U	NA	NA	NA	NA

Table 4-3. SRC in Surface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2ss-044**	**DA2ss-045**	**DA2ss-046**	**DA2ss-047**	**DA2ss-048**	**DA2ss-049**
Sample ID			**DA2ss-044-0669-SO**	**DA2ss-045-0671-SO**	**DA2ss-046-0673-SO**	**DA2ss-047-0675-SO**	**DA2ss-048-0677-SO**	**DA2ss-049-0679-SO**
Date			**07/24/2002**	**07/15/2002**	**07/25/2002**	**07/15/2002**	**07/15/2002**	**08/01/2002**
Depth (ft)			**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**						
Explosives								
1,3,5-Trinitrobenzene	MG/KG		0.086 J/J	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.087 J/J	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.065 J/J	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.056 J/J	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	7.2 J/J	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		4.2	0.2 U/U	0.2 U/U	0.2 U/U	3.4	0.2 U/U
Inorganics								
Aluminum	MG/KG	17700	14400	10800	11000	8550	9400	7820
Antimony	MG/KG	0.96	0.27 UN/UN	0.42 BN/U	0.21 UN/UN	0.63 BN/U	0.48 BN/U	0.3 UN/UN
Arsenic	MG/KG	15.4	14.8	16.6 *N/*N#	16.2 #	13.6 *N/*N	19.9 *N/*N#	3.5
Barium	MG/KG	88.4	135 #	168 #	175 #	107 #	93.1 #	52.9
Beryllium	MG/KG	0.88	0.66	0.57 */*	0.64	0.44 */*	0.51 */*	0.35
Cadmium	MG/KG		1.2 #	3 */*#	9.5 #	2 */*#	1.5 */*#	0.32 #
Calcium	MG/KG	15800	1720	2010 */*	2430	1770 */*	1860 */*	2040
Chromium	MG/KG	17.4	18.2 #	15.5	16.6	12.6	13.9	8.3
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA	NA
Cobalt	MG/KG	10.4	10.5 #	9.6	10.1	8.5	8.8	4.1
Copper	MG/KG	17.7	53.1 */*#	107 N/N#	161 #	71.6 N/N#	90 N/N#	8.3
Iron	MG/KG	23100	28600 #	26900 #	28500 #	20400	22900	10200 */*
Lead	MG/KG	26.1	28.7 *N/*N#	39.6 #	32.9 #	24.6	29.6 #	12.1
Magnesium	MG/KG	3030	3380 #	3090 *N/*N#	3280 #	2440 *N/*N	2580 *N/*N	1250 N/N
Manganese	MG/KG	1450	392	370 */*	388	347 */*	333 */*	310
Mercury	MG/KG	0.036	0.07 #	0.28 *N/*N#	0.2 #	0.12 *N/*N#	0.37 *N/*N#	0.06 B/U
Nickel	MG/KG	21.1	22.9 #	29 #	31.2 #	18.3	19.9	7.6
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA	NA
Potassium	MG/KG	927	1570 N/N#	1160 N/N#	1190 N/N#	1120 N/N#	1300 N/N#	399 N/N
Selenium	MG/KG	1.4	1.5 #	0.22 U/U	0.21 U/U	0.23 U/U	0.28 U/U	0.41 B/U
Silver	MG/KG		0.06 U/U	0.05 U/U	0.05 U/U	0.05 U/U	0.07 U/U	0.07 U/U
Sodium	MG/KG	123	52.5 B/U	30.3 B/U	42.8 B/U	25.2 B/U	36 B/U	65.5 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA	NA
Vanadium	MG/KG	31.1	23.5	18.2	18.1 N/N	14.7	16	12.1
Zinc	MG/KG	61.8	93 NE/NE#	168 #	205 #	130 #	114 #	50.1
Organic Pesticides								
4,4-DDD	MG/KG		NA	NA	NA	NA	NA	NA
Organic-Semivolatiles								
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA	NA
Organic-Volatiles								
2-Butanone	MG/KG		NA	NA	NA	NA	NA	NA
Acetone	MG/KG		NA	NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA	NA
Toluene	MG/KG		NA	NA	NA	NA	NA	NA

Table 4-3. SRC in Surface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2ss-050**	**DA2ss-051**	**DA2ss-052**	**DA2ss-053**	**DA2ss-054**	**DA2ss-055**
Sample ID			**DA2ss-050-0681-SO**	**DA2ss-051-0683-SO**	**DA2ss-052-0685-SO**	**DA2ss-053-0687-SO**	**DA2ss-054-0689-SO**	**DA2ss-055-0691-SO**
Date			**08/01/2002**	**08/01/2002**	**08/01/2002**	**08/01/2002**	**07/31/2002**	**07/31/2002**
Depth (ft)			**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**						
Explosives								
1,3,5-Trinitrobenzene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.15	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.26	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.18	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	31	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2	0.2 U/U	0.2 U/U
Inorganics								
Aluminum	MG/KG	17700	8780	7620	8840	8310	9480	12500
Antimony	MG/KG	0.96	0.25 UN/UN	0.28 UN/UN	0.28 UN/UN	0.22 UN/UN	0.23 UN/UN	1.1 UN/UN
Arsenic	MG/KG	15.4	11.7	10.2	12.8	15.4	14.1	16.7 #
Barium	MG/KG	88.4	62.2	48.2	61.1	50.9	93.2 #	115 #
Beryllium	MG/KG	0.88	0.51	0.44	0.52	0.52	0.56	0.8
Cadmium	MG/KG		0.44 #	0.44 #	0.38 #	1.1 #	1.5 */*#	0.43 */*#
Calcium	MG/KG	15800	1700	1300	2300	690	3110	983
Chromium	MG/KG	17.4	12.7	10.6	12.8	13.7	13.2	14.8
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	5 U/U	NA
Cobalt	MG/KG	10.4	8.1	7.1	8.6	9.2	8.6	6.1
Copper	MG/KG	17.7	17.1	16	18 #	92.8 #	87.8 */*#	36.5 */*#
Iron	MG/KG	23100	20900 */*	17700 */*	21700	26300 */*#	21800	23300 #
Lead	MG/KG	26.1	16.9	17.3	15.9	24.1	36.8 #	24.3
Magnesium	MG/KG	3030	2430 N/N	1940 N/N	2660 N/N	2510 N/N	2430	1880
Manganese	MG/KG	1450	630	413	615	444	548	1540 #
Mercury	MG/KG	0.036	0.05 B/U	0.08 #	0.11 #	1.9 #	0.95 #	0.15 #
Nickel	MG/KG	21.1	17.8	14.3	18.8	20.8	18.1	18.5
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	4 #	NA
Potassium	MG/KG	927	864 N/N	717 N/N	962 N/N#	1040 N/N#	1030 E/E#	813 E/E
Selenium	MG/KG	1.4	0.36 B/U	0.28 U/U	0.28 U/U	0.22 U/U	0.46 B/U	1.1 U/U
Silver	MG/KG		0.06 U/U	0.07 U/U	0.07 U/U	0.08 B/U	0.05 U/U	0.27 U/U
Sodium	MG/KG	123	46.5 B/U	54.1 B/U	119	29.4 B/U	48.2 B/U	90.6 U/U
Sulfide	MG/KG		NA	NA	NA	NA	52 #	NA
Vanadium	MG/KG	31.1	15.7	13.4	15.9	15.5	15.9	21.4
Zinc	MG/KG	61.8	82.1 #	64.6 #	86.4 #	134 #	151 N*/N*#	86 N*/N*#
Organic Pesticides								
4,4-DDD	MG/KG		NA	NA	NA	NA	0.0021 U/U	NA
Organic-Semivolatiles								
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	0.022 J/J	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	0.86	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	0.1 J/J	NA
Organic-Volatiles								
2-Butanone	MG/KG		NA	NA	NA	NA	0.012 U/U	NA
Acetone	MG/KG		NA	NA	NA	NA	0.031 B/U	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	0.0048 J/J	NA
Toluene	MG/KG		NA	NA	NA	NA	0.0062 U/U	NA

Table 4-3. SRC in Surface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2ss-056**	**DA2ss-057**	**DA2ss-058**	**DA2ss-059**	**DA2ss-060**	**DA2ss-061**
Sample ID			**DA2ss-056-0693-SO**	**DA2ss-057-0695-SO**	**DA2ss-058-0697-SO**	**DA2ss-059-0699-SO**	**DA2ss-060-0701-SO**	**DA2ss-061-0703-SO**
Date			**07/31/2002**	**07/29/2002**	**07/25/2002**	**07/25/2002**	**07/29/2002**	**07/29/2002**
Depth (ft)			**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**						
Explosives								
1,3,5-Trinitrobenzene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.48	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics								
Aluminum	MG/KG	17700	12900	14300	10500	16600	14300	17500
Antimony	MG/KG	0.96	1.3 UN/UN	1.4 UN/UN	0.23 UN/UN	0.23 UN/UN	0.22 UN/UN	0.24 UN/UN
Arsenic	MG/KG	15.4	11.6	13.5	8.2	15.5 #	11.8	14.7
Barium	MG/KG	88.4	65.8	101 #	54.7	52.8	52	55.7
Beryllium	MG/KG	0.88	0.65	0.88	0.46	0.63	0.75	0.69
Cadmium	MG/KG		0.28 B*/U	0.7 #	0.18 #	0.12 #	0.23 #	0.31 #
Calcium	MG/KG	15800	350	481	889	505	399	628
Chromium	MG/KG	17.4	14.5	16.6	12.6	21.3 #	17.8 #	22.7 #
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA	NA
Cobalt	MG/KG	10.4	7.9	24.6 #	7.3	6.6	10.9 #	8.8
Copper	MG/KG	17.7	11.1 */*	15.4	13	20.8 #	17.6	22.7 #
Iron	MG/KG	23100	19200	27600 #	17000	30700 #	23400 #	31800 #
Lead	MG/KG	26.1	29.2 #	29.9 #	15.4	14.6	15.9	14.4
Magnesium	MG/KG	3030	1930	2090 N/N	1890	3320 #	2750 N/N	3750 N/N#
Manganese	MG/KG	1450	1600 #	2140 #	656	137	330	198
Mercury	MG/KG	0.036	0.09 #	0.13 #	0.12 #	0.03 B/U	0.02 B/U	0.03 B/U
Nickel	MG/KG	21.1	14.2	16.1	11.8	19.4	18.7	23.9 #
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA	NA
Potassium	MG/KG	927	691 E/E	909 N/N	683 N/N	1470 N/N#	1220 N/N#	1580 N/N#
Selenium	MG/KG	1.4	1.3 U/U	1.4 U/U	0.27 B/U	0.26 B/U	0.3 B/U	0.29 B/U
Silver	MG/KG		0.31 U/U	0.33 U/U	0.05 U/U	0.05 U/U	0.05 U/U	0.06 U/U
Sodium	MG/KG	123	107 U/U	114 U/U	31.1 B/U	38.7 B/U	47.4 B/U	62.1 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA	NA
Vanadium	MG/KG	31.1	23.5	29.7	19.8 N/N	28.1 N/N	23.3	27.8
Zinc	MG/KG	61.8	65.5 N*/N*#	78.5 #	49.2	58.1	57.2	62.5 #
Organic Pesticides								
4,4-DDD	MG/KG		NA	NA	NA	NA	NA	NA
Organic-Semivolatiles								
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA	NA
Organic-Volatiles								
2-Butanone	MG/KG		NA	NA	NA	NA	NA	NA
Acetone	MG/KG		NA	NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA	NA
Toluene	MG/KG		NA	NA	NA	NA	NA	NA

Table 4-3. SRC in Surface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2ss-062**	**DA2ss-063**	**DA2ss-064**	**DA2ss-065**	**DA2ss-066**	**DA2ss-067**
Sample ID			**DA2ss-062-0705-SO**	**DA2ss-063-0707-SO**	**DA2ss-064-0709-SO**	**DA2ss-065-0711-SO**	**DA2ss-066-0713-SO**	**DA2ss-067-0715-SO**
Date			**07/31/2002**	**07/30/2002**	**07/30/2002**	**07/29/2002**	**07/29/2002**	**07/19/2002**
Depth (ft)			**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**						
Explosives								
1,3,5-Trinitrobenzene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.58 J/J
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.24	0.2 U/U	0.2 U/U
Inorganics								
Aluminum	MG/KG	17700	7950	5990	8990	9520	9410	11200
Antimony	MG/KG	0.96	0.25 UN/UN	0.24 UN/UN	0.32 UN/UN	0.43 BN/U	0.26 UN/UN	1.1 UN/UN
Arsenic	MG/KG	15.4	9	10.2	12.1	9.4	11.1	12.1
Barium	MG/KG	88.4	65.9	54.4	81.1	59.9	46.3	75.3
Beryllium	MG/KG	0.88	0.43	0.45	0.49	0.46	0.53	0.81
Cadmium	MG/KG		0.54 */*#	0.57 #	1.5 #	1 #	0.57 #	0.99 #
Calcium	MG/KG	15800	394	1440	1960	376	649	13300
Chromium	MG/KG	17.4	10.7	8.3	12.9	11.8	13.2	35.7 #
Chromium, Hexavalent	MG/KG		4.7 U/U	NA	NA	NA	NA	NA
Cobalt	MG/KG	10.4	6.3	5.3	6.4	6.9	7.4	7.6
Copper	MG/KG	17.7	36.7 */*#	56 #	225 #	57.6 #	28.1 #	1210 #
Iron	MG/KG	23100	17300	23300 #	20900	17300	20300	25100 #
Lead	MG/KG	26.1	23.1	15.2	35.3 #	56.7 #	28.4 #	26.4 #
Magnesium	MG/KG	3030	1610	1440 N/N	2160 N/N	1770	1940 N/N	3460 #
Manganese	MG/KG	1450	336	545	343	324	445	648
Mercury	MG/KG	0.036	0.61 #	0.39 #	3.2 #	0.63 #	0.28 #	2.5 #
Nickel	MG/KG	21.1	11.3	12	16.1	12.2	13.9	22 #
Nitrate/Nitrite	MG/KG		1.8 U/U	NA	NA	NA	NA	NA
Potassium	MG/KG	927	578 E/E	534 N/N	854 N/N	686 N/N	726 N/N	837 N/N
Selenium	MG/KG	1.4	0.48 B/U	0.24 U/U	0.47 B/U	0.45 B/U	0.32 B/U	2.2 B/U
Silver	MG/KG		0.06 U/U	0.06 U/U	0.07 U/U	0.05 U/U	0.06 U/U	0.26 U/U
Sodium	MG/KG	123	39.6 B/U	62.9 B/U	98.1	76	58.9 B/U	92.2 B/U
Sulfide	MG/KG		190 #	NA	NA	NA	NA	NA
Vanadium	MG/KG	31.1	13.6	11.3	16	16	16.3	16.1
Zinc	MG/KG	61.8	65 N*/N*#	57.2	359 #	121 #	72.5 #	163 #
Organic Pesticides								
4,4-DDD	MG/KG		0.002 U/U	NA	NA	NA	NA	NA
Organic-Semivolatiles								
bis(2-ethylhexyl) phthalate	MG/KG		0.39 U/U	NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		0.39 U/U	NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		0.39 U/U	NA	NA	NA	NA	NA
Organic-Volatiles								
2-Butanone	MG/KG		0.012 U/U	NA	NA	NA	NA	NA
Acetone	MG/KG		0.047 B/U	NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		0.0037 J/J	NA	NA	NA	NA	NA
Toluene	MG/KG		0.0059 U/U	NA	NA	NA	NA	NA

Table 4-3. SRC in Surface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2ss-068**	**DA2ss-069**	**DA2ss-070**	**DA2ss-071**	**DA2ss-072**	**DA2ss-073**
Sample ID			**DA2ss-068-0717-SO**	**DA2ss-069-0719-SO**	**DA2ss-070-0721-SO**	**DA2ss-071-0723-SO**	**DA2ss-072-0725-SO**	**DA2ss-073-0727-SO**
Date			**07/19/2002**	**07/29/2002**	**07/29/2002**	**07/30/2002**	**07/19/2002**	**07/19/2002**
Depth (ft)			**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**						
Explosives								
1,3,5-Trinitrobenzene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	2.1	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.087 J/J	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.14	0.1 U/U
HMX	MG/KG		0.12 J/J	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.52	0.2 U/U	0.2 U/U	0.2 U/U	0.71	0.56
Inorganics								
Aluminum	MG/KG	17700	11300	9570	11500	9220	8780	7440
Antimony	MG/KG	0.96	0.46 BN/U	1.4 N/N#	0.25 UN/UN	0.25 UN/UN	0.45 UN/UN	0.51 BN/U
Arsenic	MG/KG	15.4	11.8	12.8	11.3	10.2	13.7	12.2
Barium	MG/KG	88.4	78.1	106 #	61.2	56.8	76	79.9
Beryllium	MG/KG	0.88	0.98 #	0.52	0.53	0.59	0.5	0.46
Cadmium	MG/KG		0.95 #	2 #	1.3 #	0.62 #	2.3 #	1.9 #
Calcium	MG/KG	15800	19100 #	2110	1100	860	2970	2140
Chromium	MG/KG	17.4	60.8 #	17.2	14.4	11.6	12.3	12
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA	NA
Cobalt	MG/KG	10.4	6.4	8.5	7.4	6.2	8.4	6.8
Copper	MG/KG	17.7	845 #	241 #	98.4 #	38.2 #	180 #	191 #
Iron	MG/KG	23100	22000	26800 #	21500	18300	24800 #	22100
Lead	MG/KG	26.1	37.2 #	218 #	35.5 #	33.1 #	33.8 #	63.8 #
Magnesium	MG/KG	3030	4100 #	2190	2250	1920 N/N	2190	1970
Manganese	MG/KG	1450	727	594	223	322	584	388
Mercury	MG/KG	0.036	1.4 #	3 #	0.23 #	0.52 #	3.3 #	4 #
Nickel	MG/KG	21.1	16.2	19.9	16.5	13.1	16.4	15.8
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA	NA
Potassium	MG/KG	927	1050 N/N#	928 N/N#	975 N/N#	739 N/N	838 N/N	1080 N/N#
Selenium	MG/KG	1.4	1.6 #	0.44 B/U	0.52 B/U	0.31 B/U	1.5 B/U	0.83 B/U
Silver	MG/KG		0.09 U/U	0.06 U/U	0.32 #	0.06 U/U	0.12 B/U	0.05 U/U
Sodium	MG/KG	123	223 #	61.6 B/U	67.1 B/U	64.4 B/U	79.4 B/U	57.2 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA	NA
Vanadium	MG/KG	31.1	12.6	16.3	18	15.9	16.1	13.1
Zinc	MG/KG	61.8	115 #	262 #	108 #	103 #	391 #	207 #
Organic Pesticides								
4,4-DDD	MG/KG		NA	NA	NA	NA	NA	NA
Organic-Semivolatiles								
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA	NA
Organic-Volatiles								
2-Butanone	MG/KG		NA	NA	NA	NA	NA	NA
Acetone	MG/KG		NA	NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA	NA
Toluene	MG/KG		NA	NA	NA	NA	NA	NA

Table 4-3. SRC in Surface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2ss-074**	**DA2ss-075**	**DA2ss-076**	**DA2ss-077**	**DA2ss-078**	**DA2ss-079**
Sample ID			**DA2ss-074-0729-SO**	**DA2ss-075-0731-SO**	**DA2ss-076-0733-SO**	**DA2ss-077-0735-SO**	**DA2ss-078-0737-SO**	**DA2ss-079-0739-SO**
Date			**07/19/2002**	**07/30/2002**	**07/30/2002**	**07/19/2002**	**07/19/2002**	**07/19/2002**
Depth (ft)			**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**						
Explosives								
1,3,5-Trinitrobenzene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		2.3	0.2 U/U	0.2 U/U	0.82	2.3	0.2 U/U
Inorganics								
Aluminum	MG/KG	17700	9460	12700	5700	9620	8400	9460
Antimony	MG/KG	0.96	0.21 UN/UN	0.26 UN/UN	0.24 UN/UN	2.1 N/N#	0.45 UN/UN	0.23 UN/UN
Arsenic	MG/KG	15.4	14.1	11.4	9.8	13.9	10.6	14.5
Barium	MG/KG	88.4	72.8	70	58.4	164 #	90.6 #	88.8 #
Beryllium	MG/KG	0.88	0.5	0.54	0.36	0.51	0.48	0.5
Cadmium	MG/KG		2.2 #	1.2 #	0.93 #	3.8 #	1.7 #	2.4 #
Calcium	MG/KG	15800	1820	1210	1480	2860	1580	2320
Chromium	MG/KG	17.4	34.7 #	15.9	8.5	15	11.2	13.5
Chromium, Hexavalent	MG/KG		NA	NA	NA	28 #	NA	NA
Cobalt	MG/KG	10.4	8.8	8.1	6.2	7.6	6.8	8.7
Copper	MG/KG	17.7	195 #	97.2 #	38.9 #	664 #	97.1 #	180 #
Iron	MG/KG	23100	24200 #	23000	18200	29200 #	19200	23800 #
Lead	MG/KG	26.1	56.3 #	30.3 #	17.3	172 #	27.6 #	42.1 #
Magnesium	MG/KG	3030	2570	2330	1500 N/N	2260	2000	2730
Manganese	MG/KG	1450	381	403	439	627	421	372
Mercury	MG/KG	0.036	2 #	0.79 #	0.17 #	9.9 #	1.4 #	0.23 #
Nickel	MG/KG	21.1	28.8 #	15.8	12.7	19.2	15.3	20
Nitrate/Nitrite	MG/KG		NA	NA	NA	2 U/U	NA	NA
Potassium	MG/KG	927	1070 N/N#	923 N/N	681 N/N	942 N/N#	876 N/N	1290 N/N#
Selenium	MG/KG	1.4	0.86	0.38 B/U	0.24 U/U	1.5 B/U	1.4 B/U	0.92
Silver	MG/KG		0.05 U/U	0.15 B/U	0.06 U/U	0.28 B/U	0.11 U/U	0.05 U/U
Sodium	MG/KG	123	61.8 B/U	62.4 B/U	60.7 B/U	80.6 B/U	55.5 B/U	60.1 B/U
Sulfide	MG/KG		NA	NA	NA	130 #	NA	NA
Vanadium	MG/KG	31.1	15.2	20.2	10.5	15.2	14.4	15.4
Zinc	MG/KG	61.8	303 #	111 #	91.8 #	492 #	422 #	217 #
Organic Pesticides								
4,4-DDD	MG/KG		NA	NA	NA	0.002 U/U	NA	NA
Organic-Semivolatiles								
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	0.39 U/U	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	0.39 U/U	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	0.39 U/U	NA	NA
Organic-Volatiles								
2-Butanone	MG/KG		NA	NA	NA	0.012 U/U	NA	NA
Acetone	MG/KG		NA	NA	NA	0.019	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	0.0037 J/J	NA	NA
Toluene	MG/KG		NA	NA	NA	0.0059 U/U	NA	NA

Table 4-3. SRC in Surface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2ss-080**	**DA2ss-081**	**DA2ss-082**	**DA2ss-083**	**DA2ss-084**	**DA2ss-085**
Sample ID			**DA2ss-080-0741-SO**	**DA2ss-081-0743-SO**	**DA2ss-082-0745-SO**	**DA2ss-083-0747-SO**	**DA2ss-084-0749-SO**	**DA2ss-085-0751-SO**
Date			**07/19/2002**	**07/30/2002**	**08/01/2002**	**07/25/2002**	**07/18/2002**	**07/18/2002**
Depth (ft)			**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**						
Explosives								
1,3,5-Trinitrobenzene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics								
Aluminum	MG/KG	17700	7560	4020	14600	14400	11900	11300
Antimony	MG/KG	0.96	0.2 UN/UN	0.21 UN/UN	0.23 UN/UN	0.24 UN/UN	0.47 BN/U	0.23 UN/UN
Arsenic	MG/KG	15.4	11.4	8.2	11.1	9.8	19.9 N/N#	16.9 N/N#
Barium	MG/KG	88.4	56.5	31	64.5	67.8	96 #	66.4
Beryllium	MG/KG	0.88	0.4	0.27	0.69	0.54	0.7	0.64
Cadmium	MG/KG		1 #	0.53 #	0.44 #	0.27 #	2 #	1.3 #
Calcium	MG/KG	15800	1890	1550	632	881	6710 */*	7770 */*
Chromium	MG/KG	17.4	10.6	6.8	17.1	17.7 #	17.3	16.2
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA	NA
Cobalt	MG/KG	10.4	6.1	4.5	9.5	8.3	10.1	9.6
Copper	MG/KG	17.7	68.8 #	32.6 #	35.5 #	20.4 #	113 */*#	84.1 */*#
Iron	MG/KG	23100	19800	13400	23300 */*#	23500 #	29600 #	26900 #
Lead	MG/KG	26.1	27.4 #	12.6	25.8	18.6	59.4 #	22.3
Magnesium	MG/KG	3030	1890	1150	2490 N/N	2540	4060 #	3930 #
Manganese	MG/KG	1450	344	236	448	564	434	393
Mercury	MG/KG	0.036	0.21 #	0.07 #	0.12 #	0.08 #	0.18 #	0.14 #
Nickel	MG/KG	21.1	14.3	9.5	18	14.6	24 #	23.7 #
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA	NA
Potassium	MG/KG	927	820 N/N	538 N/N	987 N/N#	1060 N/N#	1540 N/N#	1640 N/N#
Selenium	MG/KG	1.4	0.74 B/U	0.3 B/U	0.35 B/U	0.39 B/U	0.52 B/U	0.46 B/U
Silver	MG/KG		0.05 U/U	0.05 U/U	0.06 U/U	0.06 U/U	0.05 U/U	0.05 U/U
Sodium	MG/KG	123	50.5 B/U	67.7	30.1 B/U	40.9 B/U	70.6	55.2 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA	NA
Vanadium	MG/KG	31.1	12.9	7.8	23.5	24.8 N/N	19.4	17.9
Zinc	MG/KG	61.8	119 #	57	131 #	62.1 #	244 #	123 #
Organic Pesticides								
4,4-DDD	MG/KG		NA	NA	NA	NA	NA	NA
Organic-Semivolatiles								
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA	NA
Organic-Volatiles								
2-Butanone	MG/KG		NA	NA	NA	NA	NA	NA
Acetone	MG/KG		NA	NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA	NA
Toluene	MG/KG		NA	NA	NA	NA	NA	NA

Table 4-3. SRC in Surface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2ss-086**	**DA2ss-092**	**DA2ss-093**	**DA2ss-114**
Sample ID			**DA2ss-086-0753-SO**	**DA2ss-092-0765-SO**	**DA2ss-093-0767-SO**	**DA2ss-114-0870-SO**
Date			**07/24/2002**	**08/05/2002**	**08/05/2002**	**08/05/2002**
Depth (ft)			**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**	**0.0 - 1.0**
Filtered			**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**				
Explosives						
1,3,5-Trinitrobenzene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.15 J/J
Tetryl	MG/KG		0.2 U/U	0.2 U/U	1.3	0.2 U/U
Inorganics						
Aluminum	MG/KG	17700	10200	16400	15500	8660
Antimony	MG/KG	0.96	0.46 BN/U	0.23 UN/UN	1.3 UN/UN	0.22 UN/UN
Arsenic	MG/KG	15.4	16.1 #	14.1	14.3	15.4
Barium	MG/KG	88.4	168 #	66.1	83.5	44.6
Beryllium	MG/KG	0.88	0.57	0.62	0.7	0.44
Cadmium	MG/KG		1.7 #	0.61 #	0.28 B/U	0.35 #
Calcium	MG/KG	15800	7500	1310	614	496
Chromium	MG/KG	17.4	14.5	22.2 #	17.8 #	11.1
Chromium, Hexavalent	MG/KG		2.2 U/U	NA	NA	NA
Cobalt	MG/KG	10.4	8.9	8.5	14.2 #	6.3
Copper	MG/KG	17.7	122 */*#	46 #	25.1 #	33.4 #
Iron	MG/KG	23100	24700 #	29700 */*#	27600 */*#	20300 */*
Lead	MG/KG	26.1	101 *N/*N#	18.4	23.7	15.1
Magnesium	MG/KG	3030	3730 #	3320 N/N#	2420 N/N	1940 N/N
Manganese	MG/KG	1450	416	216	1570 #	265
Mercury	MG/KG	0.036	0.21 #	0.05 B/U	0.08 #	0.03 B/U
Nickel	MG/KG	21.1	21.4 #	21.7 #	15.4	16
Nitrate/Nitrite	MG/KG		1.8 U/U	NA	NA	NA
Potassium	MG/KG	927	1400 N/N#	1330 N/N#	1070 N/N#	934 N/N#
Selenium	MG/KG	1.4	1.3	0.39 B/U	1.3 U/U	0.22 U/U
Silver	MG/KG		0.05 U/U	0.05 U/U	0.3 U/U	0.05 U/U
Sodium	MG/KG	123	67.4	42.5 B/U	101 U/U	23 B/U
Sulfide	MG/KG		71 #	NA	NA	NA
Vanadium	MG/KG	31.1	16.2	27.9	26.7	14
Zinc	MG/KG	61.8	204 NE/NE#	89.4 #	72.9 #	71.1 #
Organic Pesticides						
4,4-DDD	MG/KG		0.0018 U/U	NA	NA	NA
Organic-Semivolatiles						
bis(2-ethylhexyl) phthalate	MG/KG		0.026 J/J	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		0.36 U/U	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		0.36 U/U	NA	NA	NA
Organic-Volatiles						
2-Butanone	MG/KG		0.011 U/U	NA	NA	NA
Acetone	MG/KG		0.023 B/U	NA	NA	NA
Tetrachloroethylene	MG/KG		0.0042 J/J	NA	NA	NA
Toluene	MG/KG		0.002 J/J	NA	NA	NA

Note: Data Qaulifiers are presented as Laboratory qualifiers/Validation qualifiers
\# - value above facility wide background = - analyte present and concentration accurate.
J - estimated value less than reporting limits. U - Not detected
N - Matrix spike recovery outside control limits * - Duplicate analysis outside control limits.
E - Result estimated because of the presence of interference. P - greater than 25% difference between two GC columns
B - for organics-compound was detected in the blank as well as the sample NA – not analyzed
B - for inorganics-result was less than the contract required detection limit but greater than the instrument detection limit.
Facility wide background was determined for the Winklepeck Burning Ground Phase II Remedial Investigation (USACE 2001c)

Table 4-4. ODA2 Geotechnical Data Summary

				Density (pcf)							
Sample Number	**Depth (ft)**	**Moisture Content (%)**	**Specific Gravity**	**Wet**	**Dry**	**Porosity**	**Permeability (cm/sec)**	**pH**	**Total Organic Carbon (mg/L)**	**USCS Classification**	**USCS Description**
DAZ-MW107-0821-SO	11.4	11	2.673	133.4	120.2	0.208	1.16E-05	7.37	3.65	SP-SC	Poorly Graded Sand with Silty Clay and Gravel
DAZ-MW107-0822-SO	13.5	12	2.716	139.6	124.3	0.267	1.73E-07	7.02	11.8	CL	Lean Clay
DAZ-MW111-0837-SO	7.5	12	2.748	143.5	127.6	0.256	3.12E-08	7.7	9.92	CL	Lean Clay with Sand
DAZ-MW104-0809-SO	24	20	2.703	131.5	110	0.348	3.83E-07	8.1	4.05	ML	Silt
DAZ-MW109-0829-SO	21.5	10	2.712	137.7	124.9	0.262	6.35E-08	8.39	11.1	CL-ML	Sandy Silty Clay
DAZ-MW109-0830-SO	23.3	11	2.697	143	129	0.234	8.14E-08	8.38	4.28	CL-ML	Sandy Silty Clay
DAZ-MW110-0833-SO	13	11	2.718	145.5	131.4	0.226	4.74E-08	8.66	7.02	CL-ML	Sandy Silty Clay with Gravel
DAZ-MW110-0834-SO	15	10	2.697	143.9	130.7	0.224	1.69E-07	7.72	10.5	CL	Sandy Lean Clay
DAZ-SD095-0770-SD	--	24	--	--	--	--	--	--	8.33	--	--
DAZ-SD096-0771-SD	--	28	--	--	--	--	--	--	8.39	--	--
DAZ-SD097-0772-SD	--	89	--	--	--	--	--	--	9.50	--	--
DAZ-SD098-0773-SD	--	40	--	--	--	--	--	--	5.75	--	--
DAZ-SD099-0774-SD	--	57	--	--	--	--	--	--	4.45	--	--
DAZ-SD100-0775-SD	--	33	--	--	--	--	--	--	5.38	--	--

Table 4-4. ODA2 Geotechnical Data Summary (continued)

Sample Number	Depth (ft)	Moisture Content (%)	Specific Gravity	Density (pcf)		Porosity	Permeability (cm/sec)	pH	Total Organic Carbon (mg/L)	USCS Classification	USCS Description
				Wet	Dry						
DAZ-SD101-0776-SD	--	28	--	--	--	--	--	--	4.62	--	--
DAZ-SD103-0778-SD	--	23	--	--	--	--	--	--	4.14	--	--
DAZ-SD094-0769-SD	--	26	--	--	--	--	--	--	4.56	--	--
DAZ-SD102-0777-SD	--	25	--	--	--	--	--	--	5.73	--	--
DAZ-SD101-0849-SD	--	27	--	--	--	--	--	--	7.88	--	--

-- Not analyzed

Table 4-5. Summary Statistics and Determination of Site-Related Contaminations in Subsurface Soil Samples

Analysis Type	Analyte	Units	Frequency of Detection	Minimum Detect	Average Result[a]	Maximum Detect	Site Background Criteria	Site Related?	Justification
Explosives	2,4,6-Trinitrotoluene	mg/kg	10/ 66	4.00E-02	7.36E-02	1.30E+00		Yes	No Background Data Available
Explosives	2,4-Dinitrotoluene	mg/kg	3/ 66	5.80E-02	5.05E-02	6.20E-02		Yes	No Background Data Available
Explosives	2-Amino-4,6-Dinitrotoluene	mg/kg	5/ 66	8.30E-02	6.30E-02	5.70E-01		Yes	No Background Data Available
Explosives	4-Amino-2,6-Dinitrotoluene	mg/kg	6/ 66	7.00E-02	6.38E-02	4.30E-01		Yes	No Background Data Available
Explosives	HMX	mg/kg	2/ 66	1.00E-01	1.06E-01	4.60E-01		Yes	No Background Data Available
Explosives	Nitroglycerine	mg/kg	1/ 66	2.60E+01	5.32E+00	2.60E+01		Yes	No Background Data Available
Explosives	RDX	mg/kg	3/ 66	1.00E-01	1.11E-01	5.20E-01		Yes	No Background Data Available
Explosives	Tetryl	mg/kg	10/ 66	1.60E-01	5.98E-01	2.20E+01		Yes	No Background Data Available
Explosives	o-Nitrotoluene	mg/kg	1/ 66	4.30E-01	1.05E-01	4.30E-01		Yes	No Background Data Available
Inorganics	Aluminum	mg/kg	66/ 66	3.84E+03	1.01E+04	1.89E+04	1.95E+04	No	Below Background
Inorganics	Antimony	mg/kg	1/ 66	2.20E+00	2.15E-01	2.20E+00	9.60E-01	No	<= 5% Detects
Inorganics	Arsenic	mg/kg	66/ 66	4.50E+00	1.34E+01	3.26E+01	1.98E+01	Yes	Above Background
Inorganics	Barium	mg/kg	66/ 66	1.66E+01	7.89E+01	7.00E+02	1.24E+02	Yes	Above Background
Inorganics	Beryllium	mg/kg	66/ 66	2.40E-01	5.70E-01	1.20E+00	8.80E-01	Yes	Above Background
Inorganics	Cadmium	mg/kg	64/ 66	1.10E-01	8.18E-01	4.70E+00		Yes	No Background Data Available
Inorganics	Calcium[b]	mg/kg	66/ 66	1.17E+02	2.67E+03	2.80E+04	3.55E+04	No	Essential Element
Inorganics	Chromium	mg/kg	66/ 66	5.10E+00	1.39E+01	2.46E+01	2.72E+01	No	Below Background
Inorganics	Chromium, Hexavalent	mg/kg	2/ 7	1.60E+01	7.23E+00	2.30E+01		Yes	No Background Data Available
Inorganics	Cobalt	mg/kg	66/ 66	3.60E+00	8.21E+00	1.51E+01	2.32E+01	No	Below Background
Inorganics	Copper	mg/kg	66/ 66	5.20E+00	5.14E+01	4.45E+02	3.23E+01	Yes	Above Background
Inorganics	Iron[b]	mg/kg	66/ 66	9.55E+03	2.37E+04	4.58E+04	3.52E+04	No	Essential Element
Inorganics	Lead	mg/kg	66/ 66	5.30E+00	2.08E+01	1.47E+02	1.91E+01	Yes	Above Background
Inorganics	Magnesium[b]	mg/kg	66/ 66	8.25E+02	2.66E+03	1.10E+04	8.79E+03	No	Essential Element
Inorganics	Manganese	mg/kg	66/ 66	9.62E+01	4.50E+02	2.62E+03	3.03E+03	No	Below Background

Table 4-5. Summary Statistics and Determination of Site-Related Contaminations in Subsurface Soil Samples (continued)

Analysis Type	Analyte	Units	Frequency of Detection	Minimum Detect	Average Result[a]	Maximum Detect	Site Background Criteria	Site Related?	Justification
Inorganics	Mercury	mg/kg	31/ 66	6.00E-02	7.54E-01	1.81E+01	4.40E-02	Yes	Above Background
Inorganics	Nickel	mg/kg	66/ 66	6.00E+00	1.85E+01	5.64E+01	6.07E+01	No	Below Background
Inorganics	Nitrate/Nitrite	mg/kg	2/ 7	2.00E+00	1.44E+00	3.70E+00		Yes	No Background Data Available
Inorganics	Potassium[b]	mg/kg	66/ 66	2.90E+02	9.96E+02	1.99E+03	3.35E+03	No	Essential Element
Inorganics	Selenium	mg/kg	7/ 66	8.80E-01	3.43E-01	1.70E+00	1.50E+00	Yes	Above Background
Inorganics	Sodium[b]	mg/kg	5/ 66	5.94E+01	3.06E+01	1.59E+02	1.45E+02	No	Essential Element
Inorganics	Sulfide	mg/kg	7/ 7	5.00E+01	5.24E+02	1.90E+03		Yes	No Background Data Available
Inorganics	Vanadium	mg/kg	66/ 66	7.10E+00	1.70E+01	2.96E+01	3.76E+01	No	Below Background
Inorganics	Zinc	mg/kg	66/ 66	2.43E+01	1.44E+02	2.77E+03	9.33E+01	Yes	Above Background
Organic-Semivolatiles	bis(2-ethylhexyl) phthalate	mg/kg	5/ 7	1.90E-02	9.44E-02	1.30E-01		Yes	No Background Data Available
Organic-Semivolatiles	di-n-Butyl Phthalate	mg/kg	4/ 7	1.60E-01	2.20E-01	3.40E-01		Yes	No Background Data Available
Organic-Semivolatiles	n-Nitrosodiphenylamine	mg/kg	1/ 7	2.60E-02	1.71E-01	2.60E-02		Yes	No Background Data Available
Organic-Volatiles	2-Butanone	mg/kg	1/ 7	1.20E-02	6.71E-03	1.20E-02		Yes	No Background Data Available
Organic-Volatiles	Tetrachloroethylene	mg/kg	1/ 7	2.40E-03	2.80E-03	2.40E-03		Yes	No Background Data Available
Organic-Volatiles	Toluene	mg/kg	1/ 7	7.00E-03	3.50E-03	7.00E-03	3.40E-03	Yes	Above Background

[a] Values less than the detection limit were set to one-half of the reporting limit in calculation of the average.

[b] Eliminated as an SRC based on the essential element screen

Site Background Criteria was determined for the Winklepeck Burning Ground Phase II Remedial Investigation (USACE 2001c)

Table 4-6. SRC in Subsurface Soil Samples at ODA2

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2mw-104**	**DA2mw-105**	**DA2mw-106**	**DA2mw-107**	**DA2mw-108**
Sample ID			**DA2MW-104-0808-SO**	**DA2MW-105-0812-SO**	**DA2MW-106-0816-SO**	**DA2MW-107-0820-SO**	**DA2MW-108-0824-SO**
Date			**07/15/2002**	**07/15/2002**	**07/15/2002**	**07/18/2002**	**07/15/2002**
Depth (ft)			**2.0 - 4.0**	**2.0 - 4.0**	**2.0 - 4.0**	**2.0 - 4.0**	**2.0 - 4.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.058 J/J	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics							
Aluminum	MG/KG	19500	13000	11000	15900	8860	10300
Antimony	MG/KG	0.96	0.23 UN/UN	0.24 UN/UN	0.23 UN/UN	2.1 BN/U	0.47 BN/U
Arsenic	MG/KG	19.8	15.4	19.5 *N/*N	15.9 *N/*N	21.9 N/N#	9.8 *N/*N
Barium	MG/KG	124	81.4	80.7	77.3	68	52.9
Beryllium	MG/KG	0.88	0.74	0.62 */*	0.86 */*	0.49	0.78 */*
Cadmium	MG/KG		0.37 #	3.8 */*#	0.44 */*#	1.5 #	0.33 */*#
Calcium	MG/KG	35500	2300 N/N	1740 */*	2010 */*	19300 */*	590 */*
Chromium	MG/KG	27.2	20.2	15.2	21.1	13.3	20.6
Chromium, Hexavalent	MG/KG		4.4 U/U	NA	NA	NA	NA
Cobalt	MG/KG	23.2	9.8 *N/*N	9.4	13.8	8.1	13
Copper	MG/KG	32.3	23.3	67.3 N/N#	31.2 N/N	69 */*#	27.1 N/N
Iron	MG/KG	35200	28400	33200	30600	24900	30200
Lead	MG/KG	19.1	15.8	34.3 #	21.4 #	78.6 #	24.9 #
Magnesium	MG/KG	8790	3800	2770 *N/*N	3990 *N/*N	11000 #	2850 *N/*N
Manganese	MG/KG	3030	364	482 */*	509 */*	482	828 */*
Mercury	MG/KG	0.044	0.02 U/U	0.07 #	0.1 #	0.05 B/U	0.04 B/U
Nickel	MG/KG	60.7	29.6	21.6	29.3	19.6	26.8
Nitrate/Nitrite	MG/KG		1.7 U/U	NA	NA	NA	NA
Potassium	MG/KG	3350	1730 E/E	1240 N/N	1700 N/N	1270 N/N	1990 N/N
Selenium	MG/KG	1.5	0.23 U/U	0.24 U/U	0.23 U/U	1.1 U/U	0.45 U/U
Sodium	MG/KG	145	78.3	26.3 B/U	31.3 B/U	91.7 U/U	36.5 U/U
Sulfide	MG/KG		1900 #	NA	NA	NA	NA
Vanadium	MG/KG	37.6	21	19.5	24.9	15.6	18.2
Zinc	MG/KG	93.3	71.9	110 #	89.1	637 #	97.3 #
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/KG		0.13 J/J	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		0.37 U/U	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		0.37 U/U	NA	NA	NA	NA
Organic-Volatiles							
2-Butanone	MG/KG		0.012	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		0.0056 U/U	NA	NA	NA	NA
Toluene	MG/KG		0.0056 U/U	NA	NA	NA	NA

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2mw-109**	**DA2mw-110**	**DA2mw-111**	**DA2mw-112**	**DA2mw-113**
Sample ID			**DA2MW-109-0828-SO**	**DA2MW-110-0832-SO**	**DA2MW-111-0836-SO**	**DA2MW-112-0840-SO**	**DA2MW-113-0844-SO**
Date			**07/19/2002**	**07/25/2002**	**07/18/2002**	**07/25/2002**	**07/25/2002**
Depth (ft)			**2.0 - 4.0**	**2.0 - 4.0**	**2.0 - 4.0**	**4.0 - 6.0**	**2.0 - 4.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	1.3	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.06 J/J	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.57	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.38	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics							
Aluminum	MG/KG	19500	10300	9860	10300	3870	6360
Antimony	MG/KG	0.96	0.22 UN/UN	0.22 UN/UN	0.4 UN/UN	0.21 UN/UN	0.21 UN/UN
Arsenic	MG/KG	19.8	19.4	17.9	11 N/N	10.8	6.2
Barium	MG/KG	124	90.6	34.5	61.3	23.5	34.7
Beryllium	MG/KG	0.88	0.74	0.49	0.67	0.37	0.39
Cadmium	MG/KG		0.19 #	0.22 #	1.6 #	0.25 #	0.11 #
Calcium	MG/KG	35500	1110 N/N	264	977 */*	1280	490
Chromium	MG/KG	27.2	15.4	13.4	17.1	5.9	8
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA
Cobalt	MG/KG	23.2	12.1	8.5	11.2	6.4	4.5
Copper	MG/KG	32.3	22.9	18.9	202 */*#	9.3	7.6
Iron	MG/KG	35200	28600	24300	30800	14300	14200
Lead	MG/KG	19.1	31.9 #	30.6 #	28.5 #	11.5	9.3
Magnesium	MG/KG	8790	3140	2250	3050	916	1320
Manganese	MG/KG	3030	348	294	585	96.2	101
Mercury	MG/KG	0.044	0.02 U/U	0.02 B/U	4.4 #	0.06 B/U	0.03 B/U
Nickel	MG/KG	60.7	27.6	16.5	23.6	10.4	9.1
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA
Potassium	MG/KG	3350	1090 E/E	859 E/E	1460 N/N	432 E/E	471 N/N
Selenium	MG/KG	1.5	0.88	0.49 B/U	0.77 B/U	0.31 B/U	0.21 U/U
Sodium	MG/KG	145	45.7 B/U	46.4 B/U	32.3 U/U	47.8 B/U	24.3 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA
Vanadium	MG/KG	37.6	16.3	16.8	19.5	9.3	10.8 N/N
Zinc	MG/KG	93.3	67.8	54	193 #	36.5	40.3
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA
Organic-Volatiles							
2-Butanone	MG/KG		NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA
Toluene	MG/KG		NA	NA	NA	NA	NA

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-034**	**DA2so-035**	**DA2so-036**	**DA2so-037**	**DA2so-038**
Sample ID			**DA2SO-034-0650-SO**	**DA2SO-035-0652-SO**	**DA2SO-036-0654-SO**	**DA2SO-037-0656-SO**	**DA2SO-038-0658-SO**
Date			**07/25/2002**	**07/19/2002**	**07/15/2002**	**08/02/2002**	**07/25/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.2 J/J	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.43 J/J	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics							
Aluminum	MG/KG	19500	13600	17600	13100	8260	9990
Antimony	MG/KG	0.96	1.2 UN/UN	0.22 UN/UN	0.36 BN/U	0.49 UN/UN	0.22 UN/UN
Arsenic	MG/KG	19.8	13.6	10.6	32.6 *N/*N#	22.9 #	12.8
Barium	MG/KG	124	158 #	75.9	102	68.5	34.4
Beryllium	MG/KG	0.88	0.7	0.72	0.77 */*	0.76	0.43
Cadmium	MG/KG		0.5 #	0.41 #	0.4 */*#	0.35 #	0.14 #
Calcium	MG/KG	35500	1030	1360	1570 */*	1590	523
Chromium	MG/KG	27.2	17.2	22.3	19.1	11.6	13.1
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA
Cobalt	MG/KG	23.2	11.6	11.1	12.9	8.7	6.8
Copper	MG/KG	32.3	23.3	18.5	24 N/N	23.4	16.7
Iron	MG/KG	35200	27700	29100	33600	45800 */*#	21100
Lead	MG/KG	19.1	19.5 #	15.8	26.2 #	18.2	12.5
Magnesium	MG/KG	8790	3380	3760	3920 *N/*N	1840 N/N	2250
Manganese	MG/KG	3030	2020	565	389 */*	512	214
Mercury	MG/KG	0.044	0.19 #	0.05 B/U	0.02 B/U	0.05 B/U	0.03 B/U
Nickel	MG/KG	60.7	21.8	21.9	31.3	19	15.1
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA
Potassium	MG/KG	3350	1340 N/N	1430 N/N	1780 N/N	786 N/N	923 N/N
Selenium	MG/KG	1.5	1.2 U/U	1.2	0.23 U/U	0.82 B/U	0.22 U/U
Sodium	MG/KG	145	93.7 U/U	49.9 B/U	43.1 B/U	39.2 U/U	33 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA
Vanadium	MG/KG	37.6	22.7 N/N	29.6	22.3	18.6	16.3 N/N
Zinc	MG/KG	93.3	86.4	63	97.3 #	92	51.5
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA
Organic-Volatiles							
2-Butanone	MG/KG		NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA
Toluene	MG/KG		NA	NA	NA	NA	NA

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-039**	**DA2so-040**	**DA2so-041**	**DA2so-042**	**DA2so-043**
Sample ID			**DA2SO-039-0660-SO**	**DA2SO-040-0662-SO**	**DA2SO-041-0664-SO**	**DA2SO-042-0666-SO**	**DA2SO-043-0668-SO**
Date			**07/15/2002**	**07/25/2002**	**07/25/2002**	**07/15/2002**	**07/26/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics							
Aluminum	MG/KG	19500	14200	14300	13800	8430	10400
Antimony	MG/KG	0.96	0.26 UN/UN	0.25 UN/UN	0.23 UN/UN	0.2 UN/UN	1.2 UN/UN
Arsenic	MG/KG	19.8	23.5 *N/*N#	12.7	16.2	13.7 *N/*N	15.4
Barium	MG/KG	124	66.2	116	59.3	38.8	91.7
Beryllium	MG/KG	0.88	0.82 */*	0.79	0.77	0.52 */*	0.65
Cadmium	MG/KG		0.67 */*#	0.55 #	0.11 #	0.55 */*#	0.56 #
Calcium	MG/KG	35500	3170 */*	1910	1240	1280 */*	1470
Chromium	MG/KG	27.2	20	16.8	18.3	11.8	12.6
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA
Cobalt	MG/KG	23.2	15.1	9.8	11.1	7.4	9
Copper	MG/KG	32.3	30 N/N	19.9	27.3	25.6 N/N	14.9
Iron	MG/KG	35200	35100	26000	28000	20000	21400
Lead	MG/KG	19.1	17.6	16.6	16.2	11.6	16
Magnesium	MG/KG	8790	4460 *N/*N	2930	3320	2330 *N/*N	2050
Manganese	MG/KG	3030	515 */*	542	270	269 */*	2620
Mercury	MG/KG	0.044	0.2 #	0.06 B/U	0.02 U/U	0.05 B/U	0.09 #
Nickel	MG/KG	60.7	31.6	21.4	23.7	16.7	17.6
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA
Potassium	MG/KG	3350	1810 N/N	1050 N/N	1480 N/N	1050 N/N	817 N/N
Selenium	MG/KG	1.5	0.26 U/U	0.28 B/U	0.23 U/U	0.2 U/U	1.2 U/U
Sodium	MG/KG	145	45.2 B/U	47.5 B/U	40 B/U	28.5 B/U	99.6 U/U
Sulfide	MG/KG		NA	NA	NA	NA	NA
Vanadium	MG/KG	37.6	22.3	22.9 N/N	21.3 N/N	13.9	18.9
Zinc	MG/KG	93.3	87.5	74.6	68.6	62.2	73.9
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA
Organic-Volatiles							
2-Butanone	MG/KG		NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA
Toluene	MG/KG		NA	NA	NA	NA	NA

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-044**	**DA2so-045**	**DA2so-046**	**DA2so-047**	**DA2so-048**
Sample ID			**DA2SO-044-0670-SO**	**DA2SO-045-0672-SO**	**DA2SO-046-0674-SO**	**DA2SO-047-0676-SO**	**DA2SO-048-0678-SO**
Date			**07/24/2002**	**07/15/2002**	**07/25/2002**	**07/15/2002**	**07/15/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
2,4,6-Trinitrotoluene	MG/KG		0.057 J/J	0.18	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.086 J/J	0.1 U/U	0.083 J/J	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.081 J/J	0.1 U/U	0.07 J/J	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	26	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.52 J/J	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	1.4	2.1	0.2 U/U	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics							
Aluminum	MG/KG	19500	11200	11400	11400	9570	8020
Antimony	MG/KG	0.96	0.21 UN/UN	2 UN/UN	0.21 UN/UN	0.33 BN/U	0.39 BN/U
Arsenic	MG/KG	19.8	16	16.9 *N/*N	16.1	12.8 *N/*N	13.7 *N/*N
Barium	MG/KG	124	120	700 #	182 #	111	175 #
Beryllium	MG/KG	0.88	0.53	0.51 */*	0.58	0.47 */*	0.43 */*
Cadmium	MG/KG		3.5 #	4.7 */*#	1.8 #	1.7 */*#	1.5 */*#
Calcium	MG/KG	35500	1900	14300 */*	4510	1040 */*	1530 */*
Chromium	MG/KG	27.2	15.4	17	16.1	13.5	12.6
Chromium, Hexavalent	MG/KG		4.7 U/U	NA	NA	NA	NA
Cobalt	MG/KG	23.2	9.6	9.5	10.1	8.4	8.4
Copper	MG/KG	32.3	85.8 */*#	87.8 N/N#	85.4 #	50.2 N/N#	57 N/N#
Iron	MG/KG	35200	25500	26100	26700	20200	21000
Lead	MG/KG	19.1	41.7 *N/*N#	45.3 #	25.1 #	22.6 #	22.8 #
Magnesium	MG/KG	8790	2640	3290 *N/*N	3730	2300 *N/*N	2250 *N/*N
Manganese	MG/KG	3030	453	393 */*	398	355 */*	373 */*
Mercury	MG/KG	0.044	0.15 #	0.14 *N/*N#	0.24 #	0.16 #	0.14 *N/*N#
Nickel	MG/KG	60.7	18.6	22.3	23.4	17.5	17.8
Nitrate/Nitrite	MG/KG		3.7 #	NA	NA	NA	NA
Potassium	MG/KG	3350	1140 N/N	1120 N/N	1320 N/N	1050 N/N	947 N/N
Selenium	MG/KG	1.5	1.3	2 U/U	0.21 U/U	0.23 U/U	0.23 U/U
Sodium	MG/KG	145	51.8 B/U	163 U/U	56.2 B/U	29.8 B/U	22.4 B/U
Sulfide	MG/KG		76 #	NA	NA	NA	NA
Vanadium	MG/KG	37.6	18.7	18.2	18.7 N/N	16.5	14.5
Zinc	MG/KG	93.3	119 NE/NE#	2770 #	148 #	91.8	78.7
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/KG		0.024 J/J	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		0.34 J/J	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		0.4 U/U	NA	NA	NA	NA
Organic-Volatiles							
2-Butanone	MG/KG		0.012 U/U	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		0.0059 U/U	NA	NA	NA	NA
Toluene	MG/KG		0.0059 U/U	NA	NA	NA	NA

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-049**	**DA2so-050**	**DA2so-051**	**DA2so-052**	**DA2so-053**
Sample ID			**DA2SO-049-0680-SO**	**DA2SO-050-0682-SO**	**DA2SO-051-0684-SO**	**DA2SO-052-0686-SO**	**DA2SO-053-0688-SO**
Date			**08/01/2002**	**08/01/2002**	**08/01/2002**	**08/01/2002**	**08/01/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.23
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.14
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.63
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics							
Aluminum	MG/KG	19500	5350	9090	3840	7970	7480
Antimony	MG/KG	0.96	0.24 UN/UN	0.47 UN/UN	0.22 UN/UN	0.25 UN/UN	0.21 UN/UN
Arsenic	MG/KG	19.8	6.6	10	4.5	8.5	14
Barium	MG/KG	124	28.8	78.3	16.6	51.6	53.4
Beryllium	MG/KG	0.88	0.33	0.54	0.24	0.45	0.42
Cadmium	MG/KG		0.15 #	0.29 #	0.13 #	0.35 #	1.8 #
Calcium	MG/KG	35500	605	1240	395	1140	621
Chromium	MG/KG	27.2	6.6	12	5.1	11.2	10.5
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA
Cobalt	MG/KG	23.2	4.6	7.6	3.6	6.1	7.7
Copper	MG/KG	32.3	6.4	13.6	5.2	22.7	186 #
Iron	MG/KG	35200	11200 */*	19100 */*	9550 */*	17300	21100 */*
Lead	MG/KG	19.1	6.6	14.8	5.3	10.8	36.7 #
Magnesium	MG/KG	8790	976 N/N	1820 N/N	825 N/N	1800 N/N	2410 N/N
Manganese	MG/KG	3030	198	875	225	351	397
Mercury	MG/KG	0.044	0.02 B/U	0.06 #	0.02 U/U	0.16 #	3.7 #
Nickel	MG/KG	60.7	7.8	14.4	6	12.6	16.8
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA
Potassium	MG/KG	3350	349 N/N	657 N/N	290 N/N	538 N/N	865 N/N
Selenium	MG/KG	1.5	0.24 U/U	0.47 U/U	0.25 B/U	0.28 B/U	0.21 U/U
Sodium	MG/KG	145	35.9 B/U	60.7 B/U	32.1 B/U	58.6 B/U	31.9 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA
Vanadium	MG/KG	37.6	9.4	17.4	7.1	13.5	12.9
Zinc	MG/KG	93.3	29.3	70.9	24.3	87.4	290 #
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA
Organic-Volatiles							
2-Butanone	MG/KG		NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA
Toluene	MG/KG		NA	NA	NA	NA	NA

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-054**	**DA2so-055**	**DA2so-056**	**DA2so-057**	**DA2so-058**
Sample ID			**DA2SO-054-0690-SO**	**DA2SO-055-0692-SO**	**DA2SO-056-0694-SO**	**DA2SO-057-0696-SO**	**DA2SO-058-0698-SO**
Date			**07/31/2002**	**07/31/2002**	**07/31/2002**	**07/29/2002**	**07/25/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics							
Aluminum	MG/KG	19500	7080	8640	9980	13100	14300
Antimony	MG/KG	0.96	0.23 UN/UN	0.47 UN/UN	0.21 UN/UN	0.23 UN/UN	0.22 UN/UN
Arsenic	MG/KG	19.8	8.3	26.4 #	18	18.5	13.8
Barium	MG/KG	124	62.5	80.7	35.2	55.1	43.2
Beryllium	MG/KG	0.88	0.41	0.51	0.49	0.67	0.54
Cadmium	MG/KG		0.55 */*#	0.18 */*#	0.36 */*#	0.27 #	0.05 B/U
Calcium	MG/KG	35500	1630	1060	859	599	765
Chromium	MG/KG	27.2	9.4	12.6	13.2	16.6	18.5
Chromium, Hexavalent	MG/KG		NA	NA	4.6 U/U	NA	NA
Cobalt	MG/KG	23.2	5.4	6.6	6.4	12.5	5.4
Copper	MG/KG	32.3	75.1 */*#	20.1 */*	16.8 */*	24.6	19.7
Iron	MG/KG	35200	16100	28400	25500	30300	28000
Lead	MG/KG	19.1	14.8	16.1	14.8	16.1	12.5
Magnesium	MG/KG	8790	1520	1830	1850	2770 N/N	3030
Manganese	MG/KG	3030	380	861	300	469	177
Mercury	MG/KG	0.044	1.5 #	0.04 B/U	0.04 B/U	0.03 B/U	0.03 B/U
Nickel	MG/KG	60.7	11.5	18.3	13.5	18.9	15.8
Nitrate/Nitrite	MG/KG		NA	NA	1.7 U/U	NA	NA
Potassium	MG/KG	3350	559 E/E	826 E/E	790 E/E	995 N/N	1130 N/N
Selenium	MG/KG	1.5	0.23 U/U	0.59 B/U	0.55 B/U	0.29 B/U	0.3 B/U
Sodium	MG/KG	145	56.6 B/U	38 B/U	43.1 B/U	41.8 B/U	37.9 B/U
Sulfide	MG/KG		NA	NA	77 #	NA	NA
Vanadium	MG/KG	37.6	12.5	17.4	18.2	24.1	28 N/N
Zinc	MG/KG	93.3	114 N*/N*#	73 N*/N*	51.7 N*/N*	62.1	44.1
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	0.39 U/U	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	0.39 U/U	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	0.39 U/U	NA	NA
Organic-Volatiles							
2-Butanone	MG/KG		NA	NA	0.012 U/U	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	0.0058 U/U	NA	NA
Toluene	MG/KG		NA	NA	0.0058 U/U	NA	NA

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-059**	**DA2so-060**	**DA2so-061**	**DA2so-062**	**DA2so-063**
Sample ID			**DA2SO-059-0700-SO**	**DA2SO-060-0702-SO**	**DA2SO-061-0704-SO**	**DA2SO-062-0706-SO**	**DA2SO-063-0708-SO**
Date			**07/25/2002**	**07/29/2002**	**07/29/2002**	**07/31/2002**	**07/30/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics							
Aluminum	MG/KG	19500	15700	13700	16700	5750	4450
Antimony	MG/KG	0.96	0.24 UN/UN	0.27 UN/UN	0.22 UN/UN	0.22 UN/UN	0.27 UN/UN
Arsenic	MG/KG	19.8	20.6 #	15	15.6	6.5	23.9 #
Barium	MG/KG	124	72	44.4	75.5	43.3	28.5
Beryllium	MG/KG	0.88	0.85	0.6	0.87	0.38	0.67
Cadmium	MG/KG		0.36 #	0.22 #	0.33 #	0.28 */*#	0.56 #
Calcium	MG/KG	35500	875	375	1320	902	1000
Chromium	MG/KG	27.2	20.5	17.7	22	7.9	8.6
Chromium, Hexavalent	MG/KG		4.6 U/U	NA	NA	NA	NA
Cobalt	MG/KG	23.2	10.6	9.3	11.3	5.3	6.1
Copper	MG/KG	32.3	24.7 */*	19.5	22.6	8.4 */*	13.7
Iron	MG/KG	35200	33900	26600	30900	14100	40800 #
Lead	MG/KG	19.1	16.9 *N/*N	12.4	13.3	7.9	13.8
Magnesium	MG/KG	8790	3560	2930 N/N	4310 N/N	1360	1160 N/N
Manganese	MG/KG	3030	234	179	233	378	512
Mercury	MG/KG	0.044	0.02 B/U	0.02 U/U	0.02 U/U	0.03 B/U	0.03 B/U
Nickel	MG/KG	60.7	25.9	20.6	29.7	10.4	12.4
Nitrate/Nitrite	MG/KG		2 #	NA	NA	NA	NA
Potassium	MG/KG	3350	1620 N/N	1310 N/N	1860 N/N	468 E/E	480 N/N
Selenium	MG/KG	1.5	1.7 #	0.27 B/U	0.22 U/U	0.41 B/U	0.43 B/U
Sodium	MG/KG	145	41.4 B/U	59.9 B/U	62.5 B/U	49.8 B/U	44.5 B/U
Sulfide	MG/KG		50 J/J#	NA	NA	NA	NA
Vanadium	MG/KG	37.6	25.2	20.7	25.4	10.2	16
Zinc	MG/KG	93.3	71.2 NE/NE	59.3	69.4	37.2 N*/N*	54.2
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/KG		0.021 J/J	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		0.16 J/J	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		0.39 U/U	NA	NA	NA	NA
Organic-Volatiles							
2-Butanone	MG/KG		0.012 U/U	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		0.0058 U/U	NA	NA	NA	NA
Toluene	MG/KG		0.0058 U/U	NA	NA	NA	NA

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-064**	**DA2so-065**	**DA2so-066**	**DA2so-067**	**DA2so-068**
Sample ID			**DA2SO-064-0710-SO**	**DA2SO-065-0712-SO**	**DA2SO-066-0714-SO**	**DA2SO-067-0716-SO**	**DA2SO-068-0718-SO**
Date			**07/30/2002**	**07/29/2002**	**07/29/2002**	**07/19/2002**	**07/19/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.071 J/J	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.062 J/J	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.43	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.46	0.1 J/J
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics							
Aluminum	MG/KG	19500	5190	8760	5180	11300	6580
Antimony	MG/KG	0.96	0.27 UN/UN	0.24 UN/UN	0.24 UN/UN	1.2 UN/UN	0.22 UN/UN
Arsenic	MG/KG	19.8	7.1	6.6	8.2	11.7	11.5
Barium	MG/KG	124	38.9	42.6	35.5	120	85.2
Beryllium	MG/KG	0.88	0.36	0.43	0.43	0.75	0.52
Cadmium	MG/KG		0.27 #	0.42 #	0.27 #	0.86 #	1.1 #
Calcium	MG/KG	35500	812	219	584	7660	5730
Chromium	MG/KG	27.2	7.4	10.6	7.2	15.4	12.8
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	16 #
Cobalt	MG/KG	23.2	5.9	6.4	5.1	9.2	5.8
Copper	MG/KG	32.3	17.1	11.8	9.2	217 #	98.1 #
Iron	MG/KG	35200	12000	15000	15400	22700	28700
Lead	MG/KG	19.1	8.5	11.6	8.9	20.5 #	19.8 #
Magnesium	MG/KG	8790	1250 N/N	1620	1160 N/N	2690	1870
Manganese	MG/KG	3030	123	174	186	2530	410
Mercury	MG/KG	0.044	0.25 #	0.16 #	0.06 B/U	0.85 #	1 #
Nickel	MG/KG	60.7	11.8	11	11.2	14.4	15.1
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	1.6 U/U
Potassium	MG/KG	3350	489 N/N	507 N/N	434 N/N	749 N/N	649 N/N
Selenium	MG/KG	1.5	0.27 U/U	0.32 B/U	0.27 B/U	2 B/U	1.2
Sodium	MG/KG	145	70.5 B/U	60.4 B/U	57.9 B/U	92.5 U/U	72.2
Sulfide	MG/KG		NA	NA	NA	NA	72 #
Vanadium	MG/KG	37.6	9.8	14.5	9.8	16.8	11.4
Zinc	MG/KG	93.3	55.8	49.5	41.4	195 #	164 #
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	0.38 U/U
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	0.38 U/U
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	0.38 U/U
Organic-Volatiles							
2-Butanone	MG/KG		NA	NA	NA	NA	0.011 U/U
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	0.0056 U/U
Toluene	MG/KG		NA	NA	NA	NA	0.007

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-069**	**DA2so-070**	**DA2so-071**	**DA2so-072**	**DA2so-073**	**DA2so-074**
Sample ID			**DA2SO-069-0720-SO**	**DA2SO-070-0722-SO**	**DA2SO-071-0724-SO**	**DA2SO-072-0726-SO**	**DA2SO-073-0728-SO**	**DA2SO-074-0730-SO**
Date			**07/29/2002**	**07/29/2002**	**07/30/2002**	**07/19/2002**	**07/19/2002**	**07/24/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**						
Explosives								
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.051 J/J	0.053 J/J	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.41 J/J	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	2.3	22	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics								
Aluminum	MG/KG	19500	5360	6950	9940	7720	9090	9890
Antimony	MG/KG	0.96	0.23 UN/UN	0.24 UN/UN	0.24 UN/UN	0.45 UN/UN	2.2 N/N#	0.64 BN/U
Arsenic	MG/KG	19.8	7.1	9.8	4.9	13.4	13.7	6.7
Barium	MG/KG	124	41.4	29.9	75.3	110	123	53
Beryllium	MG/KG	0.88	0.32	0.43	0.6	0.42	0.5	0.39
Cadmium	MG/KG		0.45 #	0.39 #	0.26 #	3.3 #	3 #	0.79 #
Calcium	MG/KG	35500	1120	279	676	2000	2240	998
Chromium	MG/KG	27.2	7	9	11.7	12.1	12.7	12.1
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA	4.9 U/U
Cobalt	MG/KG	23.2	5.4	6.7	4.6	7.5	7.8	5.1
Copper	MG/KG	32.3	24.4	17	8.6	206 #	445 #	40.2 */*#
Iron	MG/KG	35200	15500	17200	13400	22900	23400	14900
Lead	MG/KG	19.1	10	10.5	9.9	41.9 #	147 #	22.6 *N/*N#
Magnesium	MG/KG	8790	1210	1310	1890 N/N	2200	2390	1720
Manganese	MG/KG	3030	317	267	162	473	469	160
Mercury	MG/KG	0.044	0.39 #	0.05 B/U	0.04 B/U	18.1 #	14.4 #	0.98 #
Nickel	MG/KG	60.7	10.2	10.6	12.7	17.7	18.5	10.9
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA	1.8 U/U
Potassium	MG/KG	3350	475 N/N	467 N/N	636 N/N	747 N/N	987 N/N	627 N/N
Selenium	MG/KG	1.5	0.23 U/U	0.41 B/U	0.24 U/U	1.5 B/U	1.4 B/U	0.83 B/U
Sodium	MG/KG	145	61.2 B/U	51.1 B/U	62.3 B/U	72 B/U	37.8 B/U	53 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA	530 #
Vanadium	MG/KG	37.6	9.4	12.9	14.4	14.1	15.3	16.1
Zinc	MG/KG	93.3	59.3	46.5	51.1	422 #	335 #	330 NE/NE#
Organic-Semivolatiles								
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA	0.082 J/J
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA	0.16 J/J
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA	0.41 U/U
Organic-Volatiles								
2-Butanone	MG/KG		NA	NA	NA	NA	NA	0.012 U/U
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA	0.0024 J/J
Toluene	MG/KG		NA	NA	NA	NA	NA	0.0062 U/U

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-075**	**DA2so-076**	**DA2so-077**	**DA2so-078**	**DA2so-079**	**DA2so-080**
Sample ID			**DA2SO-075-0732-SO**	**DA2SO-076-0734-SO**	**DA2SO-077-0736-SO**	**DA2SO-078-0738-SO**	**DA2SO-079-0740-SO**	**DA2SO-080-0742-SO**
Date			**07/30/2002**	**07/30/2002**	**07/19/2002**	**07/19/2002**	**07/19/2002**	**07/19/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**						
Explosives								
2,4,6-Trinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.051 J/J	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.26	0.41	4.4	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics								
Aluminum	MG/KG	19500	7860	6230	6260	8200	8920	9370
Antimony	MG/KG	0.96	0.23 UN/UN	0.22 UN/UN	0.24 UN/UN	0.25 UN/UN	0.36 BN/U	0.21 UN/UN
Arsenic	MG/KG	19.8	6.4	9.4	7.5	8	12.7	7.9
Barium	MG/KG	124	33	39.3	52.4	53.3	65.1	48
Beryllium	MG/KG	0.88	0.41	0.49	0.38	0.48	0.51	0.46
Cadmium	MG/KG		0.34 #	0.32 #	0.49 #	0.33 #	2 #	0.29 #
Calcium	MG/KG	35500	228	1070	1270	1320	1950	590
Chromium	MG/KG	27.2	9.2	10.3	8.5	10.4	12.2	11.1
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA	NA
Cobalt	MG/KG	23.2	6.7	7.8	5.3	6.4	8.2	5.9
Copper	MG/KG	32.3	12.4	18.2	145 #	16.6	53.3 #	13.9
Iron	MG/KG	35200	15500	18400	15400	17400	25700	17200
Lead	MG/KG	19.1	9.3	11.9	10.6	10.2	21.5 #	11.2
Magnesium	MG/KG	8790	1450	1860 N/N	1430	1780	2280	1710
Manganese	MG/KG	3030	144	327	389	336	482	164
Mercury	MG/KG	0.044	0.05 B/U	0.08 #	0.28 #	0.14 #	0.42 #	0.04 B/U
Nickel	MG/KG	60.7	11.5	15.8	11.4	12.3	17	11.1
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA	NA
Potassium	MG/KG	3350	473 N/N	895 N/N	559 N/N	565 N/N	889 N/N	549 N/N
Selenium	MG/KG	1.5	0.26 B/U	0.25 B/U	0.52 B/U	0.76 B/U	1.1	0.73 B/U
Sodium	MG/KG	145	49.2 B/U	63.1 B/U	58.6 B/U	52.3 B/U	60.2 B/U	59 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA	NA
Vanadium	MG/KG	37.6	12.8	10.9	11.4	13.8	15.6	15
Zinc	MG/KG	93.3	51.6	64	68.7	58.1	97.8 #	50.5
Organic-Semivolatiles								
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA	NA	NA
Organic-Volatiles								
2-Butanone	MG/KG		NA	NA	NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA	NA	NA
Toluene	MG/KG		NA	NA	NA	NA	NA	NA

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-081**	**DA2so-082**	**DA2so-083**	**DA2so-084**	**DA2so-085**
Sample ID			**DA2SO-081-0744-SO**	**DA2SO-082-0746-SO**	**DA2SO-083-0748-SO**	**DA2SO-084-0750-SO**	**DA2SO-085-0752-SO**
Date			**07/30/2002**	**08/01/2002**	**07/25/2002**	**07/18/2002**	**07/18/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
2,4,6-Trinitrotoluene	MG/KG		0.04 J/J	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.1 J/J	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.16 J/J	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics							
Aluminum	MG/KG	19500	6430	9120	18900	14500	12700
Antimony	MG/KG	0.96	0.21 UN/UN	0.24 UN/UN	0.42 UN/UN	0.23 UN/UN	0.2 UN/UN
Arsenic	MG/KG	19.8	7.6	8.5	15.9	15.3 N/N	16.3 N/N
Barium	MG/KG	124	41.9	27.7	60.4	97.4	69.7
Beryllium	MG/KG	0.88	0.39	0.45	0.75	1.2 #	0.68
Cadmium	MG/KG		0.58 #	0.14 #	0.1 B/U	1.9 #	1.7 #
Calcium	MG/KG	35500	1690	117	700	28000 */*	20600 */*
Chromium	MG/KG	27.2	9.6	11.4	24.6	22.3	17.3
Chromium, Hexavalent	MG/KG		NA	NA	NA	23 #	NA
Cobalt	MG/KG	23.2	5.8	3.9	8.7	8.9	9.9
Copper	MG/KG	32.3	55.9 #	9.8	24.2	106 */*#	75.6 */*#
Iron	MG/KG	35200	14200	19300 */*	36800 #	25400	28200
Lead	MG/KG	19.1	23.4 #	10.5	15.3	25.7 #	20.3 #
Magnesium	MG/KG	8790	1590	1480 N/N	3900	7690	4500
Manganese	MG/KG	3030	161	109	191	679	381
Mercury	MG/KG	0.044	0.3 #	0.04 B/U	0.03 B/U	0.17 #	0.15 #
Nickel	MG/KG	60.7	12.4	10.3	24.8	56.4	24.9
Nitrate/Nitrite	MG/KG		NA	NA	NA	1.9 U/U	NA
Potassium	MG/KG	3350	666 N/N	649 N/N	1720 N/N	1490 N/N	1830 N/N
Selenium	MG/KG	1.5	0.25 B/U	0.41 B/U	0.42 U/U	0.39 B/U	0.23 B/U
Sodium	MG/KG	145	59.7 B/U	32.8 B/U	33.9 U/U	159 #	59.4
Sulfide	MG/KG		NA	NA	NA	960 #	NA
Vanadium	MG/KG	37.6	11.7	15.5	29.1 N/N	16.6	19.5
Zinc	MG/KG	93.3	58.8	44.2	64.8	167 #	170 #
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	0.019 J/J	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	0.31 J/J	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	0.026 J/J	NA
Organic-Volatiles							
2-Butanone	MG/KG		NA	NA	NA	0.011 U/U	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	0.0057 U/U	NA
Toluene	MG/KG		NA	NA	NA	0.0057 U/U	NA

Table 4-6. SRC in Subsurface Soil Samples at ODA2 (continued)

Media			**Soil**	**Soil**	**Soil**	**Soil**
Location			**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2so-086**	**DA2so-092**	**DA2so-093**	**DA2so-114**
Sample ID			**DA2SO-086-0754-SO**	**DA2SO-092-0766-SO**	**DA2SO-093-0768-SO**	**DA2SO-114-0871-SO**
Date			**07/24/2002**	**08/05/2002**	**08/05/2002**	**08/05/2002**
Depth (ft)			**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**	**1.0 - 3.0**
Filtered			**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**				
Explosives						
2,4,6-Trinitrotoluene	MG/KG		0.052 J/J	0.1 U/U	0.1 U/U	0.1 U/U
2,4-Dinitrotoluene	MG/KG		0.1 U/U	0.1 U/U	0.1 U/U	0.1 U/U
2-Amino-4,6-Dinitrotoluene	MG/KG		0.14	0.1 U/U	0.1 U/U	0.1 U/U
4-Amino-2,6-Dinitrotoluene	MG/KG		0.11 J/J	0.1 U/U	0.1 U/U	0.1 U/U
HMX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Nitroglycerine	MG/KG		10 U/U	10 U/U	10 U/U	10 U/U
RDX	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Tetryl	MG/KG		0.18 J/J	0.2 U/U	0.2 U/U	0.2 U/U
o-Nitrotoluene	MG/KG		0.2 U/U	0.2 U/U	0.2 U/U	0.2 U/U
Inorganics						
Aluminum	MG/KG	19500	10000	18000	16200	9540
Antimony	MG/KG	0.96	0.2 UN/UN	0.22 UN/UN	0.24 UN/UN	0.22 UN/UN
Arsenic	MG/KG	19.8	15.3	12.2	14.3	15.4
Barium	MG/KG	124	203 #	73.4	73.6	41.1
Beryllium	MG/KG	0.88	0.56	0.85	0.79	0.5
Cadmium	MG/KG		1.9 #	0.25 #	0.3 #	0.18 #
Calcium	MG/KG	35500	10700	1700	1090	664
Chromium	MG/KG	27.2	14	23.4	21.6	13.2
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA
Cobalt	MG/KG	23.2	8.5	10	13	8.3
Copper	MG/KG	32.3	152 */*#	23.3	21.3	21
Iron	MG/KG	35200	24200	30900 */*	30800 */*	23600 */*
Lead	MG/KG	19.1	29.3 *N/*N#	12.4	12.7	12
Magnesium	MG/KG	8790	4190	4640 N/N	3650 N/N	2540 N/N
Manganese	MG/KG	3030	416	204	368	354
Mercury	MG/KG	0.044	0.21 #	0.02 B/U	0.03 B/U	0.02 U/U
Nickel	MG/KG	60.7	20.1	29.4	27.9	20.2
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA
Potassium	MG/KG	3350	1370 N/N	1710 N/N	1490 N/N	1120 N/N
Selenium	MG/KG	1.5	1	0.22 U/U	0.28 B/U	0.22 U/U
Sodium	MG/KG	145	86.8	45.1 B/U	42 B/U	35.6 B/U
Sulfide	MG/KG		NA	NA	NA	NA
Vanadium	MG/KG	37.6	16.2	26.6	25.4	14.1
Zinc	MG/KG	93.3	154 NE/NE#	64.6	58.7	58
Organic-Semivolatiles						
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA
n-Nitrosodiphenylamine	MG/KG		NA	NA	NA	NA
Organic-Volatiles						
2-Butanone	MG/KG		NA	NA	NA	NA
Tetrachloroethylene	MG/KG		NA	NA	NA	NA
Toluene	MG/KG		NA	NA	NA	NA

Note: Data Qaulifiers are presented as Laboratory qualifiers/Validation qualifiers
- value above facility wide background
= - analyte present and concentration accurate.
J - estimated value less than reporting limits.
U - Not detected
N - Matrix spike recovery outside control limits
* - Duplicate analysis outside control limits.
E - Result estimated because of the presence of interference
P - greater than 25% difference between two GC columns
B - for organics-compound was detected in the blank as well as the sample
NA – not analyzed
B - for inorganics-result was less than the contract required detection limit but greater than the instrument detection limit.
Facility wide background was determined for the Winklepeck Burning Ground Phase II Remedial Investigation (USACE 2001c)

Table 4-7. Summary Statistics and Determination of Site-Related Contaminations in Sediment Samples

Analysis Type	Analyte	Units	Results >Detection Limit	Average Result[a]	Minimum Detect	Maximum Detect	Site Background Criteria	Max Detect > Bkg	Site Related?
	Total Organic Carbon	mg/kg	5/ 5	1.87E+04	2.60E+03	3.90E+04		Yes	Yes
Explosives	Nitrocellulose	mg/kg	1/ 10	1.38E+01	2.90E+01	2.90E+01		Yes	Yes
Metals	Aluminum	mg/kg	15/ 15	6.59E+03	1.33E+03	1.73E+04	1.39E+04	Yes	Yes
Metals	Arsenic	mg/kg	15/ 15	9.75E+00	3.00E+00	1.81E+01	1.95E+01	No	No
Metals	Barium	mg/kg	15/ 15	6.55E+01	7.90E+00	3.17E+02	1.23E+02	Yes	Yes
Metals	Beryllium	mg/kg	15/ 15	4.72E-01	1.20E-01	1.20E+00	3.80E-01	Yes	Yes
Metals	Cadmium	mg/kg	15/ 15	7.39E-01	1.00E-01	2.30E+00		Yes	Yes
Metals	Calcium[b]	mg/kg	15/ 15	1.97E+03	5.22E+02	5.35E+03	5.51E+03	No	No
Metals	Chromium	mg/kg	15/ 15	9.22E+00	2.10E+00	1.94E+01	1.81E+01	Yes	Yes
Metals	Chromium, Hexavalent	mg/kg	1/ 10	2.20E+00	6.10E+00	6.10E+00		Yes	Yes
Metals	Cobalt	mg/kg	15/ 15	5.93E+00	1.80E+00	1.05E+01	9.10E+00	Yes	Yes
Metals	Copper	mg/kg	15/ 15	2.40E+01	2.90E+00	6.23E+01	2.76E+01	Yes	Yes
Metals	Iron[b]	mg/kg	15/ 15	1.75E+04	4.81E+03	3.01E+04	2.82E+04	Yes	No
Metals	Lead	mg/kg	15/ 15	1.41E+01	3.00E+00	3.13E+01	2.74E+01	Yes	Yes
Metals	Magnesium[b]	mg/kg	15/ 15	1.78E+03	5.42E+02	3.85E+03	2.76E+03	Yes	No
Metals	Manganese	mg/kg	15/ 15	4.32E+02	1.03E+02	1.47E+03	1.95E+03	No	No
Metals	Mercury	mg/kg	8/ 15	8.80E-02	5.00E-02	3.70E-01	5.90E-02	Yes	Yes
Metals	Nickel	mg/kg	15/ 15	1.39E+01	3.40E+00	2.52E+01	1.77E+01	Yes	Yes
Metals	Nitrate/Nitrite	mg/kg	4/ 10	2.68E+00	3.20E+00	9.10E+00		Yes	Yes
Metals	Potassium[b]	mg/kg	15/ 15	7.61E+02	2.19E+02	1.54E+03	1.95E+03	No	No
Metals	Sodium[b]	mg/kg	2/ 15	3.73E+01	7.66E+01	9.27E+01	1.12E+02	No	No
Metals	Sulfide	mg/kg	9/ 10	3.63E+02	7.50E+01	1.10E+03		Yes	Yes
Metals	Vanadium	mg/kg	15/ 15	1.23E+01	2.90E+00	3.09E+01	2.61E+01	Yes	Yes
Metals	Zinc	mg/kg	15/ 15	7.89E+01	1.43E+01	2.12E+02	5.32E+02	No	No
Organics-Pesticide/PCB	Dieldrin	mg/kg	1/ 10	1.13E-03	6.40E-04	6.40E-04		Yes	Yes

Table 4-7. Summary Statistics and Determination of Site-Related Contaminations in Sediment Samples (continued)

Analysis Type	Analyte	Units	Results >Detection Limit	Average Result[a]	Minimum Detect	Maximum Detect	Site Background Criteria	Max Detect > Bkg	Site Related?
Organics-Semivolatile	Fluoranthene	mg/kg	1/ 10	2.23E-01	1.20E-01	1.20E-01		Yes	Yes
Organics-Semivolatile	bis(2-ethylhexyl) phthalate	mg/kg	1/ 10	2.11E-01	3.20E-02	3.20E-02		Yes	Yes
Organics-Semivolatile	di-n-Butyl Phthalate	mg/kg	3/ 10	2.09E-01	8.40E-02	2.00E-01		Yes	Yes
Organics-Volatile	2-Butanone	mg/kg	2/ 10	7.74E-03	7.90E-03	1.60E-02		Yes	Yes
Organics-Volatile	Chloromethane	mg/kg	1/ 10	6.75E-03	4.00E-03	4.00E-03		Yes	Yes
Organics-Volatile	Trichloroethene	mg/kg	1/ 3	3.88E-03	3.80E-03	3.80E-03		Yes	Yes

[a] Values less than the detection limit were set to one-half of the reporting limit in calculation of the average.

[b] Eliminated as an SRC based on the essential element screen

Site Background Criteria was determined for the Winklepeck Burning Ground Phase II Remedial Investigation (USACE 2001c)

Table 4-8. SRC in Sediment Samples at ODA2

Media			**Sediment**	**Sediment**	**Sediment**	**Sediment**	**Sediment**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2sd-087**	**DA2sd-088**	**DA2sd-089**	**DA2sd-090**	**DA2sd-091**
Sample ID			**DA2SD-087-0755-SD**	**DA2SD-088-0757-SD**	**DA2SD-089-0759-SD**	**DA2SD-090-0761-SD**	**DA2SD-091-0763-SD**
Date			**07/26/2002**	**07/26/2002**	**08/01/2002**	**08/01/2002**	**08/02/2002**
Depth (ft)			**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
Nitrocellulose	MG/KG		NA	NA	NA	NA	NA
Inorganics							
Aluminum	MG/KG	13900	8650	8410	6760	2810	8560
Arsenic	MG/KG	19.5	18.1	12.7	8.6	5.5	7.4
Barium	MG/KG	123	89.9	60.1	39.8	22.1	72.8
Beryllium	MG/KG	0.38	0.67 #	0.49 #	0.57 #	0.24	0.54 #
Cadmium	MG/KG	0	1.2 #	0.65 #	1.1 #	0.2 #	1.8 #
Calcium	MG/KG	5510	1900	1900	5350	1200	1890
Chromium	MG/KG	18.1	11.6	10.8	11.7	4.5	11.8
Chromium, Hexavalent	MG/KG		NA	NA	NA	NA	NA
Cobalt	MG/KG	9.1	8.3	6.8	8.7	3.5	6.5
Copper	MG/KG	27.6	29.4 #	19.1	52.7 #	11.3	62.3 #
Iron	MG/KG	28200	30100 #	16700	22000	10400	17300 */*
Lead	MG/KG	27.4	19.5	13.3	30.8 #	7.2	17.5
Magnesium	MG/KG	2760	1960 N/N	2030	2530 N/N	951 N/N	1920 N/N
Manganese	MG/KG	1950	595	135	356	282	246
Mercury	MG/KG	0.059	0.07 #	0.04 B/U	0.37 #	0.05 B/U	0.24 #
Nickel	MG/KG	17.7	16.8	15.4	18.2 #	6.7	17.2
Nitrate/Nitrite	MG/KG		NA	NA	NA	NA	NA
Potassium	MG/KG	1950	916 N/N	783 N/N	966 N/N	383 N/N	934 N/N
Sodium	MG/KG	112	81.2 B/U	92.7	97.9 B/U	76.6	63.8 B/U
Sulfide	MG/KG		NA	NA	NA	NA	NA
Vanadium	MG/KG	26.1	17.5	15.2	13.2	6.1	14.9
Zinc	MG/KG	532	93.3	65.6	124	36.8	212
Organic Pesticides							
Dieldrin	MG/KG		NA	NA	NA	NA	NA
Organic-Semivolatiles							
Fluoranthene	MG/KG		NA	NA	NA	NA	NA
bis(2-ethylhexyl) phthalate	MG/KG		NA	NA	NA	NA	NA
di-n-Butyl Phthalate	MG/KG		NA	NA	NA	NA	NA
Organic-Volatiles							
2-Butanone	MG/KG		NA	NA	NA	NA	NA
Chloromethane	MG/KG		NA	NA	NA	NA	NA
Trichloroethene	MG/KG		NA	NA	NA	NA	NA

Table 4-8. SRC in Sediment Samples at ODA2 (continued)

Media			Sediment	Sediment	Sediment	Sediment	Sediment
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2sd-094**	**DA2sd-095**	**DA2sd-096**	**DA2sd-097**	**DA2sd-098**
Sample ID			**DA2SD-094-0769-SD**	**DA2SD-095-0770-SD**	**DA2SD-096-0771-SD**	**DA2SD-097-0772-SD**	**DA2SD-098-0773-SD**
Date			**07/10/2002**	**07/11/2002**	**07/11/2002**	**07/11/2002**	**07/11/2002**
Depth (ft)			**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
Nitrocellulose	MG/KG		22 U/U	23 U/U	22 U/U	27 U/U	25 U/U
Inorganics							
Aluminum	MG/KG	13900	10500 N/N	1950 N/N	1330 N/N	12600 N/N	2700 N/N
Arsenic	MG/KG	19.5	17.7 */*	5.4 */*	3 */*	17.3 */*	5.4 */*
Barium	MG/KG	123	62.4	11.2	7.9	317 #	23.6
Beryllium	MG/KG	0.38	0.58 #	0.14	0.12	0.69 #	0.22
Cadmium	MG/KG	0	0.53 #	0.13 #	0.1 #	2.3 #	0.33 #
Calcium	MG/KG	5510	1720 */*	2890 */*	522 */*	3520 */*	1260 */*
Chromium	MG/KG	18.1	14.6	2.9	2.1	17.3	3.9
Chromium, Hexavalent	MG/KG		0.99 U/U	1 U/U	1 U/U	12 U/U	1.1 U/U
Cobalt	MG/KG	9.1	8	2.4	1.8	10.5 #	2.8
Copper	MG/KG	27.6	22.1	4.6	2.9	60.7 #	9.6
Iron	MG/KG	28200	26900	7100	4810	29600 #	8180
Lead	MG/KG	27.4	13.5 */*	4.4 */*	3 */*	31.3 */*#	6 */*
Magnesium	MG/KG	2760	2860 */*#	1180 */*	542 */*	3850 */*#	790 */*
Manganese	MG/KG	1950	439 N/N	103 N/N	125 N/N	1420 N/N	157 N/N
Mercury	MG/KG	0.059	0.03 B/U	0.01 U/U	0.01 U/U	0.12 #	0.01 U/U
Nickel	MG/KG	17.7	20.5 #	4.9	3.4	24.3 #	5.5
Nitrate/Nitrite	MG/KG		2 U/U	2 U/U	2.1 U/U	4.9 #	2.2 U/U
Potassium	MG/KG	1950	1100 N/N	324 N/N	219 N/N	1540 N/N	347 N/N
Sodium	MG/KG	112	39.4 B/U	48.8 B/U	53.3 B/U	45.8 U/U	58.3 B/U
Sulfide	MG/KG		330 #	110 #	56 U/U	760 #	340 #
Vanadium	MG/KG	26.1	17.5	4.1	2.9	21	5.8
Zinc	MG/KG	532	76.7 */*	18.6 */*	14.3 */*	160 */*	31.6 */*
Organic Pesticides							
Dieldrin	MG/KG		0.0021 U/U	0.0022 U/U	0.0022 U/U	0.0026 U/U	0.0024 U/U
Organic-Semivolatiles							
Fluoranthene	MG/KG		0.42 U/U	0.12 J/J	0.43 U/U	0.51 U/U	0.48 U/U
bis(2-ethylhexyl) phthalate	MG/KG		0.42 U/U	0.44 U/U	0.43 U/U	0.032 J/J	0.48 U/U
di-n-Butyl Phthalate	MG/KG		0.42 U/U	0.17 J/J	0.084 J/J	0.2 J/J	0.48 U/U
Organic-Volatiles							
2-Butanone	MG/KG		0.013 U/U	0.013 U/U	0.013 U/U	0.015 U/U	0.0079 J/J
Chloromethane	MG/KG		0.013 U/U	0.013 U/U	0.013 U/U	0.015 U/U	0.014 U/U
Trichloroethene	MG/KG		NA	NA	NA	NA	NA

Table 4-8. SRC in Sediment Samples at ODA2 (continued)

Media			**Sediment**	**Sediment**	**Sediment**	**Sediment**	**Sediment**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2sd-099**	**DA2sd-100**	**DA2sd-101**	**DA2sd-102**	**DA2sd-103**
Sample ID			**DA2SD-099-0774-SD**	**DA2SD-100-0775-SD**	**DA2SD-101-0776-SD**	**DA2SD-102-0777-SD**	**DA2SD-103-0778-SD**
Date			**07/11/2002**	**07/10/2002**	**07/10/2002**	**07/10/2002**	**07/10/2002**
Depth (ft)			**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**	**0.0 - 0.5**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/kg)	**Units**	**Facility Wide Background**					
Explosives							
Nitrocellulose	MG/KG		32 U/U	29	21 U/U	23 U/U	23 U/U
Inorganics							
Aluminum	MG/KG	13900	5850 N/N	17300 N/N#	5610 N/N	1820 N/N	4000 N/N
Arsenic	MG/KG	19.5	7.4 */*	16.9 */*	5.7 */*	3.7 */*	11.4 */*
Barium	MG/KG	123	43.3	148 #	42.1	11.7	30.8
Beryllium	MG/KG	0.38	0.42 #	1.2 #	0.5 #	0.18	0.52 #
Cadmium	MG/KG	0	0.53 #	0.75 #	0.81 #	0.19 #	0.46 #
Calcium	MG/KG	5510	2490 */*	2250 */*	913 */*	669 */*	1080 */*
Chromium	MG/KG	18.1	8.4	19.4 #	8.3	3.3	7.7
Chromium, Hexavalent	MG/KG		6.1 #	11 U/U	2.6 U/U	1 U/U	1 U/U
Cobalt	MG/KG	9.1	6.1	8.8	6.7	2.3	5.8
Copper	MG/KG	27.6	19.6	17	28.6 #	6.8	13.9
Iron	MG/KG	28200	15900	29000 #	12400	7730	24100
Lead	MG/KG	27.4	11.7 */*	28.3 */*#	11.3 */*	4.5 */*	9.5 */*
Magnesium	MG/KG	2760	1980 */*	2580 */*	1630 */*	600 */*	1250 */*
Manganese	MG/KG	1950	380 N/N	1470 N/N	156 N/N	162 N/N	457 N/N
Mercury	MG/KG	0.059	0.12 #	0.14 #	0.13 #	0.01 B/U	0.05
Nickel	MG/KG	17.7	12.5	25.2 #	19.9 #	4.8	12.4
Nitrate/Nitrite	MG/KG		3.2 #	9.1 #	1.9 U/U	3.5 #	1.9 U/U
Potassium	MG/KG	1950	768 N/N	1490 N/N	756 N/N	305 N/N	587 N/N
Sodium	MG/KG	112	52.7 B/U	97.5 U/U	51.8 B/U	49.2 B/U	39.1 B/U
Sulfide	MG/KG		1100 #	610 #	150 #	130 #	75 #
Vanadium	MG/KG	26.1	11.2	30.9 #	10.3	4.2	9.7
Zinc	MG/KG	532	70.6 */*	118 */*	81.2 */*	24 */*	57.4 */*
Organic Pesticides							
Dieldrin	MG/KG		0.0031 U/U	0.0023 U/U	0.0022 U/U	0.0022 U/U	0.00064 J/J
Organic-Semivolatiles							
Fluoranthene	MG/KG		0.62 U/U	0.47 U/U	0.43 U/U	0.43 U/U	0.43 U/U
bis(2-ethylhexyl) phthalate	MG/KG		0.62 U/U	0.47 U/U	0.43 U/U	0.43 U/U	0.43 U/U
di-n-Butyl Phthalate	MG/KG		0.62 U/U	0.47 U/U	0.43 U/U	0.43 U/U	0.43 U/U
Organic-Volatiles							
2-Butanone	MG/KG		0.016 J/J	0.014 U/U	0.013 U/U	0.013 U/U	0.013 U/U
Chloromethane	MG/KG		0.019 U/U	0.014 U/U	0.013 U/U	0.013 U/U	0.004 J/J
Trichloroethene	MG/KG		0.0093 U/U	NA	0.0038 J/J	NA	0.0064 U/U

Note: Data Qaulifiers are presented as Laboratory qualifiers/Validation qualifiers
\# - value above facility wide background = - analyte present and concentration accurate.
J - estimated value less than reporting limits. U - Not detected
N - Matrix spike recovery outside control limits * - Duplicate analysis outside control limits.
E - Result estimated because of the presence of interference. P - greater than 25% difference between two GC columns
B - for organics-compound was detected in the blank as well as the sample NA – not analyzed
B - for inorganics-result was less than the contract required detection limit but greater than the instrument detection limit.
Facility wide background was determined for the Winklepeck Burning Ground Phase II Remedial Investigation (USACE 2001c)

Table 4-9. Summary Statistics and Determination of Site-Related Contaminations in Surface Water Samples

Analysis Type	Analyte	Units	Results >Detection Limit	Average Result[a]	Minimum Detect	Maximum Detect	Site Background Criteria	Site Related?
Explosives	Nitrocellulose	ug/L	3/ 12	1.48E+02	2.20E+02	2.50E+02		Yes
Metals	Aluminum	ug/L	6/ 12	1.36E+02	1.26E+02	3.81E+02	3.37E+03	No
Metals	Barium	ug/L	12/ 12	2.94E+01	2.13E+01	4.04E+01	4.75E+01	No
Metals	Calcium[b]	ug/L	12/ 12	4.62E+04	2.66E+04	6.92E+04	4.14E+04	No
Metals	Chromium	ug/L	1/ 12	4.08E+00	3.86E+01	3.86E+01		Yes
Metals	Iron[b]	ug/L	11/ 12	3.89E+02	1.87E+02	6.56E+02	2.56E+03	No
Metals	Magnesium[b]	ug/L	12/ 12	1.15E+04	6.38E+03	1.74E+04	1.08E+04	No
Metals	Manganese	ug/L	12/ 12	5.82E+01	1.70E+01	9.81E+01	3.91E+02	No
Metals	Nickel	ug/L	1/ 12	1.78E+00	1.49E+01	1.49E+01		Yes
Metals	Nitrate/Nitrite	ug/L	9/ 12	9.96E+01	5.00E+01	2.40E+02		Yes
Metals	Potassium[b]	ug/L	12/ 12	2.13E+03	1.39E+03	2.86E+03	3.17E+03	No
Metals	Sodium[b]	ug/L	12/ 12	7.81E+03	4.37E+03	1.33E+04	2.13E+04	No
Metals	Sulfide	ug/L	1/ 12	1.10E+03	2.20E+03	2.20E+03		Yes
Metals	Zinc	ug/L	1/ 12	5.48E+00	3.21E+01	3.21E+01	4.20E+01	No
Organics-Semivolatile	bis(2-ethylhexyl) phthalate	ug/L	1/ 12	5.34E+00	2.10E+00	2.10E+00		Yes
Organics-Volatile	Carbon Disulfide	ug/L	3/ 12	6.63E-01	6.60E-01	1.70E+00		Yes
Organics-Volatile	Chloroform	ug/L	3/ 12	8.75E-01	1.90E+00	2.10E+00		Yes

[a] Values less than the detection limit were set to one-half of the reporting limit in calculation of the average.

[b] Eliminated as an SRC based on the essential element screen

Site Background Criteria was determined for the Winklepeck Burning Ground Phase II Remedial Investigation (USACE 2001c)

Table 4-10. SRC in Surface Water Samples at ODA2

Media			**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**
Location			**OD2**	**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2sw-095**	**DA2sw-095**	**DA2sw-095**	**DA2sw-095**	**DA2sw-099**
Sample ID			**DA2SW-095-0779-SW**	**DA2SW-095-0780-SW**	**DA2SW-095-0781-SW**	**DA2SW-095-0782-SW**	**DA2SW-099-0783-SW**
Date			**07/10/2002**	**09/10/2002**	**11/26/2002**	**04/04/2003**	**07/10/2002**
Filtered			**Total**	**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**	**grab**
Analyte (mg/L)	**Units**	**Facility Wide Background**					
Explosives							
Nitrocellulose	MG/L		0.18 U/U	0.22	0.18 U/U	0.36 U/U	0.18 U/U
Inorganics							
Aluminum	MG/L	3.37	0.381	0.0651 B/U	0.147 B/U	0.27	0.146
Barium	MG/L	0.0475	0.0232	0.0373	0.0297	0.0213	0.0319
Calcium	MG/L	41.4	38	69.2 #	41.7 #	27	53.5 #
Chromium	MG/L	0	0.0013 U/U	0.0013 U/U	0.0032 U/U	0.0386 */*#	0.0013 U/U
Iron	MG/L	2.56	0.656	0.265	0.385	0.621	0.357
Magnesium	MG/L	10.8	8.39	17.4 #	10.5	6.38 E/E	12.6 #
Manganese	MG/L	0.391	0.0534	0.0981	0.04	0.0682	0.0792
Nickel	MG/L	0	0.0014 B/U	0.0011 U/U	0.0013 U/U	0.0149 */*#	0.0011 U/U
Nitrate/Nitrite	MG/L		0.23 #	0.13 #	0.09 #	0.05 #	0.2 #
Potassium	MG/L	3.17	1.89	2.29	2.86 E/E	1.39	1.96
Sodium	MG/L	21.3	4.37	7.46	13.3	6.58	5.64
Sulfide	MG/L		2 U/U	2 U/U	2 U/U	2 U/U	2.2 #
Zinc	MG/L	0.042	0.0053 B/U	0.0115 B/U	0.007 U/U	0.0054 B/U	0.0049 B/U
Organic-Semivolatiles							
bis(2-ethylhexyl) phthalate	MG/L		0.012 U/U	0.011 U/U	0.011 U/U	0.011 U/U	0.011 U/U
Organic-Volatiles							
Carbon Disulfide	MG/L		0.001 U/U	0.001 U/U	0.001 U/U	0.001 U/U	0.00066 J/J
Chloroform	MG/L		0.001 U/U	0.001 U/U	0.0019	0.001 U/U	0.001 U/U

Table 4-10.SRC in Surface Water Samples at ODA2 (continued)

Media			**Surface Water**	**Surface Water**	**Surface Water**	**Surface Water**
Location			**OD2**	**OD2**	**OD2**	**OD2**
Station			**DA2sw-099**	**DA2sw-099**	**DA2sw-099**	**DA2sw-102**
Sample ID			**DA2SW-099-0784-SW**	**DA2SW-099-0785-SW**	**DA2SW-099-0786-SW**	**DA2SW-102-0787-SW**
Date			**09/10/2002**	**11/26/2002**	**04/04/2003**	**07/09/2002**
Filtered			**Total**	**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**	**grab**
Analyte (mg/L)	**Units**	**Facility Wide Background**				
Explosives						
Nitrocellulose	MG/L		0.22	0.18 U/U	0.36 U/U	0.18 U/U
Inorganics						
Aluminum	MG/L	3.37	0.126	0.0846 B/U	0.217	0.0769 B/U
Barium	MG/L	0.0475	0.0404	0.029	0.0222	0.0329
Calcium	MG/L	41.4	66.3 #	42.3 #	27.7	56.1 #
Chromium	MG/L	0	0.0023 B/U	0.0032 U/U	0.0011 B*/U	0.0013 U/U
Iron	MG/L	2.56	0.326	0.42	0.535	0.187
Magnesium	MG/L	10.8	17.2 #	10.8	6.67 E/E	13.5 #
Manganese	MG/L	0.391	0.0962	0.0573	0.0727	0.0293
Nickel	MG/L	0	0.0011 U/U	0.0013 U/U	0.0011 U*/U*	0.0011 U/U
Nitrate/Nitrite	MG/L		0.05 U/U	0.05 J/J#	0.05 U/U	0.24 #
Potassium	MG/L	3.17	2.41	2.81 E/E	1.43	1.97
Sodium	MG/L	21.3	7.58	12	6.07	6.33
Sulfide	MG/L		2 U/U	2 U/U	2 U/U	2 U/U
Zinc	MG/L	0.042	0.0321	0.007 U/U	0.0051 B/U	0.0047 B/U
Organic-Semivolatiles						
bis(2-ethylhexyl) phthalate	MG/L		0.011 U/U	0.012 U/U	0.011 U/U	0.011 U/U
Organic-Volatiles						
Carbon Disulfide	MG/L		0.001 U/U	0.001 U/U	0.0011	0.001 U/U
Chloroform	MG/L		0.001 U/U	0.0021	0.001 U/U	0.001 U/U

1 **Table 4-10.SRC in Surface Water Samples at ODA2 (continued)**

Media			**Surface Water**	**Surface Water**	**Surface Water**
Location			**OD2**	**OD2**	**OD2**
Station			**DA2sw-102**	**DA2sw-102**	**DA2sw-102**
Sample ID			**DA2SW-102-0788-SW**	**DA2SW-102-0789-SW**	**DA2SW-102-0790-SW**
Date			**09/09/2002**	**11/26/2002**	**04/04/2003**
Filtered			**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**
Analyte (mg/L)	**Units**	**Facility Wide Background**			
Explosives					
Nitrocellulose	MG/L		0.25	0.18 U/U	0.36 U/U
Inorganics					
Aluminum	MG/L	3.37	0.0667 B/U	0.071 B/U	0.236
Barium	MG/L	0.0475	0.0339	0.0288	0.0218
Calcium	MG/L	41.4	63.6 #	42.5 #	26.6
Chromium	MG/L	0	0.0013 U/U	0.0032 U/U	0.0011 B*/U
Iron	MG/L	2.56	0.0386 B/U	0.356	0.538
Magnesium	MG/L	10.8	16.7 #	10.9 #	6.43 E/E
Manganese	MG/L	0.391	0.017	0.029	0.0584
Nickel	MG/L	0	0.0011 U/U	0.0013 U/U	0.0011 U*/U*
Nitrate/Nitrite	MG/L		0.06 #	0.05 U/U	0.07 #
Potassium	MG/L	3.17	2.37	2.74 E/E	1.41
Sodium	MG/L	21.3	6.14	12.2	6.07
Sulfide	MG/L		2 U/U	2 U/U	2 U/U
Zinc	MG/L	0.042	0.004 U/U	0.007 U/U	0.0053 B/U
Organic-Semivolatiles					
bis(2-ethylhexyl) phthalate	MG/L		0.011 U/U	0.012 U/U	0.0021 J/J

Table 4-10.SRC in Surface Water Samples at ODA2 (continued)

Media			**Surface Water**	**Surface Water**	**Surface Water**
Location			**OD2**	**OD2**	**OD2**
Station			**DA2sw-102**	**DA2sw-102**	**DA2sw-102**
Sample ID			**DA2SW-102-0788-SW**	**DA2SW-102-0789-SW**	**DA2SW-102-0790-SW**
Date			**09/09/2002**	**11/26/2002**	**04/04/2003**
Filtered			**Total**	**Total**	**Total**
Field Type			**grab**	**grab**	**grab**
Analyte (mg/L)	**Units**	**Facility Wide Background**			
Organic-Volatiles					
Carbon Disulfide	MG/L		0.0017	0.001 U/U	0.001 U/U
Chloroform	MG/L		0.001 U/U	0.002	0.001 U/U

Note: Data Qaulifiers are presented as Laboratory qualifiers/Validation qualifiers

# - value above facility wide background	= - analyte present and concentration accurate.
J - estimated value less than reporting limits.	U - Not detected
N - Matrix spike recovery outside control limits	* - Duplicate analysis outside control limits.
E - Result estimated because of the presence of interference.	P - greater than 25% difference between two GC columns

B - for organics-compound was detected in the blank as well as the sample

B - for inorganics-result was less than the contract required detection limit but greater than the instrument detection limit.

Facility wide background was determined for the Winklepeck Burning Ground Phase II Remedial Investigation (USACE 2001c)

Table 4-11. Summary Statistics and Determination of Site-Related Contaminations in Groundwater Samples

Analysis Type	Units	Analyte	Frequency of Detection	Minimum Detect	Maximum Detect	Average Result[a]	Site Background Criteria [b]	Site Related?	Justification
Metals	mg/L	Aluminum	6/ 16	1.46E-01	7.34E+00	5.23E-01		Yes	No Background Data Available
Metals	mg/L	Arsenic	1/ 16	1.35E-02	1.35E-02	3.21E-03	1.17E-02	Yes	Above Background
Metals	mg/L	Barium	16/ 16	1.68E-02	1.22E-01	4.13E-02	8.21E-02	Yes	Above Background
Metals	mg/L	Calcium[c]	16/ 16	3.09E+01	1.66E+02	8.31E+01	1.15E+02	No	Essential Element
Metals	mg/L	Chromium	2/ 16	5.60E-03	1.35E-02	1.90E-03	7.30E-03	Yes	Above Background
Metals	mg/L	Chromium, Hexavalent	5/ 16	2.00E-02	1.20E-01	2.97E-02		Yes	No Background Data Available
Metals	mg/L	Cobalt	1/ 16	6.90E-03	6.90E-03	7.77E-04		Yes	No Background Data Available
Metals	mg/L	Copper	2/ 16	4.70E-03	1.94E-02	2.24E-03		Yes	No Background Data Available
Metals	mg/L	Iron[c]	11/ 16	1.72E-01	1.66E+01	2.11E+00	2.79E-01	No	Essential Element
Metals	mg/L	Lead	1/ 16	1.05E-02	1.05E-02	1.44E-03		Yes	No Background Data Available
Metals	mg/L	Magnesium[c]	16/ 16	8.76E+00	5.32E+01	2.46E+01	4.33E+01	No	Essential Element
Metals	mg/L	Manganese	16/ 16	5.00E-03	1.09E+00	3.15E-01	1.02E+00	Yes	Above Background
Metals	mg/L	Nickel	4/ 16	4.90E-03	2.13E-02	4.03E-03		Yes	No Background Data Available
Metals	mg/L	Nitrate/Nitrite	11/ 16	5.00E-02	1.00E+00	2.05E-01		Yes	No Background Data Available
Metals	mg/L	Potassium[c]	16/ 16	8.20E-01	1.43E+01	3.55E+00	2.89E+00	No	Essential Element
Metals	mg/L	Sodium[c]	16/ 16	3.62E+00	1.73E+01	8.79E+00	4.57E+01	No	Essential Element
Metals	mg/L	Vanadium	1/ 16	1.35E-02	1.35E-02	1.22E-03		Yes	No Background Data Available
Metals	mg/L	Zinc	3/ 16	1.70E-02	6.17E-02	9.20E-03	6.09E-02	Yes	Above Background
Organics-Explosives	mg/L	2-Amino-4,6-Dinitrotoluene	1/ 16	1.20E-03	1.20E-03	1.97E-04		Yes	No Background Data Available

1

Table 4-11. Summary Statistics and Determination of Site-Related Contaminations in Groundwater Samples (continued)

Analysis Type	Units	Analyte	Frequency of Detection	Minimum Detect	Maximum Detect	Average Result[a]	Site Background Criteria[b]	Site Related?	Justification
Organics-Explosives	mg/L	4-Amino-2,6-Dinitrotoluene	1/ 15	4.70E-04	4.70E-04	1.53E-04		Yes	No Background Data Available
Organics-Explosives	mg/L	Nitrocellulose	16/ 16	1.80E-01	1.30E+00	4.08E-01		Yes	No Background Data Available
Organics-Explosives	mg/L	RDX	4/ 16	2.80E-04	6.60E-04	3.03E-04		Yes	No Background Data Available
Organics-Semivolatile	mg/L	di-n-Butyl Phthalate	2/ 15	1.50E-03	1.70E-03	4.82E-03		Yes	No Background Data Available
Organics-Volatile	mg/L	Carbon Disulfide	5/ 15	6.20E-04	1.30E-03	6.06E-04		Yes	No Background Data Available

[a] Values less than the detection limit were set to one-half of the reporting limit in calculation of the average.

[b] Background values are for unconsolidated zone filtered groundwater.

[c] Eliminated as an SRC based on the essential element screen

Site Background Criteria was determined for the Winklepeck Burning Ground Phase II Remedial Investigation (USACE 2001c)

2

Table 4-12. SRC in Groundwater Samples at ODA2

Media					**Groundwater**	**Groundwater**	**Groundwater**
Location					**OD2**	**OD2**	**OD2**
Station					**DA2mw-104**	**DA2mw-105**	**DA2mw-106**
Sample ID					**DA2MW-104-0791-GW**	**DA2MW-105-0792-GW**	**DA2MW-106-0793-GW**
Sample ID (metals)					**DA2MW-104-0791-GF**	**DA2MW-104-0791-GF**	**DA2MW-104-0791-GF**
Date					**09/05/2002**	**09/09/2002**	**09/09/2002**
Field Type					**grab**	**grab**	**grab**
Analyte (mg/L)	**Units**	**Facility Wide Background**	**MCL**	**Region 9 PRG, Tap Water**			
Explosives							
2-Amino-4,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.00026 U/U	0.00026 U/U
4-Amino-2,6-Dinitrotoluene	MG/L		NA	7.3E-03	NA	0.00026 U/U	0.00026 U/U
Nitrocellulose	MG/L		NA	NA	0.21	0.19	0.26
RDX	MG/L		NA	6.1E-04	0.00052 U/U	0.00052 U/U	0.00028 J/J
Inorganics							
Aluminum	MG/L		*0.05 to 0.2*	3.6E+01	7.34 N/N#	0.0309 U/U	0.0309 U/U
Arsenic	MG/L	0.0117	0.010	4.5E-05	0.0135 #	0.0051 B/U	0.0034 U/U
Barium	MG/L	0.0821	2.0	2.6E+00	0.053	0.0599	0.122 #
Calcium	MG/L	115	NA	NA	48.5	88.2	166 #
Chromium	MG/L	0.0073	0.1	5.5E+01	0.0135 #	0.0013 U/U	0.0013 U/U
Chromium, Hexavalent	MG/L		NA	1.1E-01	0.12 #	0.01 U/U	0.02 #
Cobalt	MG/L		NA	7.3E-01	0.0069 #	0.00077 B/U	0.0017 B/U
Copper	MG/L		1.3	1.5E+00	0.0194 #	0.0013 B/U	0.0047 #
Iron	MG/L	0.279	*0.3*	1.1E+01	16.6 #	0.354 #	0.0243 U/U
Lead	MG/L		0.015	NA	0.0105 #	0.0016 U/U	0.0016 U/U
Magnesium	MG/L	43.3		NA	13.2	22.3 */*	53.2 */*#
Manganese	MG/L	1.02	*0.05*	8.8E-01	0.245	0.276	0.328
Nickel	MG/L		NA	NA	0.0169 #	0.0011 U/U	0.0213 #
Nitrate/ Nitrite	MG/L		10/ 1	1.0E+01/ 1.0E+00	0.11 #	0.29 #	1 #
Potassium	MG/L	2.89	NA	NA	3.4 N/N#	2.15	14.3 #
Sodium	MG/L	45.7	NA	NA	5.31	8.75	16.5
Vanadium	MG/L		NA	3.6E-02	0.0135 #	0.0007 U/U	0.0007 U/U
Zinc	MG/L	0.0609	*5.0*	1.1E+01	0.0617 #	0.0129 B/U	0.017
Organic-Semivolatiles							
di-n-Butyl Phthalate	MG/L		NA	3.6E+00	0.011 U/U	0.011 U/U	0.011 U/U
Organic-Volatiles							
Carbon Disulfide	MG/L		NA	1.0E+00	0.001 U/U	0.001 U/U	0.001 U/U

Table 4-12. SRC in Groundwater Samples at ODA2 (continued)

Media					**Groundwater**	**Groundwater**	**Groundwater**
Location					**OD2**	**OD2**	**OD2**
Station					**DA2mw-107**	**DA2mw-108**	**DA2mw-109**
Sample ID					**DA2MW-107-0794-GW**	**DA2MW-108-0795-GW**	**DA2MW-109-0796-GW**
Sample ID (metals)					**DA2MW-104-0791-GF**	**DA2MW-104-0791-GF**	**DA2MW-104-0791-GF**
Date					**09/11/2002**	**09/09/2002**	**09/11/2002**
Field Type					**grab**	**grab**	**grab**
Analyte (mg/L)	**Units**	**Facility Wide Background**	**MCL**	**Region 9 PRG, Tap Water**			
Explosives							
2-Amino-4,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.00026 U/U	0.00026 U/U
4-Amino-2,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.00026 U/U	0.00026 U/U
Nitrocellulose	MG/L		NA	NA	0.58	0.23	0.59
RDX	MG/L		NA	6.1E-04	0.00052 U/U	0.00052 U/U	0.00052 U/U
Inorganics							
Aluminum	MG/L		*0.05 to 0.2*	3.6E+01	0.0309 U/U	0.0488 B/U	0.146 #
Arsenic	MG/L	0.0117	0.010	4.5E-05	0.0076 B/U	0.0034 U/U	0.0034 U/U
Barium	MG/L	0.0821	2.0	2.6E+00	0.0298	0.0323	0.0256
Calcium	MG/L	115	NA	NA	84.8	53.2	84.5
Chromium	MG/L	0.0073	0.1	5.5E+01	0.0013 U/U	0.0013 U/U	0.0022 B/U
Chromium, Hexavalent	MG/L		NA	1.1E-01	0.01 U/U	0.09 #	0.01 U/U
Cobalt	MG/L		NA	7.3E-01	0.0006 U/U	0.0006 U/U	0.00097 B/U
Copper	MG/L		1.3	1.5E+00	0.0017 B/U	0.001 U/U	0.0019 B/U
Iron	MG/L	0.279	*0.3*	1.1E+01	0.61 #	10.5 #	0.172
Lead	MG/L		0.015	NA	0.0016 U/U	0.0016 U/U	0.0023 B/U
Magnesium	MG/L	43.3		NA	25.8	24.8 */*	26.7
Manganese	MG/L	1.02	*0.05*	8.8E-01	0.194	1.09 #	0.55
Nickel	MG/L		NA	NA	0.0011 U/U	0.0011 U/U	0.0023 B/U
Nitrate/ Nitrite	MG/L		10/ 1	1.0E+01/ 1.0E+00	0.05 #	0.15 #	0.05 U/U
Potassium	MG/L	2.89	NA	NA	2.45	3.43 #	2.59
Sodium	MG/L	45.7	NA	NA	9.8	7.01	7
Vanadium	MG/L		NA	3.6E-02	0.0007 U/U	0.0007 U/U	0.001 B/U
Zinc	MG/L	0.0609	*5.0*	1.1E+01	0.004 U/U	0.0087 B/U	0.004 U/U
Organic-Semivolatiles							
di-n-Butyl Phthalate	MG/L		NA	3.6E+00	0.011 U/U	0.011 U/U	0.013 U/U
Organic-Volatiles							
Carbon Disulfide	MG/L		NA	1.0E+00	0.00062 J/J	0.0013	0.001 U/U

Table 4-12. SRC in Groundwater Samples at ODA2 (continued)

Media					**Groundwater**	**Groundwater**	**Groundwater**
Location					**OD2**	**OD2**	**OD2**
Station					**DA2mw-110**	**DA2mw-111**	**DA2mw-112**
Sample ID					**DA2MW-110-0797-GW**	**DA2MW-111-0798-GW**	**DA2MW-112-0799-GW**
Sample ID (metals)					**DA2MW-104-0791-GF**	**DA2MW-104-0791-GF**	**DA2MW-104-0791-GF**
Date					**09/11/2002**	**09/11/2002**	**09/10/2002**
Field Type					**grab**	**grab**	**grab**
Analyte (mg/L)	**Units**	**Facility Wide Background**	**MCL**	**Region 9 PRG, Tap Water**			
Explosives							
2-Amino-4,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.00026 U/U	0.00026 U/U
4-Amino-2,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.00026 U/U	0.00026 U/U
Nitrocellulose	MG/L		NA	NA	0.58	0.18	0.58
RDX	MG/L		NA	6.1E-04	0.00031 J/J	0.00048 J/J	0.00052 U/U
Inorganics							
Aluminum	MG/L		*0.05 to 0.2*	3.6E+01	0.0578 B/U	0.0322 B/U	0.0309 U/U
Arsenic	MG/L	0.0117	0.010	4.5E-05	0.0034 U/U	0.0034 U/U	0.0034 U/U
Barium	MG/L	0.0821	2.0	2.6E+00	0.0466	0.0215	0.0389
Calcium	MG/L	115	NA	NA	64.4	98.5	90.8
Chromium	MG/L	0.0073	0.1	5.5E+01	0.0015 B/U	0.0013 U/U	0.0013 U/U
Chromium, Hexavalent	MG/L		NA	1.1E-01	0.01 U/U	0.01 U/U	0.01 U/U
Cobalt	MG/L		NA	7.3E-01	0.0006 U/U	0.00069 B/U	0.0006 U/U
Copper	MG/L		1.3	1.5E+00	0.0017 B/U	0.0025 B/U	0.0016 B/U
Iron	MG/L	0.279	*0.3*	1.1E+01	0.0243 U/U	0.0243 U/U	0.221
Lead	MG/L		0.015	NA	0.0016 U/U	0.0019 B/U	0.0016 U/U
Magnesium	MG/L	43.3		NA	20.4	34.8	25.2
Manganese	MG/L	1.02	*0.05*	8.8E-01	0.512	0.272	0.318
Nickel	MG/L		NA	NA	0.0011 U/U	0.0049 #	0.0011 U/U
Nitrate/ Nitrite	MG/L		10/ 1	1.0E+01/ 1.0E+00	0.05 U/U	0.05 U/U	0.05 U/U
Potassium	MG/L	2.89	NA	NA	6.07 #	5.26 #	4.15 #
Sodium	MG/L	45.7	NA	NA	6.65	17.3	10.1
Vanadium	MG/L		NA	3.6E-02	0.0007 U/U	0.0007 U/U	0.0007 U/U
Zinc	MG/L	0.0609	*5.0*	1.1E+01	0.0041 B/U	0.0073 B/U	0.0057 B/U
Organic-Semivolatiles							
di-n-Butyl Phthalate	MG/L		NA	3.6E+00	0.0015 J/J	0.013 U/U	0.012 U/U
Organic-Volatiles							
Carbon Disulfide	MG/L		NA	1.0E+00	NA	0.001 U/U	0.001 U/U

Table 4-12. SRC in Groundwater Samples at ODA2 (continued)

Media					**Groundwater**	**Groundwater**	**Groundwater**
Location					**OD2**	**OD2**	**OD2**
Station					**DA2mw-113**	**DA2mw-DET1**	**DA2mw-DET2**
Sample ID					**DA2MW-113-0800-GW**	**DA2MW-DET10801-GW**	**DA2MW-DET20802-GW**
Sample ID (metals)					**DA2MW-104-0791-GF**	**DA2MW-104-0791-GF**	**DA2MW-104-0791-GF**
Date					**09/10/2002**	**09/05/2002**	**09/04/2002**
Field Type					**grab**	**grab**	**grab**
Analyte (mg/L)	**Units**	**Facility Wide Background**	**MCL**	**Region 9 PRG, Tap Water**			
Explosives							
2-Amino-4,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.00026 U/U	0.00026 U/U
4-Amino-2,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.00026 U/U	0.00026 U/U
Nitrocellulose	MG/L		NA	NA	0.61	0.27	0.22
RDX	MG/L		NA	6.1E-04	0.00052 U/U	0.00052 U/U	0.00052 U/U
Inorganics							
Aluminum	MG/L		*0.05 to 0.2*	3.6E+01	0.167 #	0.164 N/N#	0.0309 UN/UN
Arsenic	MG/L	0.0117	0.010	4.5E-05	0.0066 B/U	0.0072 B/U	0.0119 B/U
Barium	MG/L	0.0821	2.0	2.6E+00	0.058	0.0281	0.032
Calcium	MG/L	115	NA	NA	75.5	74.4	83.7
Chromium	MG/L	0.0073	0.1	5.5E+01	0.0013 U/U	0.0056	0.0013 U/U
Chromium, Hexavalent	MG/L		NA	1.1E-01	0.01 U/U	0.01 U/U	0.1 #
Cobalt	MG/L		NA	7.3E-01	0.0006 U/U	0.0006 U/U	0.00093 B/U
Copper	MG/L		1.3	1.5E+00	0.001 U/U	0.0021 B/U	0.0015 B/U
Iron	MG/L	0.279	*0.3*	1.1E+01	3.32 #	0.0243 U/U	0.731 #
Lead	MG/L		0.015	NA	0.0016 U/U	0.0016 U/U	0.0016 U/U
Magnesium	MG/L	43.3		NA	17.7	25.1	28.2
Manganese	MG/L	1.02	*0.05*	8.8E-01	0.495	0.285	0.193
Nickel	MG/L		NA	NA	0.0011 U/U	0.013 #	0.0011 U/U
Nitrate/ Nitrite	MG/L		10/ 1	1.0E+01/ 1.0E+00	0.07 #	0.18 #	0.33 #
Potassium	MG/L	2.89	NA	NA	2.33	2.25 N/N	2.24 N/N
Sodium	MG/L	45.7	NA	NA	3.62	9.84	12.5
Vanadium	MG/L		NA	3.6E-02	0.0007 U/U	0.0011 B/U	0.00091 B/U
Zinc	MG/L	0.0609	*5.0*	1.1E+01	0.0046 B/U	0.0073 B/U	0.0129 B/U
Organic-Semivolatiles							
di-n-Butyl Phthalate	MG/L		NA	3.6E+00	0.0017 J/J	0.0013 JB/U	0.011 U/U
Organic-Volatiles							
Carbon Disulfide	MG/L		NA	1.0E+00	0.001 U/U	0.0007 J/J	0.001 U/U

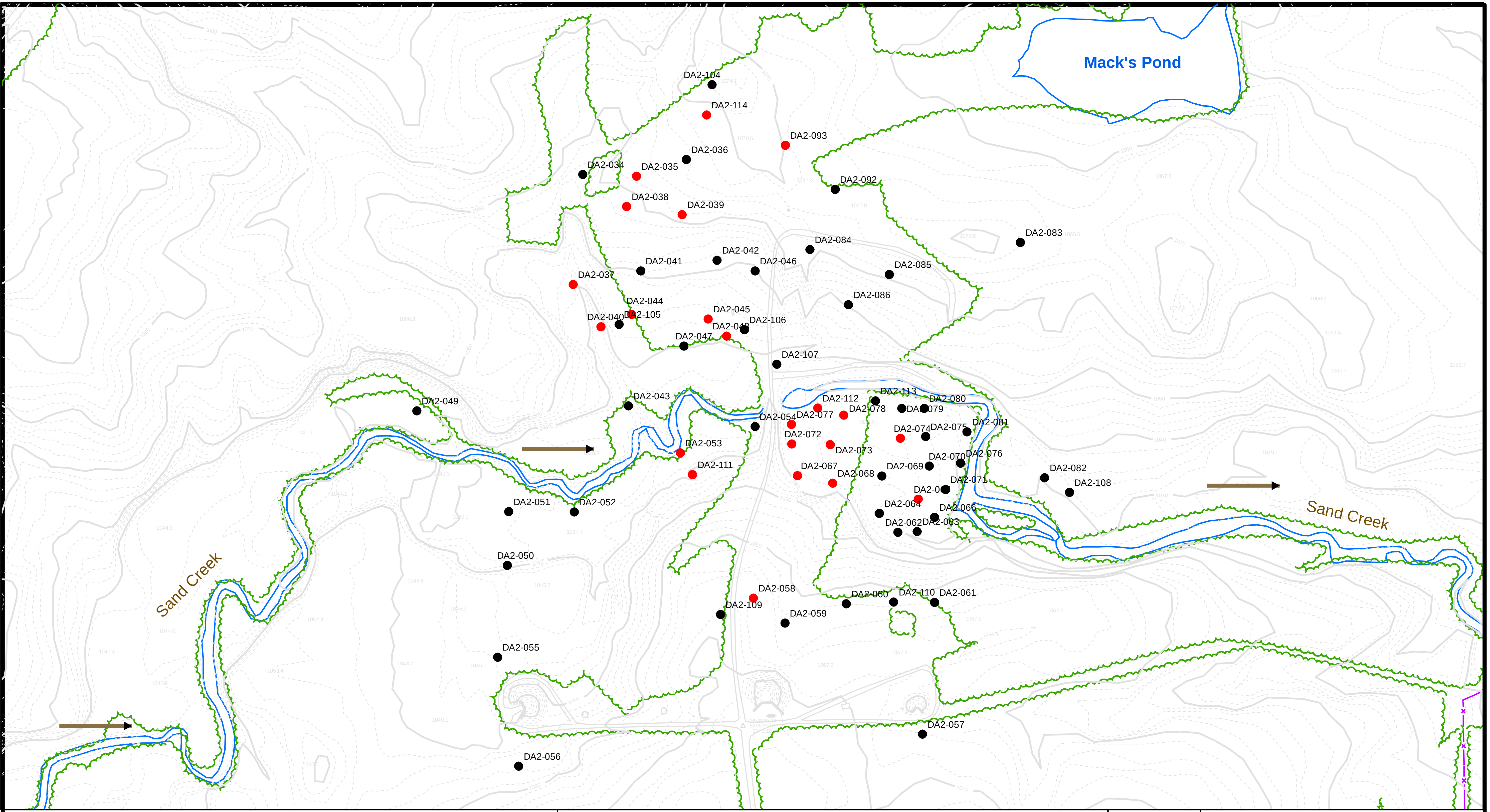
Table 4-12. SRC in Groundwater Samples at ODA2 (continued)

Media					**Groundwater**	**Groundwater**
Location					**OD2**	**OD2**
Station					**DA2mw-DET3**	**DA2mw-DET4**
Sample ID					**DA2MW-DET30803-GW**	**DA2MW-DET40804-GW**
Sample ID (metals)					**DA2MW-104-0791-GF**	**DA2MW-104-0791-GF**
Date					**09/04/2002**	**09/05/2002**
Field Type					**grab**	**grab**
Analyte (mg/L)	**Units**	**Facility Wide Background**	**MCL**	**Region 9 PRG, Tap Water**		
Explosives						
2-Amino-4,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.00026 U/U
4-Amino-2,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.00026 U/U
Nitrocellulose	MG/L		NA	NA	0.24	0.24
RDX	MG/L		NA	6.1E-04	0.00052 U/U	0.00052 U/U
Inorganics						
Aluminum	MG/L		*0.05 to 0.2*	3.6E+01	0.0551 BN/U	0.0743 BN/U
Arsenic	MG/L	0.0117	0.010	4.5E-05	0.0066 B/U	0.0034 U/U
Barium	MG/L	0.0821	2.0	2.6E+00	0.0441	0.032
Calcium	MG/L	115	NA	NA	82.1	150 #
Chromium	MG/L	0.0073	0.1	5.5E+01	0.0013 B/U	0.0014 B/U
Chromium, Hexavalent	MG/L		NA	1.1E-01	0.09 #	0.01 U/U
Cobalt	MG/L		NA	7.3E-01	0.0006 U/U	0.0006 U/U
Copper	MG/L		1.3	1.5E+00	0.0014 B/U	0.0031 B/U
Iron	MG/L	0.279	*0.3*	1.1E+01	0.665 #	0.0243 U/U
Lead	MG/L		0.015	NA	0.0016 U/U	0.0016 U/U
Magnesium	MG/L	43.3		NA	27.4	26.1
Manganese	MG/L	1.02	*0.05*	8.8E-01	0.242	0.0149
Nickel	MG/L		NA	NA	0.0011 U/U	0.0011 U/U
Nitrate/Nitrite	MG/L		10/1	1.0E+01/1.0E+00	0.3 #	0.05 U/U
Potassium	MG/L	2.89	NA	NA	2.04 N/N	2.29 N/N
Sodium	MG/L	45.7	NA	NA	11.3	6
Vanadium	MG/L		NA	3.6E-02	0.00094 B/U	0.00093 B/U
Zinc	MG/L	0.0609	*5.0*	1.1E+01	0.0075 B/U	0.0132 B/U
Organic-Semivolatiles						
di-n-Butyl Phthalate	MG/L		NA	3.6E+00	0.011 U/U	NA
Organic-Volatiles						
Carbon Disulfide	MG/L		NA	1.0E+00	0.001 U/U	0.0008 J/J

Table 4-12. SRC in Groundwater Samples at ODA2 (continued)

Media					**Groundwater**	**Groundwater**
Location					**OD2**	**OD2**
Station					**WBGmw-012**	**WBGmw-013**
Sample ID					**WBGMW-012-0805-GW**	**WBGMW-013-0806-GW**
Sample ID (metals)					**DA2MW-104-0791-GF**	**DA2MW-104-0791-GF**
Date					**08/28/2002**	**09/03/2002**
Field Type					**grab**	**grab**
Analyte (mg/L)	**Units**	**Facility Wide Background**	**MCL**	**Region 9 PRG, Tap Water**		
Explosives						
2-Amino-4,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.0012
4-Amino-2,6-Dinitrotoluene	MG/L		NA	7.3E-03	0.00026 U/U	0.00047
Nitrocellulose	MG/L		NA	NA	1.3	0.25
RDX	MG/L		NA	6.1E-04	0.00052 U/U	0.00066
Inorganics						
Aluminum	MG/L		*0.05 to 0.2*	3.6E+01	0.147 NE/NE#	0.189 #
Arsenic	MG/L	0.0117	0.010	4.5E-05	0.0034 U/U	0.0034 U/U
Barium	MG/L	0.0821	2.0	2.6E+00	0.0204	0.0168
Calcium	MG/L	115	NA	NA	54.6	30.9
Chromium	MG/L	0.0073	0.1	5.5E+01	0.0013 U/U	0.0044 B/U
Chromium, Hexavalent	MG/L		NA	1.1E-01	0.01 U/U	0.01 U/U
Cobalt	MG/L		NA	7.3E-01	0.0006 U/U	0.0006 U/U
Copper	MG/L		1.3	1.5E+00	0.0017 B/U	0.001 B/U
Iron	MG/L	0.279	*0.3*	1.1E+01	0.296 #	0.282 #
Lead	MG/L		0.015	NA	0.0016 U/U	0.0016 U/U
Magnesium	MG/L	43.3		NA	13.7	8.76
Manganese	MG/L	1.02	*0.05*	8.8E-01	0.005	0.0143
Nickel	MG/L		NA	NA	0.0011 U/U	0.0035 B/U
Nitrate/ Nitrite	MG/L		10/ 1	1.0E+01/ 1.0E+00	0.34 #	0.34 #
Potassium	MG/L	2.89	NA	NA	0.82	1.09
Sodium	MG/L	45.7	NA	NA	3.98	5.02
Vanadium	MG/L		NA	3.6E-02	0.0007 U/U	0.0007 U/U
Zinc	MG/L	0.0609	*5.0*	1.1E+01	0.0075 B/U	0.0187
Organic-Semivolatiles						
di-n-Butyl Phthalate	MG/L		NA	3.6E+00	0.011 U/U	0.011 U/U
Organic-Volatiles						
Carbon Disulfide	MG/L		NA	1.0E+00	0.00067 J/J	0.001 U/U

Note: Data Qaulifiers are presented as Laboratory qualifiers/Validation qualifiers
Secondary MCLs are presented in Italics.
\# - value above facility wide background = - analyte present and concentration accurate.
J - estimated value less than reporting limits. U - Not detected
N - Matrix spike recovery outside control limits * - Duplicate analysis outside control limits.
E - Result estimated because of the presence of interference. P - greater than 25% difference between two GC columns
B - for organics-compound was detected in the blank as well as the sample
B - for inorganics-result was less than the contract required detection limit but greater than the instrument detection limit.
NA – not analyzed
Facility wide background was determined for the Winklepeck Burning Ground Phase II Remedial Investigation (USACE 2001c)



Legend

Road	10 Ft. Contour
Vegetation	Surface Water Flow Direction
Water	● Non-detects
2 Ft. Contour	🟥 Detects

0 100 200 400 600 800 Feet

Figure 4-1

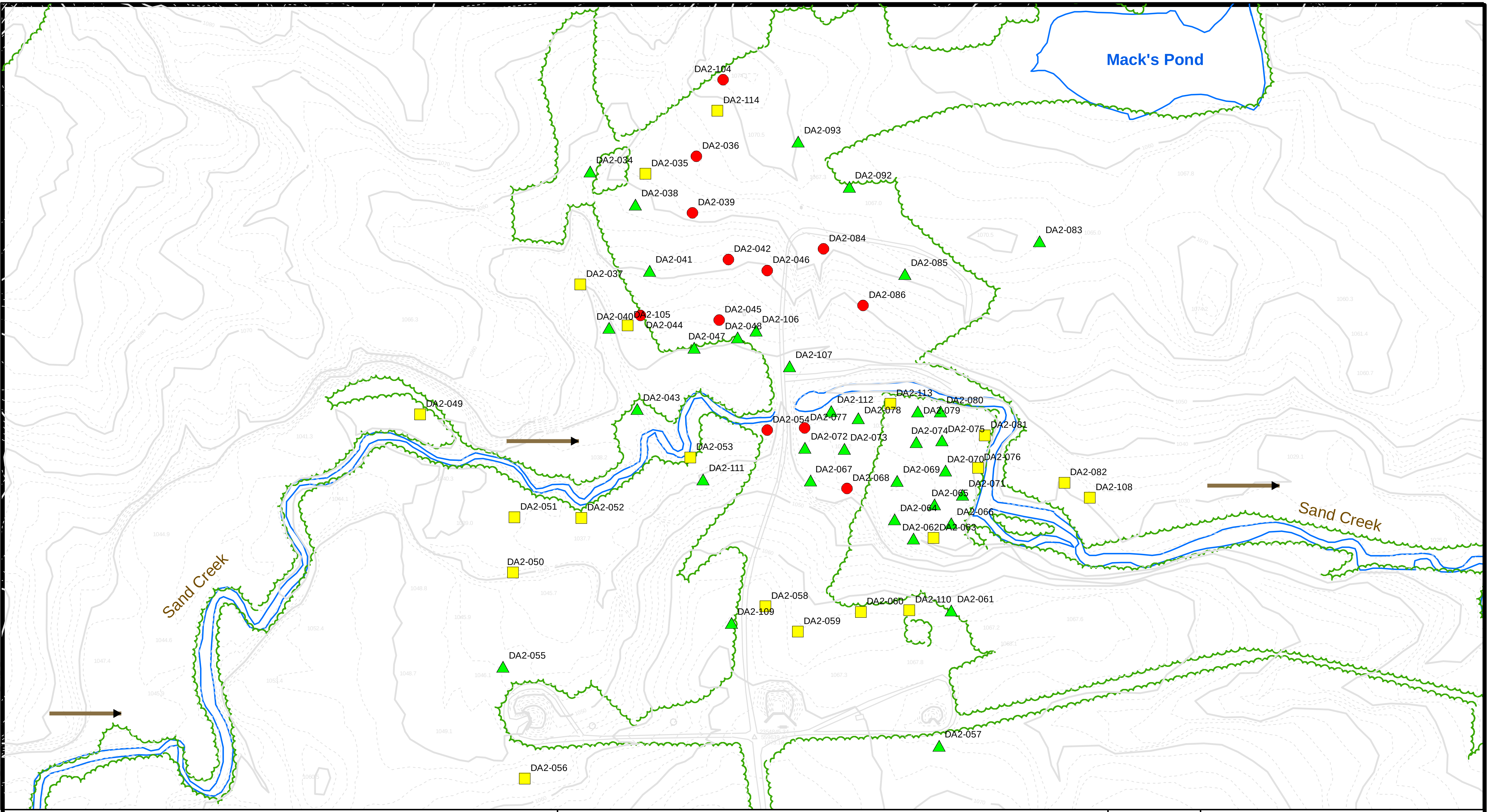
Distribution of Detected Explosives and Propellants in Surface Soil Samples

Drawn By: HRA

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/September/14

Z:\PUBLIC\RVAAP PBC 2005\GIS\ODA2_figure_revisions\ODA2_Fig_4_1.mxd



Z:\PUBLIC\RVAAP PBC 2005\GIS\ODA2_figure_revisions\ODA2_Fig_4_2.mxd

Legend

Road	10 Ft. Contour
Vegetation	Surface Water Flow Direction
Water	🟨 < or= 4 SRCs
2 Ft. Contour	▲ 5, 6, or 7 SRCs
	● > or= 8 SRCs

0 100 200 400 600 800 Feet

From Science to Solutions™

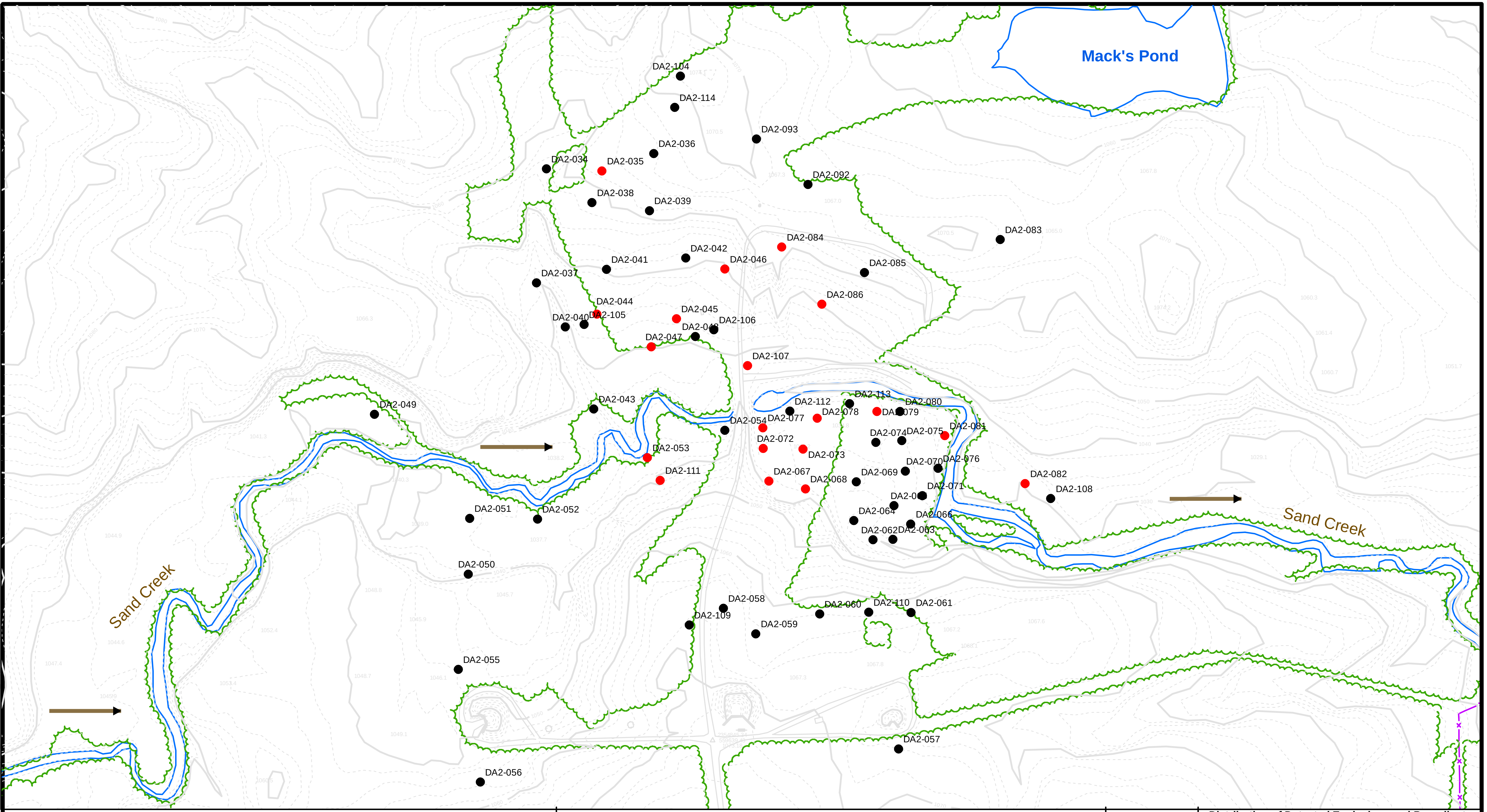
Figure 4-2

Distribution of Detected Inorganics Above Background Levels in Surface Soil

Drawn By: HRA

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/September/14



Z:\PUBLIC\RVAAP PBC 2005\GIS\ODA2_figure_revisions\ODA2_Fig_4_3.mxd

Legend

Road
Vegetation
Water
2 Ft. Contour
10 Ft. Contour
Surface Water Flow Direction
● Non-detects
● Detects

0 100 200 400 600 800 Feet

SAIC
From Science to Solutions™

N

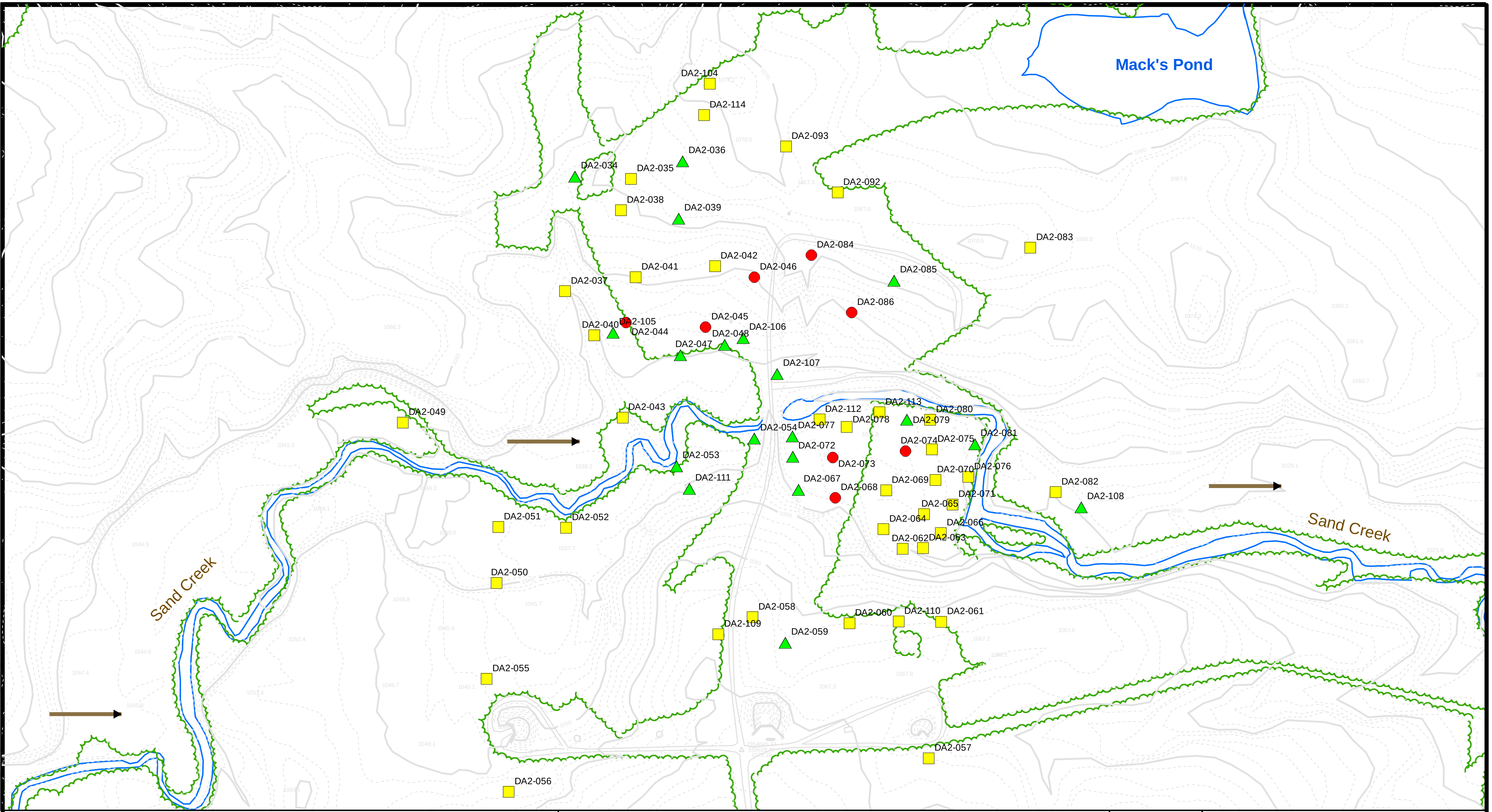
Figure 4-3

Distribution of Detected Explosives and Propellants in Subsurface Soil Samples

Drawn By: HRA

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/September/14



Z:\PUBLIC\RVAAP PBC 2005\GIS\ODA2_figure_revisions\ODA2_Fig_4_4.mxd

Legend

- Road
- Vegetation
- Water
- 2 Ft. Contour
- 10 Ft. Contour
- → Surface Water Flow Direction
- 🟨 < or= 2 SRCs
- ▲ 3, 4, or 5 SRCs
- ● > or= 6 SRCs

From Science to Solutions™

0 100 200 400 600 800 Feet

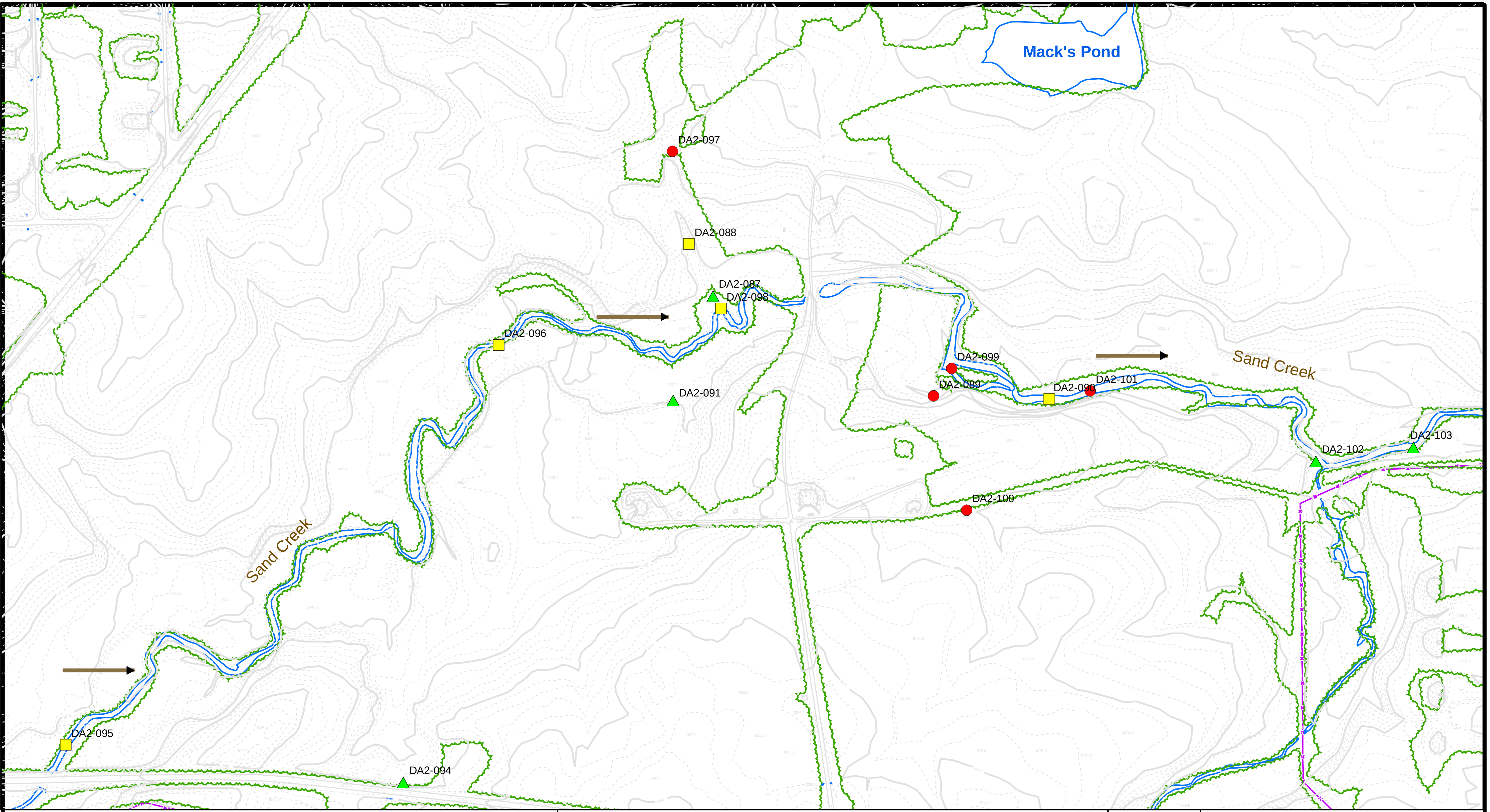
Figure 4-4

Distribution of Detected Inorganics Above Background Levels in Subsurface Soil

Drawn By: HRA

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/September/14



Legend

Road
🟩 Vegetation
Water
2 Ft. Contour
10 Ft. Contour
→ Surface Water Flow Direction
🟨 < or= 2 SRCs
▲ 3, 4, or 5 SRCs
● > or= 6 SRCs

From Science to Solutions™

0 100 200 400 600 800
Feet

Figure 4-5

Distribution of Detected Inorganics Above Background Levels in Sediment

Drawn By: HRA

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/September/14

Z:\PUBLIC\RVAAP PBC 2005\GIS\ODA2_figure_revisions\ODA2_Fig_4_5.mxd

5.0 CONTAMINANT FATE AND TRANSPORT

5.1 INTRODUCTION

This section describes the potential migration pathways and mechanisms for transport of chemical substances found in surface and subsurface soils and groundwater at ODA2. Computer-based contaminant fate and transport analyses were performed to predict the rate of contaminant migration in the identified primary transport media and to project likely future contaminant concentrations at receptor locations through these media. The ultimate objectives of these analyses are to evaluate potential future impacts to human health and the environment and to provide a basis for evaluating the effectiveness of the future remedial alternatives.

Fate and transport modeling was used to simulate vertical transport of contaminants from a principal source area containing maximum observed contaminants in soil to groundwater, as well as horizontal transport within the groundwater system from the source area to receptor locations. A summary of the principles of contaminant fate and transport is presented in this section along with the results of modeling activities. Section 5.2 describes the physical and chemical properties of the SRCs (including metals, organic compounds, and explosives found at ODA2). Section 5.3 presents a SCM for contaminant fate and transport at ODA2 that considers site topography, hydrogeology, contaminant sources, and release mechanisms through the transport media. Section 5.4 presents a soil leachability analysis to identify CMCOPCs. Sections 5.5 describes the fate and transport modeling. The summary and conclusions of the fate and transport analyses are presented in Section 5.6.

5.2 PHYSICAL AND CHEMICAL PROPERTIES OF SRCs

Inorganic and organic constituents in soil and groundwater are in continuous chemical and physical interaction with ambient surface and subsurface environments. The observed distributions of chemical concentrations in the environment are the result of these interactions. These interactions also determine the chemical fate of these materials in the transport media. Chemicals released into the environment are susceptible to several degradation pathways including hydrolysis, oxidation, reduction, isomerization, photolysis, photo-oxidation, biotransformation, and biodegradation. Transformation products resulting from these processes will behave distinctively in the environment.

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

The physical properties of the chemical constituents that were detected in the transport media at ODA2 are summarized in Tables M-1, M-2, and M-3 of Appendix M. The properties are used to assess the anticipated behavior of each compound under environmental conditions.

5.2.1 Chemical Factors Affecting Fate and Transport

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

The octanol-water partition coefficient (K_{ow}) can be used to estimate the tendency for a chemical to partition between environmental phases of different polarity. The K_{ow} is a laboratory-determined ratio of the concentration of a chemical in the n-octanol phase of a two-phase system to the concentration in the water phase. Compounds with log K_{ow} values less than 1 are highly hydrophilic, while compounds with log K_{ow} values greater than 4 will partition to soil particles (Lyman, Reehl, and Rosenblatt 1990).

The water/organic carbon partition coefficient (K_{oc}) is a measure of the tendency of a compound to partition between soil and water. The K_{oc} is defined as the ratio of the absorbed compound per unit weight of organic carbon to the aqueous solute concentration. This coefficient can be used to estimate the degree to which a compound will adsorb to soil and, thus, not migrate with groundwater. Compounds with higher K_{oc} values have a greater tendency to partition into soil. The sorption coefficient (K_d) is calculated by multiplying the K_{oc} value by the fraction of organic carbon in the soil.

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

The Henry's Law Constant value (KH) for a compound is a measure of the ratio of the compound's vapor pressure to its aqueous solubility. The KH value can be used to make general predictions about the compound’s tendency to volatilize from water. Substances with KH values less than 10^{-7} atm-m^3/mol will generally volatilize slowly, while compounds with a KH greater than 10^{-3} atm-m^3/mol will volatilize rapidly (Lyman, Reehl, and Rosenblatt 1990).

5.2.2 Biodegradation

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

$$-dC/dt = kC \tag{5-1}$$

where

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

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

5.2.3 Inorganic Compounds

Inorganic constituents detected in soil samples at ODA2 are associated with both the aqueous phase and with leachable metal ions on soil particles. The transport of these materials from unsaturated soils to the underlying groundwater is controlled by the physical processes of precipitation, infiltration, chemical interaction with the soil, and downward transport of removed metal ions by continued infiltration. The chemistry of inorganic interaction with percolating precipitation and varying soil conditions is complex and includes numerous chemical transformations that may result in altered oxidation states, ion exchange, adsorption, precipitation, or complexation. The chemical reactions, which are affected by environmental conditions including pH, oxidation/reduction conditions, and the type and amount of organic matter, clay, and the presence of hydrous oxides, may act to enhance or reduce the mobility and toxicity of the metal ions. In general, these reactions are reversible and add to the variability commonly observed in distributions of inorganics in soil.

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

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

The attenuation of metal ions in the environment can be estimated numerically using the retardation factor (R_d). The extent to which the velocity of the contaminant is slowed is largely derived from the soil/water partitioning coefficient (K_d). The retardation factor is calculated using the following equation:

$$R_d = 1 + (K_d \rho_b)/\phi_w \qquad \textbf{(5-2)}$$

where

ρb = the soil bulk dry density, (g/cm^3),
ϕw = soil moisture content, (dimensionless).

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

5.2.4 Organic Compounds

Organic compounds, such as SVOCs and VOCs, detected in soil, sediment, or water at ODA2 may be transformed or degraded in the environment by various processes, including hydrolysis, oxidation/reduction, photolysis, volatilization, biodegradation, or biotransformation. The half-life of organic compounds in the transport media can vary from minutes to years, depending on environmental conditions and the chemical structures of the compounds. Some types of organic compounds are very stable, and degradation rates can be very slow. Organic degradation may either enhance (through the production of more toxic byproducts) or reduce (through concentration reduction) the toxicity of a chemical in the environment.

5.2.5 Explosives – Related Compounds

Explosive compounds were detected in soil at ODA2. With regard to these compounds, microbiological and photochemical transformation may affect the fate and distribution of this class of constituents in the environment as well. For example, based on the results of culture studies involving the removal of TNT by activated sludge microorganisms, it has been concluded that TNT undergoes biotransformation, but not biodegradation (Burrows et al. 1989). It has been found (Funk et al. 1993) that the anaerobic metabolism occurs in two stages. The first stage is the reductive stage in which TNT is reduced to its amino derivatives. In the second stage, degradation to non-aromatic products begins after the reduction of the third nitro group.

The biotransformation pathway for TNT in simulated composting systems is shown on Figure 5-1 (Kaplan and Kaplan 1990). The biotransformation of 2,4-dinitrotoluene (DNT) has been systematically studied in laboratory cell cultures. The pathway proposal for this biotransformation is shown in Figure 5-2. The reduction products include the amino and azoxy derivatives as observed with TNT biotransformation. As with TNT and DNT, the principal mode of microbial transformation of the nitroaromatic compounds trinitrobenzene and 1,3-dinitrobenzene is reduction of nitro groups to form amino groups.

Limited information exists regarding biotransformation or biodegradation of RDX. One pilot, study being conducted by the USACE evaluating treatment of pinkwater wastes using an anaerobic fluidized-bed granular activated carbon bioreactor, indicated RDX biodegradation in the presence of ethanol. Such data may be useful for evaluating potential use of enhanced bioremediation as a remedial option.

5.3 CONCEPTUAL MODEL FOR FATE AND TRANSPORT

To effectively represent site-specific conditions in numerical modeling applications, the SCM is relied upon to provide inputs on site conditions that serve as the framework for quantitative modeling. Site conditions described by the SCM, include contaminant source information, the surrounding geologic and hydrologic conditions, and the magnitude of SRCs and their current spatial distribution. This information is used to identify chemical migration pathways at ODA2 for fate and transport analysis. The predictive function of the SCM, which is of primary importance to contaminant fate and transport analysis, relies on known information and informed assumptions about the site. Assumptions contained in the SCM are reiterated throughout this section. The better the information and the greater the accuracy of the assumptions, the more accurately the SCM describes the AOC and, therefore, the more reliable the numerical modeling predictions can be.
A summary of the salient elements of the SCM that apply to fate and transport modeling is below.

5.3.1 Contaminant Sources

Based on the analysis of the field data, the following contaminant sources have been identified.

- Metals and explosive residues are present primarily in the surface/subsurface soil below the footprint of Areas A and B. Area A is to the north of Sand Creek (not including the RCRA area), while Area B is the southern flood plain area downgradient of Rocket Ridge to the south of Sand Creek (Figure 5-3). Numerous inorganic SRCs are identified in these areas: antimony, arsenic, barium, beryllium, cadmium, chromium (total), copper, lead, manganese, mercury, nickel, selenium, and zinc were most pervasive. Organic SRCs identified are acetone, tetrachloroethene (PCE), toluene, bis(2-ethylhexyl) phthalate, di-n-butyl phthalate, and n-nitrosodiphenylamine. Explosive SRCs identified are 2-amino-4,6-DNT; 4-amino-2,6-DNT; 2,4-DNT; octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine; RDX; tetryl; and 2,4,6-TNT.

- Metals and explosive residues are present in the groundwater below Areas A and B. Inorganic SRCs identified in the groundwater are aluminum, arsenic, barium, chromium, cobalt, copper, lead, manganese, nickel, vanadium, and zinc. Organics SRCs identified were di-n-butyl phthalate and carbon disulfide. Explosive SRCs identified are nitrocellulose and RDX.

5.3.2 Hydrogeology

A complete description of the site geology and hydrogeology is provided in Section 2.0 and is summarized below.

- Elevations across ODA2 vary from approximately 314 to 326 meters (1,030 to 1,071 feet) above mean sea level. In general, the land surface slopes from the north to the south towards Sand Creek over Area A, while it slopes in the reverse direction over Area B.

- Soil composition varies across ODA2; poorly graded sand with silty clay and gravel, lean clay with sand, and sandy silty clay were encountered in the borings reported in the geotechnical summary. The deepest boring was drilled to a depth of 7 meters (23 feet).

- Groundwater flows, consistent with regional drainage patterns, towards Sand Creek. The flow is to the south over Area A, while it is to the north over Area B. The depths to groundwater table varied from 3.5 to 22.2 feet on April 3, 2002.

- Contaminant concentrations are highest within a discrete zone (0- to 0.3-m [0- to 1-feet] surface soil interval). Contaminant leaching pathways from soil to the water table are through the soil cover.

5.3.3 Contaminant Release Mechanisms and Migration Pathways

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

Water infiltrating through contaminated surface soils may leach contaminants into the groundwater. The factors that affect the leaching rate include a contaminant's solubility, K_d, and the amount of infiltration. Insoluble compounds will precipitate out of solution in the subsurface or remain in their insoluble forms with little leaching. For the contaminants detected at ODA2, sorption processes and the K_d generally will have the greatest effect on leaching. Another factor that affects whether a contaminant will reach the water table through infiltration of rainwater is the contaminant’s rate of decay. Most of the organic and explosives compounds decay at characteristic rates that are described by the substance’s half-life. For a given percolation rate, those contaminants with long half-lives have a greater potential for contaminating groundwater than those with shorter half-lives.

Release by gaseous emissions and airborne particulates is not significant at ODA2. VOCs were not found at significant concentrations in surface soil as they had already volatilized; therefore, there is likely little to no gaseous emission and contaminant levels in the air pathway are minor to nonexistent.

5.3.4 Water Balance

The potential for contaminant transport begins with precipitation. Infiltration is the driving mechanism for leaching of soil contaminants to groundwater. The actual amount of rainwater available for flow and infiltration to groundwater is highly variable and dependent upon soil type and climatic conditions. A water balance calculation can be used as a tool to quantitatively account for all the components of the hydrologic cycle at ODA2. The quantified elements of the water balance are used for inputs to the soil leaching and groundwater transport models discussed later. The components of a simple steady-state water balance model include precipitation (P), evapotranspiration (ET), surface runoff (Sr), and groundwater recharge or percolation (Gr). These terms are defined as follows:

$$P = ET + Sr + Gr \tag{5-3}$$

or

$$\text{Rainwater available for flow} = Sr + Gr = P - ET \tag{5-4}$$

A relatively moderate amount of runoff occurs from the site. It is expected that loss of runoff occurs in the form of evaporation. The remaining water after runoff is infiltration, which includes loss to the atmosphere by evapotranspiration. The water balance estimations were developed using the Hydrologic Evaluation of Landfill Performance model (Schroeder et al. 1994) calculations for ODA2 site conditions using precipitation and temperature data for the 100-year period generated synthetically using coefficients for Cleveland, Ohio.

The annual average water balance estimates for ODA2 indicate an evapotranspiration of 28% (0.26 meters [10.3 in]) of total precipitation (0.94 meters [37 in]). The remaining 72% (0.68 meters [27 in]) of rainwater is available for surface water runoff and infiltration to groundwater. Of the 0.68 meters (27 in) of rainwater available for runoff or infiltration, groundwater recharge (infiltration) accounts for 10% (0.095 meters [3.7 in]), and surface runoff accounts for the remaining 62% (0.60 meters [23 in]).

5.3.5 Natural Attenuation of Contaminants in ODA2

Natural attenuation accounting for advection, dispersion, sorption, volatilization, and decay effects can effectively reduce contaminant toxicity, mobility, or volume (mass) to levels that are protective of human health and the ecosystem within an acceptable, site-specific time period. Therefore, natural attenuation as a remedial alternative has become a cost-effective approach to site remediation. The overburden materials at ODA2 generally have sufficient organic carbon content to cause retardation of organic constituents. In addition, the clay mineralogy results in significant cation retardation of inorganic constituents by adsorption reactions. Attenuation through adsorption occurs in the vadose zone because of higher organic carbon and clay content in the overburden materials. However, the available data collected to date do not allow quantification of natural attenuation. A focused investigation would be required to quantify natural attenuation at this site and to determine if it would be a viable potential remedial approach.

5.4 SOIL LEACHABILITY ANALYSIS

Soil leachability analysis is a screening analysis performed to define CMCOPCs. The CMCOPCs are defined as the constituents that may pose the greatest problem if they are migrating from a specified source.

5.4.1 Soil Screening Analysis

The first step of the soil screening analysis is the identification of SRCs, as discussed in Section 4.0. The chemical data in soils were separated into two area aggregates and screened using frequency of detection and RVAAP facility-wide background criteria to identify SRCs. The two aggregates are as follows:

- Area A – the area north of Sand Creek, not including the RCRA area; and
- Area B – the southern flood plain area downgradient of Rocket Ridge to the south of Sand Creek.

The second step of the soil screening analysis is development of the source-specific soil exposure concentrations. The soil exposure concentration of a contaminant in an aggregate represents the 95% upper confidence limit (UCL_{95}) developed using results of all the soil samples within the aggregate, or the maximum value if the UCL_{95} exceeds the maximum.

In the third step of the soil screening analysis, the soil exposure concentrations of all identified SRCs are compared with U. S. Environmental Protection Agency (USEPA) generic soil screening levels (GSSLs). The GSSLs are set for Superfund sites for the migration to groundwater pathway (USEPA 1996). A dilution attenuation factor (DAF) of 1.0 was used following USEPA guidelines (1996) and applied to the GSSLs. The GSSL is defined as the concentration of a contaminant in soil that represents a level of contamination below which there is no concern under the Comprehensive Environmental Response, Compensation, and Liability Act, provided conditions associated with GSSLs are met. Generally, if contaminant concentrations in soil fall below the GSSL, and there are no significant ecological receptors of concern, then no further study or action is warranted for that area. However, it should be noted that the purpose of this screen is not to identify the contaminants that may pose risk at downgradient locations, but to target those contaminants that may pose the greatest problem if they are migrating from the site. When the GSSL for an SRC was not available from USEPA (1996), a calculated GSSL was developed using the following equation (USEPA 1996):

$$C_s = C_w \left\{ K_d + \frac{\theta_w + \theta_a \ K_H}{\rho_b} \right\} \quad \textbf{(5-5)}$$

where

C_w = target groundwater concentration (mg/L),
C_s = calculated soil screening level (GSSL) (mg/kg),
K_d = soil adsorption coefficient (L/Kg),
K_H = Henry's Law Constant (unitless),
ρ_b = dry soil bulk density (kg/L),
θ_w = water-filled soil porosity (volume percent),
θ_a = air-filled soil porosity (volume percent).

Default values, as used by USEPA (1996) to develop the GSSLs, were used in the calculations. Non-zero maximum containment levels (MCLs) or risk-based concentrations (RBCs) for groundwater were used for target groundwater concentrations. Based on this screening, only those constituents that exceeded their published or calculated GSSL multiplied by the DAF were identified as the initial (preliminary) CMCOPCs, based on leaching to groundwater. These initial CMCOPCs, illustrated on Table M-6 in Appendix M, include metals, explosive compounds, and VOCs.

In the fourth step, the initial CMCOPCs from ODA2 were further evaluated using fate and transport models provided in Section 5.5.

5.4.2 Limitations and Assumptions of Soil Screening Analysis

It is important to recognize that acceptable soil concentrations for individual chemicals are highly site-specific. The GSSLs used in this screening are based on a number of default assumptions chosen to be protective of human health for most site conditions (USEPA 1996). These GSSLs are expected to be more conservative than site-specific screening levels based on site geotechnical conditions. The conservative assumptions included in this analysis are: (1) no adsorption in the unsaturated zone or in the aquifer, (2) no biological or chemical degradation in the soil or in the aquifer, and (3) contamination is uniformly distributed throughout the source. However, the GSSL does not incorporate the existence of contamination already present in the aquifer. In any case, to evaluate the contaminant migration potential from the source areas, a GSSL screen can be used as an effective tool.

5.5 FATE AND TRANSPORT MODELING

Contaminant fate and transport modeling is based on the conceptual model for ODA2, as was discussed in Section 5.3. Seasonal Soil Compartment (SESOIL) modeling was performed for constituents identified as CMCOPCs from the selected source (see Section 5.5.2). The modeling was performed to predict concentrations of a constituent in the leachate immediately beneath the selected source area just above the water table. If the predicted leachate concentration of a CMCOPC exceeded its MCL or RBC, then lateral migration using the Analytical Transient 1-, 2-, 3-Dimensional (AT123D) model (see Section 5.5.2) was performed to predict the groundwater concentrations at designated receptor locations. The receptor locations identified for the selected source area are

(1) the water table immediately below the source and

(2) Sand Creek at its closest point downgradient of the source area.

5.5.1 Modeling Approach

Contaminant transport in the vadose zone includes the movement of water and dissolved materials from the source area at ODA2 to groundwater. This occurs as rainwater infiltrates from the surface and percolates through the area of contamination, and its surrounding soil, into the saturated zone. The downward movement of water, driven by gravitational potential, capillary pressure, and other components of total fluid potential, mobilizes the contaminants and carries them through the vadose zone. Lateral transport is controlled by the regional groundwater gradient. Vertical transport down through the vadose zone to the water table and the horizontal transport through the glacial deposits to the downgradient locations are illustrated in Figure 5-4.

The output of the contaminant fate and transport modeling is presented as the expected maximum concentration of modeled contaminants at the selected receptor locations. For SESOIL, the receptor location was the groundwater table beneath the source area. For lateral transport using AT123D modeling, the receptor location is Sand Creek downgradient of the source area. The modeling results allow prediction of the approximate locations of future maximum concentrations resulting from the integration of the contributions from multiple sources and different pathways.

Once the leachate modeling for the source area was completed using the SESOIL model, the predicted maximum groundwater concentrations beneath the source area were determined using the AT123D model, and the concentrations were compared against the existing groundwater concentrations at the source area. The greater of the predicted or observed concentration in the groundwater was compared against the respective MCLs or RBCs. If the predicted or measured maximum groundwater concentrations were higher than the MCLs or RBCs, groundwater modeling was performed using the higher concentration as the source term concentration. If the predicted and actual concentrations were less than the MCLs or RBCs, the contaminant was eliminated from the list of CMCOPCs, and no further evaluations were performed.

5.5.2 Model Applications

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

5.5.2.1 SESOIL Modeling

The SESOIL model defines the soil compartment as a soil column extending from the ground surface through the unsaturated zone and to the upper level of the saturated soil zone. Processes simulated in SESOIL are categorized in three cycles: the hydrologic cycle, sediment cycle, and pollutant cycle. Each cycle is a separate submodule in the SESOIL code. The hydrologic cycle includes rainfall, surface runoff, infiltration, soil-water content, evapotranspiration, and groundwater recharge. The pollutant cycle includes convective transport, volatilization, adsorption/desorption, and degradation/decay. A contaminant in SESOIL can partition in up to four phases (liquid, adsorbed, air, and pure). The sediment washload cycle includes erosion and sediment transport. However, erosional transport of contaminants at this site was not considered a viable pathway of contaminant transport; therefore, this model was not used.

Data requirements for SESOIL are not extensive, utilizing a minimum of site-specific soil and chemical parameters and monthly or seasonal meteorological values as input. Output of the SESOIL model includes pollutant concentrations at various soil depths and pollutant loss from the unsaturated soil zone in terms of surface runoff, percolation to groundwater, volatilization, and degradation. The mathematical representations in SESOIL generally consider the rate at which the modeled processes occur, the interaction of different processes with each other, and the initial conditions of both the waste area and the surrounding subsurface matrix material.

SESOIL simulation for a contaminant was performed over a 1,000-year period. The period was selected considering the voluminous output and the lengthy time required to complete a simulation for a longer period of time. Also, USEPA suggested a screening value of 1,000 years to be used due to the high uncertainty associated with predicting conditions beyond that time frame. Therefore, the initial CMCOPCs at the selected source were screened against a travel time of greater than 1,000, and, to be conservative, the travel time selected for screening was 1,500 years. The travel time is the time required by a contaminant to travel from the base of its contamination to the water table. The estimated travel time for each initial CMCOPC to reach the water table is determined using the following equation:

$$T_r = \frac{T_h \times R_d}{V_p} \qquad \textbf{(5-6)}$$

where

T_t = leachate travel time (year),
T_h = thickness of attenuation zone (feet),
R_d = retardation factor (dimensionless) (Equation 5-2),
V_p = porewater velocity (feet/year).

and

$$V_p = \frac{I}{\theta} \tag{5-7}$$

where

I = infiltration rate (feet/year),

θ = fraction of total porosity that is filled by water.

If the source depth for a constituent is equal to the thickness of the vadose zone, the constituent is determined to have a travel time equal to zero using the above equations (i.e., no leaching zone). The estimated travel time is then compared to a screening value. If the travel time for a constituent from a source area exceeded 1,500 years, then the constituent was eliminated from the list of CMCOPCs. Initial CMCOPCs with travel times less than 1,500 years are considered to be COPC and are selected for further analysis.

Details of the model layers utilized in this modeling are presented in Tables M-9, M-10, and M-11 of Appendix M. The model was calibrated against the percolation rate by varying the intrinsic permeability and by keeping all other site-specific geotechnical parameters fixed. The final site-specific hydrogeologic parameter values used in this modeling are shown in Table 5-1. The intrinsic permeability was derived during calibration of the model to a percolation rate of 0.095 m/year. The chemical-specific parameters are presented in Appendix M (Table M-3). The K_ds for metals were obtained from USEPA's Soil Screening Guidance Document (USEPA 1996), unless stated otherwise. The K_ds for organic compounds were estimated from K_{oc} using the relationship $K_d = (f_{oc})(K_{oc})$, where f_{oc} = soil organic carbon content as mass fraction obtained from site-specific measurements and K_{oc} values were obtained from USEPA's Soil Screening Guidance Document (USEPA 1996), unless stated otherwise. Biodegradation rates are not applicable for the inorganic CMCOPCs, and the biodegradation values for RDX and tetryl could not be found in the literature (Table M-3). The constituents selected for SESOIL modeling are listed in Table 5-2.

Table 5-1. Unit-Specific Parameters Used in SESOIL and AT123D Modeling for ODA2

Parameters	Symbol	Units	Value	Source for Value
SESOIL				
Percolation Rate (Recharge Rate)	q	m/year	9.45E-02	HELP model
Horizontal Area of Aggregate: Area A	A_p	m^2	7,500	Estimated from soil aggregate
Horizontal Area of Aggregate: Area B	A_p	m^2	3,600	Estimated from soil aggregate
Intrinsic Permeability - clayey sand	p	cm^2	9.8E-11	Calibrated SESOIL model
Disconnectedness Index	c	unitless	10	Calibrated from SESOIL model
Freundlich Equation Exponent	n	unitless	1	SESOIL default
Fraction Organic Carbon	f_{oc}	unitless	6.60E-03	Geotech data at Winklepeck Burning Grounds [obtained from Phase III RI Report (USACE, 2005)]
Bulk Density	r_b	kg/L	2	Geotech data (site-specific based on geomean of geotechnical samples collected (see Table 4-4).)
Porosity - total	n_T	unitless	0.25	Geotech data (site-specific based on geomean of geotechnical samples collected (see Table 4-4).)
Vadose Zone Thickness	Vz	m	2.13	Based on water level data
Leaching Zone Thickness	Th	m	1.22	Based on soil contamination and water level data
AT123D				
Aquifer Thickness	h	m	infinite	Assumed aquifer to be deep
Hydraulic Conductivity in Saturated Zone	K_S	cm/s	6.4E-05	Site specific slug test data
Hydraulic Gradient in Saturated Zone	I_S	m/m	5.00E-02	Groundwater surface map (from data collected on 8/27/02)[a]
Effective Porosity	n_e	unitless	0.1	Assumed for sandstone
Distance to the compliance point: Area A	X	m	61	Shortest downgradient distance to stream boundary from source center
Distance to the compliance point: Area B	X	m	55	Shortest downgradient distance to stream boundary from source center
Dispersivity, longitudinal	a_L	m	10	Assumed
Dispersivity, transverse	a_T	m	3	0.3 a_L
Dispersivity, vertical	a_V	m	1	0.1 a_L
Retardation Factor	R_d	unitless	chemical-specific	See Table M-7

AT123D = Analytical Transient 1-, 2-, 3-Dimensional model.
HELP = Hydrologic Evaluation of Landfill Performance model.
SESOIL = Seasonal Soil Compartment model.
[a] The hydraulic gradient was extimated to range form 0.035 to 0.050 across the site.

Table 5-2. Summary of Leachate Modeling Results for ODA2

Initial CMCOPC	RME		Predicted $C_{leachate,max}$ Beneath the Source (mg/L)	Predicted Tmax (years)	Predicted $C_{gw,max}$ At the Source[a] (mg/L)	Observed $C_{gw,max}$ Downgradient of Source (mg/L)	MCL/RBC (mg/L)	Final CMCOPC[b]
	0 to 1 feet (mg/kg)	1 to 3 feet (mg/kg)						
Area A								
Explosives								
Tetryl	N/A	0.18	6.15E-01	6	1.36E-01	N/A	3.60E-01	No
Inorganics								
Arsenic	1.99E+01	1.63E+01	8.25E-01	529	3.98E-01	1.35E-02	1.00E-02	Yes
Barium	1.68E+02	2.03E+02	6.41E+00	743	3.15E+00	1.22E-01	2.00E+00	Yes
Chromium	1.73E+01	2.23E+01	1.47E+00	345	6.93E-01	1.35E-02	1.00E-01	Yes
Chromium, Hexavalent	N/A	2.30E+01	1.15E+00	340	5.37E-01	1.20E-01	1.00E-01	Yes
Copper	1.22E+02	1.52E+02	5.55E+00	636	2.70E+00	1.94E-02	1.30E+00	Yes
Organic-Volatiles								
Tetrachloroethylene	4.20E-03	N/A	1.00E-10	34	3.05E-11	N/A	5.00E-03	No
Area B								
Explosives								
2,4-Dinitrotoluene	N/A	5.60E-02	2.39E-05	12	5.52E-08	N/A	7.30E-02	No
RDX	N/A	2.56E-01	1.83E+00	3	4.11E-02	4.80E-04	6.10E-04	Yes
Tetryl	2.30E+00	2.20E+01	7.40E+01	6	1.65E+01	N/A	3.60E-01	Yes
Inorganics								
Antimony	1.21E+00	1.24E+00	3.62E-02	816	1.67E-02	N/A	6.00E-03	Yes
Barium	1.23E+02	1.17E+02	3.90E+00	743	1.79E+00	1.22E-01	2.00E+00	No
Chromium	6.08E+01	1.39E+01	1.99E+00	353	8.71E-01	1.35E-02	1.00E-01	Yes
Chromium, Hexavalent	2.80E+01	1.60E+01	1.39E+00	347	6.08E-01	1.20E-01	1.00E-01	Yes
Copper	1.21E+03	3.08E+02	2.18E+01	646	9.91E+00	1.94E-02	1.30E+00	Yes
Selenium	1.23E+00	1.01E+00	2.94E-01	93	1.04E-01	N/A	5.00E-02	Yes
Organic-Volatiles								
Tetrachloroethylene	3.70E-03	N/A	1.00E-10	34	2.89E-11	N/A	5.00E-03	No

N/A = Not available.

[a] The predicted maximum concentration in groundwater ($C_{gw,max}$) at the source was calculated using the AT123D model based on contaminant loading predicted by SESOIL.

[b] A constituent is a final CMCOPC if it reaches the water table within 1,000 years and its predicted concentration in groundwater exceeds its MCL/RBC.

CMCOPC = Contaminant migration contaminant of potential concern.

MCL = Maximum contaminant level.

RBC = Risk-based concentration.

RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.

RME = Reasonable maximum exposure.

5.5.2.2 AT123D Modeling in the Saturated Zone

The fate and transport processes accounted for in the AT123D model include advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in three dimensions in the groundwater resulting from a mass release over a source area (point, line, area, or volume source). The model can handle instantaneous, as well as continuous, source loadings of chemicals of interest at the site. AT123D is frequently used by the scientific and technical community to perform quick and conservative estimates of groundwater plume movement in space and time. SESOIL and AT123D are linked in a software package (RISKPRO) so that mass loading to the groundwater predicted by SESOIL can be directly transferred to AT123D. Therefore, AT123D was chosen to predict the future receptor concentrations for the contaminants.

The hydrogeologic parameter values used in this modeling are shown in Table 5-1. The chemical-specific parameters are presented in meters (Table M-15). A discussion of model assumptions and limitations is presented in Section 5.5.4. The constituents selected for this modeling are listed in Table 5-3, along with the results of the modeling. The CMCOPCs in this table represent all of the constituents that were identified as final CMCOPCs based on leachate modeling (SESOIL), plus any additional constituents currently observed in groundwater exceeding their respective MCL or RBC. Constituents for which the predicted maximum groundwater concentration exceeded the MCL or RBC at a receptor location were identified as the contaminant migration chemicals of concern (CMCOCs).

Table 5-3. Summary of Groundwater Modeling Results for ODA2

CMCOPC	Source Concentration[a] (mg/L)	Receptor Concentration Sand Creek (mg/L)	MCL/RBC (mg/L)	CMCOC[b]
Area A				
Inorganics				
Arsenic	3.98E-01	3.77E-01	1.00E-02	Yes
Barium	3.15E+00	2.92E+00	2.00E+00	Yes
Chromium	6.93E-01	6.72E-01	1.00E-01	Yes
Chromium, Hexavalent	5.37E-01	5.23E-01	1.00E-01	Yes
Copper	2.70E+00	2.53E+00	1.30E+00	Yes
Manganese[c]	1.09E+00	9.12E-02	8.76E-01	No
Area B				
Explosives				
RDX	4.11E-02	1.29E-01	6.10E-04	Yes
Tetryl	1.65E+01	1.47E+01	3.60E-01	Yes
Inorganics				
Antimony	1.67E-02	1.45E-02	6.00E-03	Yes
Chromium	8.71E-01	7.99E-01	1.00E-01	Yes
Chromium, Hexavalent	6.08E-01	5.58E-01	1.00E-01	Yes
Copper	9.91E+00	8.73E+00	1.30E+00	Yes
Selenium	1.04E-01	1.04E-01	5.00E-02	Yes

[a]The predicted maximum concentration in groundwater ($C_{gw,max}$) at the source was calculated using the AT123D model based on contaminant loading predicted by SESOIL.
[b]A constituent is a CMCOC if its predicted groundwater concentration at the compliance point/receptor exceeds its MCL/RBC.
[c]The source concentration for this constituent is based on observed maximum groundwater concentration.
CMCOC = Contaminant migration contaminant of concern.
CMCOPC = Contaminant migration contaminant of potential concern.
MCL = Maximum contaminant level.
RBC = Risk-based concentration.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.

5.5.3 Modeling Results

SESOIL modeling was performed for initial CMCOPCs (Table 5-2). The modeling was performed for tetryl, arsenic, barium, chromium, chromium (hexavalent), copper, and PCE for Area A and for 2,4-DNT; RDX; tetryl; antimony; barium; chromium; chromium (hexavalent); copper; selenium; and PCE for Area B. Table 5-2 presents the predicted peak leachate and groundwater concentrations beneath the source area and the corresponding time for peak leachate concentrations. In addition, this table presents, for comparison, the current observed maximum concentrations in the groundwater downgradient of the source and drinking water MCLs or RBCs (if no MCL is available). Due to the variable groundwater gradient at the site, all wells were considered downgradient from the source so that the highest groundwater concentration measured was taken as the downgradient groundwater concentration. The table shows that arsenic, antimony, barium, chromium, chromium (hexavalent), copper, selenium, RDX, and tetryl were predicted to exceed MCLs or RBCs beneath the source area. In addition, based on observed groundwater concentrations at the site, arsenic, chromium (hexavalent), and manganese exceeded their respective MCL/RBC (Table M-13). Therefore, these constituents combined with the list from SESOIL modeling (Table 5-2) were selected as final CMCOPCs for lateral migration using AT123D (Table M-14).

AT123D modeling was performed for all the CMCOPCs shown in Table M-14. The groundwater source concentrations for AT123D modeling inputs were set equal to the SESOIL-predicted groundwater concentration beneath the source for all these constituents except manganese. For manganese, the maximum observed concentration in groundwater was used as the source term for AT123D modeling. Table 5-3 presents the predicted groundwater concentration at the selected downgradient receptor locations. All these constituents except manganese were predicted to reach Sand Creek at concentrations exceeding MCLs/RBCs and were identified as CMCOCs.

5.5.4 Limitations/Assumptions

A conservative modeling approach was used, which may overestimate the contaminant concentration in the leachate for migration from observed soil concentrations. Listed below are important assumptions used in this analysis.

- The use of K_d and R_d to describe the reaction term of the transport equation assumes that an equilibrium relationship exists between the solid- and solution-phase concentrations and that the relationship is linear and reversible.

- The K_d values used in this analysis for all the CMCOPCs represent literature or calculated values and may not represent the site conditions, especially in light of the extreme disturbance associated with past usage (trenches and pits) at the AOC.

- Flow and transport in the vadose zone is one-dimensional (i.e., only in the vertical direction).

- Initial condition is disregarded in the vadose zone modeling.

- Flow and transport are not affected by density variations.

- A realistic distribution of soil contamination is not considered.

- No seasonal variation in the groundwater flow direction was considered.

- Contaminant migration from the source to the compliance point is along the shortest line.

The inherent uncertainties associated with using these assumptions must be recognized. K_d values are highly sensitive to changes in the major chemistry of the solution phase. Therefore, it is important that the values be measured or estimated under conditions that will represent as closely as possible those of the contaminant plume. It is also important to note that the contaminant plume will change over time and will be affected by multiple solutes that are present at the site. Projected organic concentrations in the aquifer are uncertain because of the lack of site-specific data on constituent decay in the vadose zone, as well as in the saturated zone. Use of literature values (particularly partition coefficients) may produce either over- or underestimation of constituent concentrations in the aquifer. In this sense, the modeling may not be conservative. Deviations of actual site-specific parameter values from assumed literature values may significantly affect contaminant fate predictions.

The effects of heterogeneity, anisotropy, and spatial distribution of fractures are not addressed in these simulations. The present modeling study using SESOIL and AT123D does not address the effects of flow and contaminant transport across interfaces in rapidly varying heterogeneous media.

For AT123D modeling, the key input parameters are hydraulic conductivity (Ks), hydraulic gradient (Is), effective porosity (ne), and Kd. The Ks, Is, and ne work as a lumped parameter controlling the seepage velocity Vs = Ks*Is/ne. The impact (sensitivity) of Kd is discussed above. The hydraulic gradient is noted to vary over a relatively narrow range below the facility (Table 5-1). Therefore, the impact of hydraulic gradient is expected to be relatively less than that of Ks. In addition, a change in groundwater flow direction will affect the travel distance from the source to the compliance point. Here, groundwater was assumed to flow from the source to the compliance point along the shortest line. This assumption is expected to produce conservative results. The impact of ne can be significant given the presence of fractures in the Sharon Group (Section 2.3.1.2).

5.6 SUMMARY AND CONCLUSION

Based on site characterization and monitoring data, metals, organics, and explosives-related compounds exist in the surface/subsurface at ODA2. Fate and transport modeling using Areas A and B as the selected sources indicate that some of these contaminants may leach from soils to the groundwater beneath the source. Migration of many of the constituents is, however, likely to be attenuated because of moderate to high retardation factors. Conclusions of the leachate and groundwater modeling are as follows.

- 2,4,6-TNT, tetryl, arsenic, barium, cadmium, chromium, chromium (hexavalent), copper, mercury, nickel, and PCE were identified as initial CMCOPCs for Area A based on soil screening analysis.
- 2,4,6-TNT, 2,4-DNT, RDX, tetryl, antimony, barium, cadmium, chromium, chromium (hexavalent), copper, manganese, mercury, nickel, selenium, and PCE were identified as initial CMCOPCs for Area B based on soil screening analysis.
- Arsenic, barium, chromium, chromium (hexavalent), and copper were identified as final CMCOPCs for Area A based on source loading predicted by the SESOIL modeling.
- RDX, tetryl, antimony, chromium, chromium (hexavalent), copper, and selenium were identified as final CMCOPCs for Area B based on source loading predicted by the SESOIL modeling.
- Arsenic, antimony, barium, chromium, chromium (hexavalent), copper, selenium, RDX, and tetryl were identified as CMCOCs based on AT123D modeling. The maximum groundwater concentrations of the constituents were predicted to exceed MCLs/RBCs at Sand Creek at the closest point downgradient of the source areas.

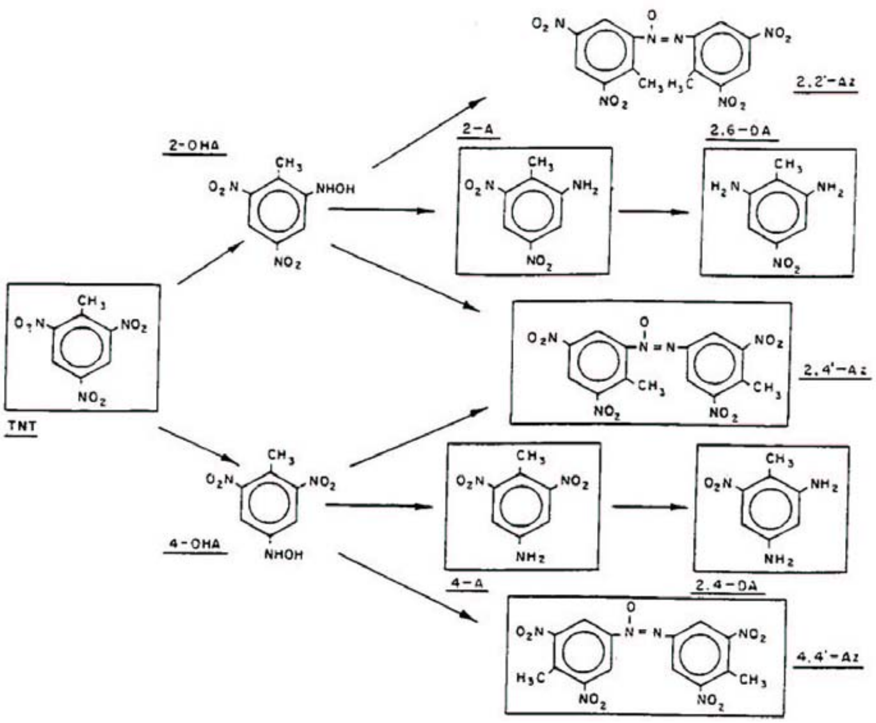


Figure 5-1. 2,4,6-TNT Biotransformation Pathway

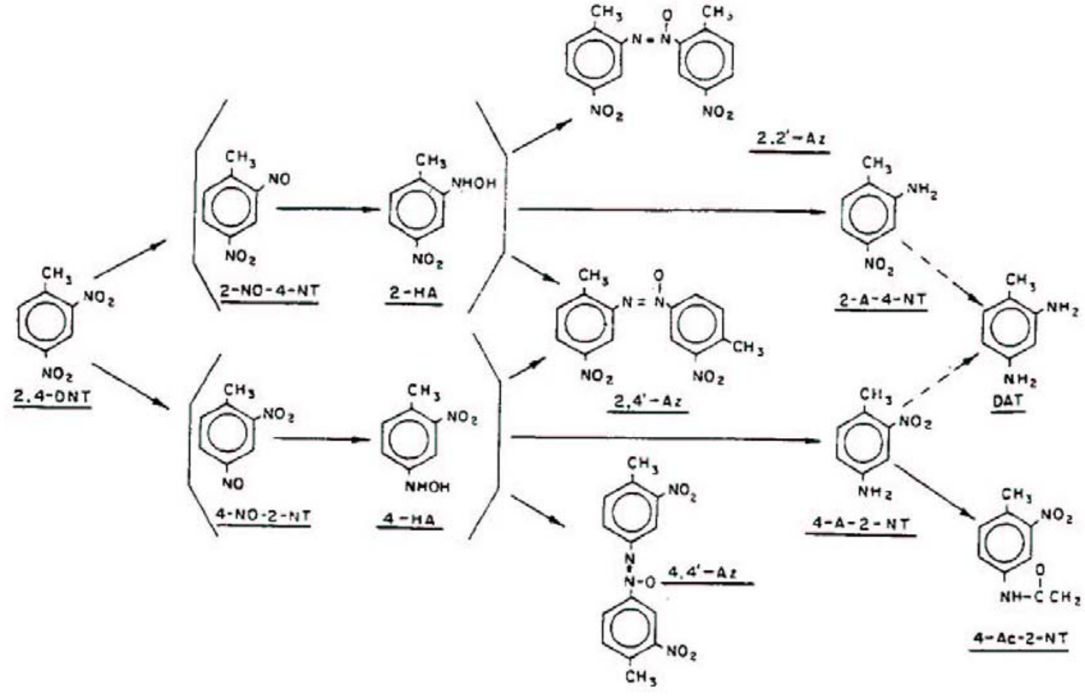


Figure 5-2. 2,4-DNT Biotransformation Pathway

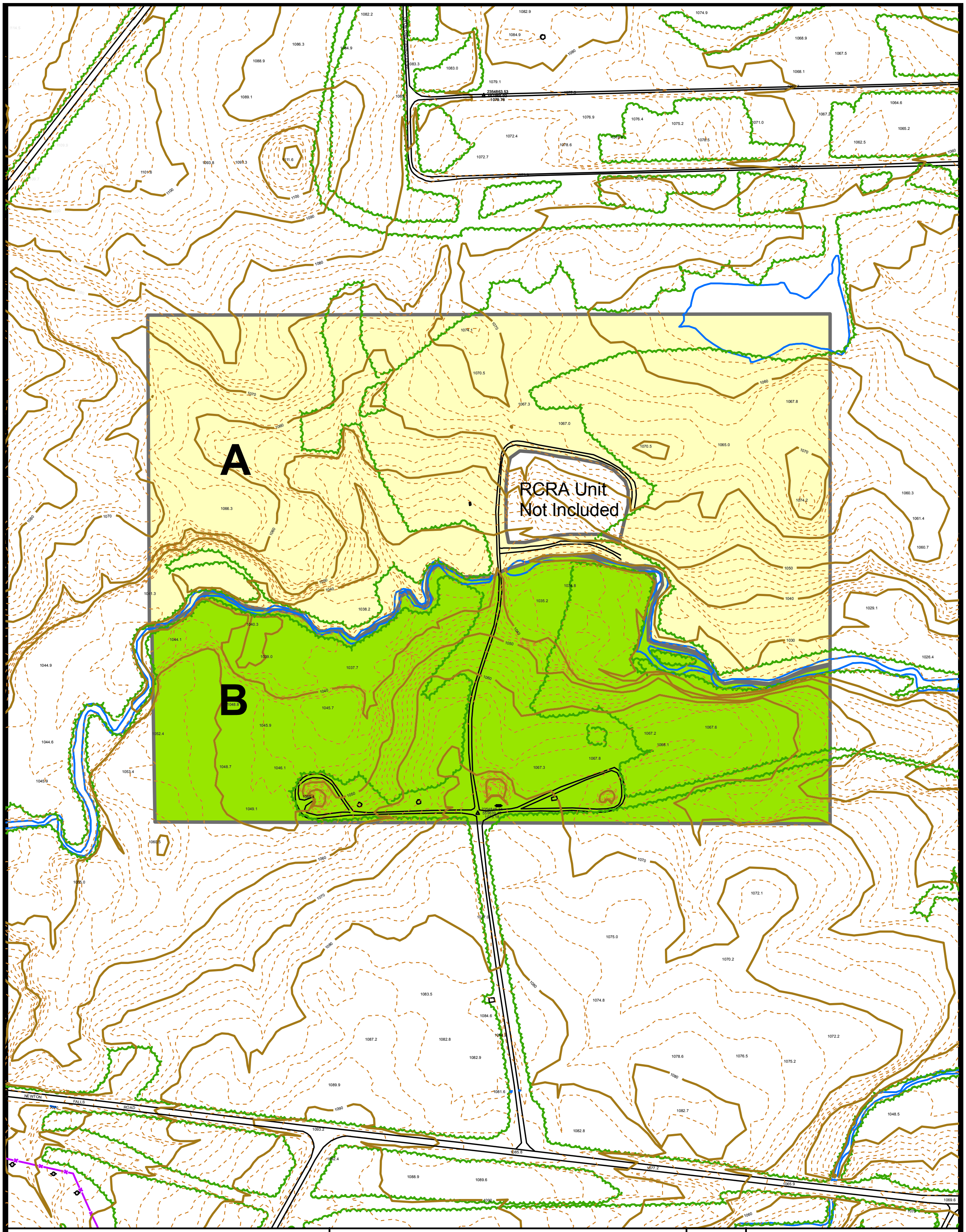


Figure 5-3 Areas A and B at ODA2

LEGEND
- Roads
- Railroads
- Vegetation
- Water
- Fence
- 2' Contour
- 10' Contour
- 🟨 Area A
- 🟩 Area B

0 100 200 400 600 800 Feet

Drawn By: DAC

CAD FILES: R51718/R51617/R41415/R41516

Date: 2005/June/06

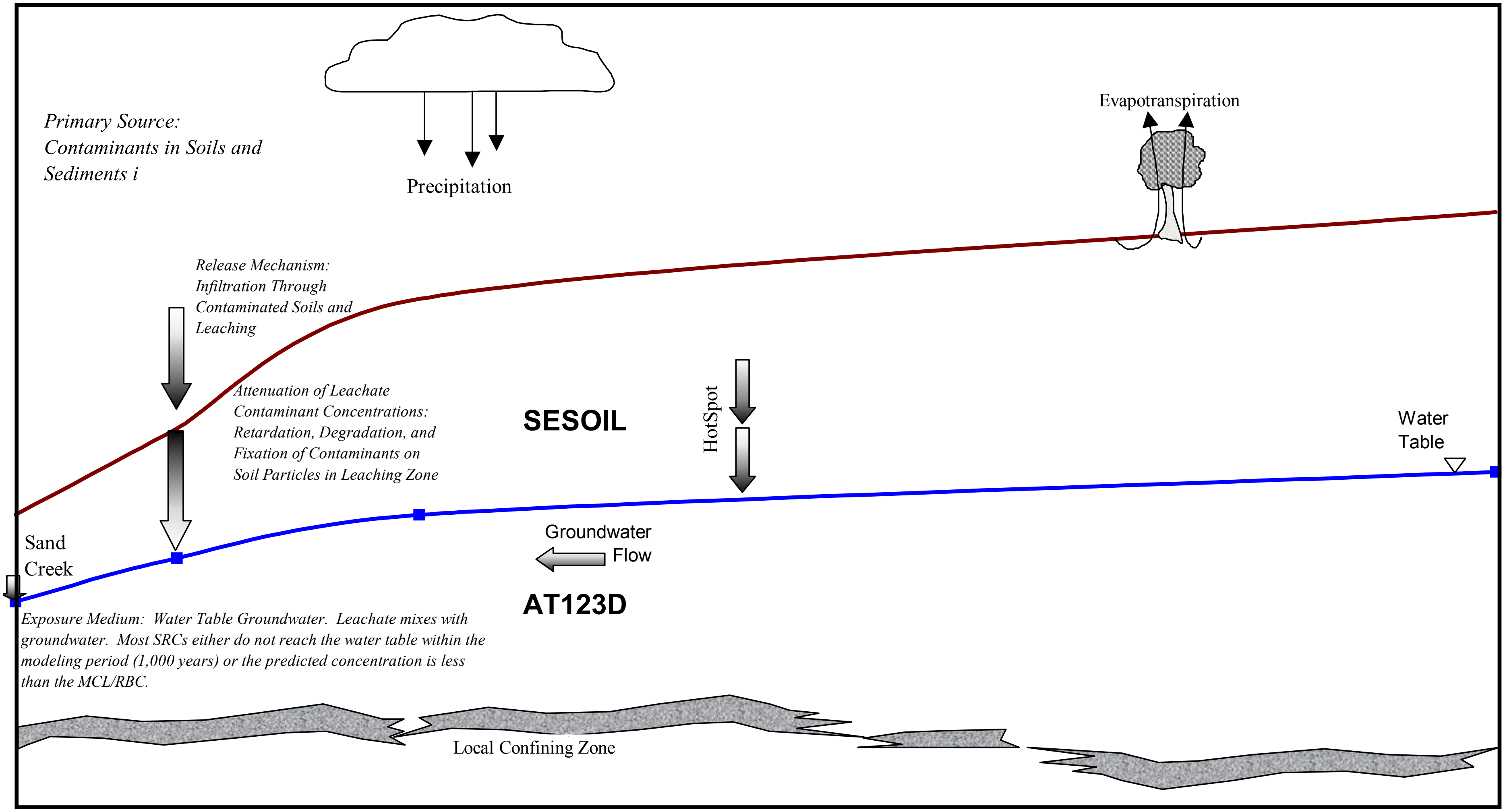


Figure 5-4. Contaminant Migration Conceptual Model

6.0 HUMAN HEALTH RISK ASSESSMENT

6.1 INTRODUCTION

This HHRA documents the potential health risks to humans resulting from exposure to contamination within the ODA2 AOC at RVAAP in Ravenna, Ohio. This HHRA is conducted as part of the Phase II RI and is based on the methods from the *RVAAP's Facility Wide Human Health Risk Assessor Manual* (FWHHRAM) (USACE 2004).

The objective of this HHRA is to evaluate and document the potential risks to human health associated with current and potential future exposures to contaminants if no remedial action is taken. Thus, this assessment represents the risks for the "no-action" alternative in a FS.

This HHRA is conducted per the FWHHRAM (USACE 2004). The methodology presented in the FWHHRAM is based on *Risk Assessment Guidance for Superfund* (RAGS) (USEPA 1989 and 1991) and additional methodology taken from *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (USEPA 2002a); *Exposure Factors Handbook* (USEPA 1997a); Integrated Risk Information System (IRIS) (USEPA 2004, updated approximately monthly); and Health Effects Assessment Summary Tables (HEAST) (USEPA 1997b). The inorganic and organic COPCs identified in this HHRA are quantitatively analyzed (when possible) to characterize the potential risks to human health from exposure to these contaminants. The results of the HHRA are used to (1) document and evaluate risks to human health; (2) determine the need, if any, for remedial action; and (3) identify chemicals of concern (COCs) that may require the development of chemical-specific remediation levels. This HHRA for ODA2 evaluates potential risks for one receptor (an OHARNG Guard/Maintenance Worker) exposed to one environmental medium (surface soil).

This risk assessment is organized into six major sections. The screening process used to identify COPCs is discussed in Section 6.2. The exposure assessment, which is performed to identify the exposure pathways by which receptors may be exposed to contaminants and calculate potential intakes, is presented in Section 6.3. The toxicity assessment for the ODA2 COPCs is presented in Section 6.4. The results of the risk characterization are presented in Section 6.5 and the uncertainty analysis is presented in Section 6.6. Remedial goal options (RGOs) are presented in Section 6.7, and the conclusions of the HHRA are summarized in Section 6.8.

6.2 DATA EVALUATION

The purpose of the data evaluation is to develop a set of chemical data suitable for use in the HHRA. Only Phase II RI data were used quantitatively for risk assessments (Table 6-1). The data obtained during previous investigations were not used quantitatively in the Phase II RI because recent MEC clearance and site grading activities resulted in significant soil disturbance in the area that these samples were taken. Accordingly, the data do not accurately represent current conditions at the AOC. Data are evaluated to establish a list of COPCs using screening criteria.

Table 6-1. Human Health Risk Assessment Data Set for Surface Soil at Open Demolition Area 2

Station	Sample ID	Depth (ft bgs)
DA2MW-104	DA2MW-104-0807-SO	0 - 2
DA2MW-105	DA2MW-105-0811-SO	0 - 2
DA2MW-106	DA2MW-106-0815-SO	0 - 2
DA2MW-107	DA2MW-107-0819-SO	0 - 2
DA2MW-108	DA2MW-108-0823-SO	0 - 2
DA2MW-109	DA2MW-109-0827-SO	0 - 2
DA2MW-110	DA2MW-110-0831-SO	0 - 2
DA2MW-111	DA2MW-111-0835-SO	0 - 2
DA2MW-112	DA2MW-112-0839-SO	0 - 2
DA2MW-113	DA2MW-113-0843-SO	0 - 2
DA2-034	DA2SS-034-0649-SO	0 - 1
DA2-035	DA2SS-035-0651-SO	0 - 1
DA2-036	DA2SS-036-0653-SO	0 - 1
DA2-037	DA2SS-037-0655-SO	0 - 1
DA2-038	DA2SS-038-0657-SO	0 - 1
DA2-039	DA2SS-039-0659-SO	0 - 1
DA2-040	DA2SS-040-0661-SO	0 - 1
DA2-041	DA2SS-041-0663-SO	0 - 1
DA2-042	DA2SS-042-0665-SO	0 - 1
DA2-043	DA2SS-043-0667-SO	0 - 1
DA2-044	DA2SS-044-0669-SO	0 - 1
DA2-045	DA2SS-045-0671-SO	0 - 1
DA2-046	DA2SS-046-0673-SO	0 - 1
DA2-047	DA2SS-047-0675-SO	0 - 1
DA2-048	DA2SS-048-0677-SO	0 - 1
DA2-049	DA2SS-049-0679-SO	0 - 1
DA2-050	DA2SS-050-0681-SO	0 - 1
DA2-051	DA2SS-051-0683-SO	0 - 1
DA2-052	DA2SS-052-0685-SO	0 - 1
DA2-053	DA2SS-053-0687-SO	0 - 1
DA2-054	DA2SS-054-0689-SO	0 - 1
DA2-055	DA2SS-055-0691-SO	0 - 1
DA2-056	DA2SS-056-0693-SO	0 - 1
DA2-057	DA2SS-057-0695-SO	0 - 1
DA2-058	DA2SS-058-0697-SO	0 - 1
DA2-059	DA2SS-059-0699-SO	0 - 1
DA2-060	DA2SS-060-0701-SO	0 - 1
DA2-061	DA2SS-061-0703-SO	0 - 1
DA2-062	DA2SS-062-0705-SO	0 - 1
DA2-063	DA2SS-063-0707-SO	0 - 1
DA2-064	DA2SS-064-0709-SO	0 - 1
DA2-065	DA2SS-065-0711-SO	0 - 1
DA2-066	DA2SS-066-0713-SO	0 - 1
DA2-067	DA2SS-067-0715-SO	0 - 1
DA2-068	DA2SS-068-0717-SO	0 - 1
DA2-069	DA2SS-069-0719-SO	0 - 1
DA2-070	DA2SS-070-0721-SO	0 - 1

Table 6-1. Human Health Risk Assessment Data Set for Surface Soil at Open Demolition Area 2 (continued)

Station	Sample ID	Depth (ft bgs)
DA2-071	DA2SS-071-0723-SO	0 - 1
DA2-072	DA2SS-072-0725-SO	0 - 1
DA2-073	DA2SS-073-0727-SO	0 - 1
DA2-074	DA2SS-074-0729-SO	0 - 1
DA2-075	DA2SS-075-0731-SO	0 - 1
DA2-076	DA2SS-076-0733-SO	0 - 1
DA2-077	DA2SS-077-0735-SO	0 - 1
DA2-078	DA2SS-078-0737-SO	0 - 1
DA2-079	DA2SS-079-0739-SO	0 - 1
DA2-080	DA2SS-080-0741-SO	0 - 1
DA2-081	DA2SS-081-0743-SO	0 - 1
DA2-082	DA2SS-082-0745-SO	0 - 1
DA2-083	DA2SS-083-0747-SO	0 - 1
DA2-084	DA2SS-084-0749-SO	0 - 1
DA2-085	DA2SS-085-0751-SO	0 - 1
DA2-086	DA2SS-086-0753-SO	0 - 1
DA2-092	DA2SS-092-0765-SO	0 - 1
DA2-093	DA2SS-093-0767-SO	0 - 1
DA2-114	DA2SS-114-0870-SO	0 - 1

This section provides a description of the data evaluation process used to identify COPCs for ODA2. The data evaluation process is conducted in accordance with the FWHHRAM (USACE 2004). The purpose of the screening HHRA data evaluation screening process is to eliminate chemicals for which no further risk evaluation is needed. Data collected at ODA2 are aggregated by environmental medium (i.e., surface soil for this HHRA). Surface soil is defined as soil coming from 0 to 1 foot bgs. Note that various sampling efforts result in soil samples being collected at various depth intervals including, but not limited to, data from: (a) 0 to 0.5 feet bgs; (b) 0 to 1 foot bgs; and (c) 0 to 2 feet bgs. Because all three of these intervals include soil within the 0 to 1-foot bgs interval, they are all considered as surface soil and are evaluated as such in this HHRA.

ODA2 encompasses approximately 25 acres bisected east to west by Sand Creek. Figure 1-5 shows the ODA2 study area. The open detonation area and open burning area make up the 2.5-acre RCRA unit located within the larger CERCLA unit. The RCRA unit is not included in the closure of the ODA2 CERCLA unit. Soil contamination at the RCRA unit will be investigated and remediated, as needed, in accordance with RCRA closure or other applicable requirements.

The surface soil data are evaluated as a single exposure unit (EU); however, data from the RCRA unit are not included in this HHRA.

Section 6.2.1 provides a summary of the COPC selection process and the data assumptions used during that process. Section 6.2.2 presents the results of the COPC screening process.

6.2.1 COPC Screening

This section provides a description of the screening process used to identify COPCs and the data assumptions used in the process.

COPCs are identified for the one EU data set for the surface soil medium. This data evaluation consists of five steps, per the FWHHRAM (USACE 2004): (1) a data quality assessment (DQA), (2) frequency-of-detection/weight-of-evidence (WOE) screening, (3) screening of essential human nutrients, (4) risk-based screening, and (5) background screening.

1. **DQA**: Analytical results were reported by the laboratory in electronic form and loaded into a ODA2 database. Site data were then extracted from the database so that only one result is used for each station and depth sampled. QC data, such as sample splits and duplicates, and laboratory re-analyses and dilutions were not included in the determination of COPCs for this risk assessment. Field screening data that were considered in the evaluation of nature and extent of contamination at ODA2 are not included in the data set for the risk assessment. Samples rejected in the validation process are also excluded from the risk assessment. The percentage of rejected data is estimated at approximately 7%. A complete summary of data quality issues is presented in the DQA appendix of this report (see Appendix K).

2. **Frequency-of-Detection/WOE Screen:** Each chemical in surface soil was evaluated to determine its frequency of detection. Chemicals that were never detected were eliminated as COPCs. For chemicals with at least 20 samples and a frequency of detection of less than 5%, a WOE approach was used to determine if the chemical is AOC-related. The magnitudes and locations (clustering) of the detections and potential source of the chemical were evaluated. If the detected results showed no clustering, the concentrations are not substantially elevated relative to the detection limit, and the chemical was not used in the area under investigation, they are considered spurious, and the chemical was eliminated from further consideration. This screen is applied to all organic and inorganic chemicals with the exception of explosives and propellants. No detected explosives and propellants are excluded from the list of COPCs based on frequency of detection.

3. **Essential Nutrients**: Chemicals that are considered essential nutrients (i.e., calcium, chloride, iodine, iron, magnesium, potassium, phosphorus, and sodium) are an integral part of the human food supply and are often added to foods as supplements. The USEPA recommends that these chemicals not be evaluated as COPCs so long as they are (1) present at low concentrations (i.e., only slightly elevated above naturally occurring levels) and (2) toxic at very high doses (i.e., much higher than those that could be associated with contact at the site) (USEPA 1989). Recommended daily allowance (RDA) and recommended daily intake (RDI) values are available for seven of these metals. Based on these RDA/RDI values, a receptor ingesting 100 mg of soil per day would receive less than the RDA/RDI of calcium, magnesium, phosphorous, potassium, and sodium, even if the soil consisted of the pure mineral (i.e., soil concentrations >1,000,000 mg/kg). Receptors ingesting 100 mg of soil per day would require soil concentrations of 1,500 mg/kg of iodine and 100,000 to 180,000 mg/kg of iron to meet their RDA/RDI for these metals. Concentrations of essential nutrients do not

exceed these levels at ODA2; thus, these constituents are not addressed as COPCs in this HHRA.

4. **Risk-Based Screen:** The objective of this evaluation is to identify COPCs that may pose a potentially significant risk to human health. The risk-based screening values are conservative values published by USEPA. The maximum detected concentration (MDC) of each chemical in surface soil is compared against the appropriate risk-based screening value. Chemicals detected below these concentrations are screened from further consideration. Detected chemicals without risk-based screening values are not eliminated from the COPC list. The risk-based screening values for surface soil are described in Section 6.2.1.1.

5. **Background Screen:** For each inorganic constituent detected, concentrations in the ODA2 samples are screened against available, naturally occurring background levels. This screening step, which applies only to the inorganics, is used to determine if detected inorganics are site related or naturally occurring. If the MDC of a constituent exceeds the background value, the constituent is considered AOC-related. All detected organic compounds are considered to be above background. Inorganic chemicals that have MDCs below background levels are eliminated from the COPC list. Background screening values are described in Section 6.2.1.2.

6.2.1.1 Risk-Based Screening Values

The risk-based screening values are conservative values published by USEPA. For surface soil, a conservative screen is performed using the most current residential preliminary remediation goals (PRGs) published by USEPA Region 9 (USEPA 2002b). To account for the potential effects of multiple chemicals, PRGs based on non-cancer endpoints are divided by 10. These screening values are very conservative (based on a 10^{-6} risk level and a hazard quotient [HQ] of 0.1). For information purposes only, data from these same media are also compared against the Region 9 industrial soil PRGs. Industrial PRGs are not used for selection of COPCs. Region 9 PRGs can be found on the USEPA Region 9 World Wide Web site (http://www.epa.gov/region09/waste/sfund/prg/index.html).

6.2.1.2 Background Screening Values

This ODA2 Phase II RI does not include determination of background data specific to ODA2. Analytical results are screened against the final facility-wide background values for RVAAP, published in the *Final Phase II Remedial Investigation Report for Winklepeck Burning Grounds at Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2001). Background values for soil are available for two soil depths: surface (0 to 1 feet bgs) and subsurface (1 to 12 feet bgs). The surface soil data at ODA2 are compared against the surface soil background values from USACE 2001.

6.2.1.3 COPC Screening Assumptions

The data set used to determine COPCs includes only data collected from Phase II. The following assumptions, used in the development of COPCs for the HHRA, are noted:

- Chemicals not detected in a medium are not considered to be COPCs.
- Physical chemical data (e.g., alkalinity, pH, etc.) are not considered to be COPCs for ODA2.

6.2.2 Constituent of Potential Concern Screening Results

The COPC screening process and results are summarized in Table 6-2. This table includes

- summary statistics, including frequency of detection, range of detected concentrations, arithmetic average concentration, and UCL_{95} on the mean concentration;
- all screening values (PRGs and background concentrations, as appropriate); and
- final COPC status.

Table 6-2. COPC Screening for Surface Soil at ODA2

Chemical	Frequency of Detection	Minimum Detect	Average Result	Maximum Detect	UCL_{95} of Mean	EPC	Region 9 Residential PRG	Region 9 Industrial PRG	Site Background Criteria	COPC?
Inorganics (mg/kg)										
Aluminum	63/63	4.0E+03	1.1E+04	2.3E+04	1.2E+04	1.2E+04	7.6E+03	9.2E+04	1.8E+04	Y
Antimony	3/63	1.4E+00	2.8E-01	2.2E+00	3.6E-01	3.6E-01	3.1E+00	4.1E+01	9.6E-01	N
Arsenic	63/63	3.5E+00	1.3E+01	2.0E+01	1.4E+01	1.4E+01	3.9E-01	1.6E+00	1.5E+01	Y
Barium	63/63	3.1E+01	7.9E+01	1.8E+02	8.5E+01	8.5E+01	5.4E+02	6.7E+03	8.8E+01	N
Beryllium	63/63	2.7E-01	5.9E-01	1.5E+00	6.3E-01	6.3E-01	1.5E+01	1.9E+02	8.8E-01	N
Cadmium	61/63	1.2E-01	1.2E+00	9.5E+00	1.5E+00	1.5E+00	3.7E+00	4.5E+01	None	Y
Calcium	63/63	2.3E+02	2.4E+03	3.4E+04	3.5E+03	3.5E+03	None	None	1.6E+04	N
Chromium	63/63	6.8E+00	1.6E+01	6.1E+01	1.8E+01	1.8E+01	2.1E+02	4.5E+02	1.7E+01	N
Chromium, Hexavalent	2/6	8.0E+00	7.6E+00	2.8E+01	1.6E+01	1.6E+01	2.2E+01	6.4E+01	None	Y
Cobalt	63/63	4.1E+00	8.5E+00	2.5E+01	9.1E+00	9.1E+00	1.4E+02	1.3E+03	1.0E+01	N
Copper	63/63	8.3E+00	1.1E+02	1.2E+03	1.5E+02	1.5E+02	3.1E+02	4.1E+03	1.8E+01	Y
Iron	63/63	1.0E+04	2.4E+04	3.9E+04	2.5E+04	2.5E+04	2.3E+03	3.1E+04	2.3E+04	N
Lead	63/63	1.2E+01	3.3E+01	2.2E+02	4.0E+01	4.0E+01	4.0E+02	7.5E+02	2.6E+01	N
Magnesium	63/63	1.2E+03	2.6E+03	5.3E+03	2.7E+03	2.7E+03	None	None	3.0E+03	N
Manganese	63/63	1.2E+02	5.2E+02	2.1E+03	6.0E+02	6.0E+02	1.8E+02	1.9E+03	1.5E+03	Y
Mercury	51/63	6.0E-02	6.8E-01	9.9E+00	1.3E+00	1.3E+00	2.3E+00	3.1E+01	3.6E-02	Y
Nickel	63/63	7.6E+00	1.8E+01	3.1E+01	2.0E+01	2.0E+01	1.6E+02	2.0E+03	2.1E+01	N
Nitrate/Nitrite	2/6	4.0E+00	2.1E+00	5.1E+00	3.7E+00	3.7E+00	None	None	None	Y
Potassium	63/63	4.0E+02	1.1E+03	2.5E+03	1.1E+03	1.1E+03	None	None	9.3E+02	N
Selenium	6/63	8.6E-01	3.6E-01	1.9E+00	4.4E-01	4.4E-01	3.9E+01	5.1E+02	1.4E+00	N
Silver	1/63	3.2E-01	5.0E-02	3.2E-01	6.1E-02	6.1E-02	3.9E+01	5.1E+02	None	N
Sodium	6/63	6.8E+01	3.5E+01	2.2E+02	4.2E+01	4.2E+01	None	None	1.2E+02	N
Sulfide	6/6	5.2E+01	5.3E+02	2.2E+03	2.3E+04	2.2E+03	None	None	None	Y
Vanadium	63/63	7.8E+00	1.9E+01	3.8E+01	2.0E+01	2.0E+01	5.5E+01	7.2E+02	3.1E+01	N
Zinc	63/63	4.9E+01	1.4E+02	5.6E+02	1.6E+02	1.6E+02	2.3E+03	3.1E+04	6.2E+01	N
Organics										
Explosives (mg/kg)										
1,3,5-Trinitrobenzene	1/63	8.6E-02	5.1E-02	8.6E-02	5.2E-02	5.2E-02	1.8E+02	1.8E+03	N/A	N
2,4,6-Trinitrotoluene	6/63	6.8E-02	1.4E-01	3.2E+00	2.3E-01	2.3E-01	3.1E+00	3.1E+01	N/A	Y
2,4-Dinitrotoluene	2/63	1.3E-01	5.4E-02	2.1E-01	5.9E-02	5.9E-02	7.2E-01	2.5E+00	N/A	N

Table 6-2. COPC Screening for Surface Soil at ODA2 (continued)

Chemical	Frequency of Detection	Minimum Detect	Average Result	Maximum Detect	UCL$_{95}$ of Mean	EPC	Region 9 Residential PRG	Region 9 Industrial PRG	Site Background Criteria	COPC?
2-Amino-4,6-Dinitrotoluene	4/63	6.5E-02	6.0E-02	3.9E-01	7.0E-02	7.0E-02	None	None	N/A	Y
4-Amino-2,6-Dinitrotoluene	4/63	5.6E-02	5.7E-02	2.5E-01	6.3E-02	6.3E-02	None	None	N/A	Y
HMX	2/63	1.2E-01	1.1E-01	5.8E-01	1.2E-01	1.2E-01	3.1E+02	3.1E+03	N/A	N
Nitroglycerine	2/63	7.2E+00	5.4E+00	3.1E+01	6.1E+00	6.1E+00	3.5E+01	1.2E+02	N/A	N
RDX	1/63	1.5E-01	1.0E-01	1.5E-01	1.0E-01	1.0E-01	4.4E+00	1.6E+01	N/A	N
Tetryl	16/63	1.2E-01	6.5E-01	1.8E+01	1.1E+00	1.1E+00	6.1E+01	6.2E+02	N/A	N
Pesticides/PCBs (mg/kg)										
4,4-DDD	1/6	2.6E-02	5.1E-03	2.6E-02	1.4E-02	1.4E-02	2.4E+00	1.0E+01	N/A	N
Semi-Volatile Organics (mg/kg)										
Bis(2-ethylhexyl)phthalate	2/6	2.2E-02	1.5E-01	1.0E-01	2.1E-01	1.0E-01	3.5E+01	1.2E+02	N/A	N
di-n-Butyl Phthalate	2/6	1.5E-01	3.0E-01	8.6E-01	5.2E-01	5.2E-01	6.1E+02	6.2E+03	N/A	N
n-Nitrosodiphenylamine	1/6	1.0E-01	1.8E-01	1.0E-01	2.1E-01	1.0E-01	9.9E+01	3.5E+02	N/A	N
Volatile Organics (mg/kg)										
2-Butanone	1/6	8.9E-03	6.3E-03	8.9E-03	7.4E-03	7.4E-03	7.3E+02	2.7E+03	N/A	N
Acetone	1/6	1.9E-02	1.8E-02	1.9E-02	2.6E-02	1.9E-02	1.6E+02	6.0E+02	N/A	N
Tetrachloroethylene	3/6	3.7E-03	3.5E-03	4.8E-03	4.3E-03	4.3E-03	1.5E+00	3.4E+00	N/A	N

Note: Only detected chemicals are shown; chemicals that were never detected are not considered to be COPCs.
N/A = Not applicable.

Table 6-2 summarizes the resulting COPCs for surface soil at ODA2. As seen, a total of 12 COPCs were identified within the single surface soil aggregate. The 12 surface soil COPCs include:

- nine inorganics (aluminum, arsenic, cadmium, hexavalent chromium, copper, manganese, mercury, nitrate/nitrite, and sulfide), and
- three explosives (TNT; 2-amino- DNT; and 4-amino-2,6-DNT).

Based on lack of toxicity information (see Section 6.3), three of these 12 surface soil COPCs are classified as qualitative COPCs (sulfide; 2-amino-4,6-DNT; and 4-amino-2,6-DNT); risks and hazards cannot be quantified for these three COPCs.

6.3 EXPOSURE ASSESSMENT

The objectives of the exposure assessment are to estimate the magnitude, frequency, and duration of potential human exposure to COPCs. The four primary steps of the exposure assessment are to

(1) identify current and future land use;
(2) identify potentially exposed populations, exposure media, and exposure pathways;
(3) calculate exposure point concentrations (EPCs); and
(4) estimate each receptor's potential intake of each COPC.

The output of the exposure assessment is used in conjunction with the output of the toxicity assessment (Section 6.4) to quantify risks and hazards to receptors in the risk characterization (Section 6.5).

6.3.1 Current and Future Land Use

The extensive presence of MEC prevents most activity at ODA2, including most OHARNG training activities. MEC concerns related to Rocket Ridge will be addressed under the Military Munitions Response Program (MMRP) currently evolving. While the future MMRP has yet to determine basic parameters for this AOC, the vast amount of already unearthed and suspected large amounts of buried MEC, including burial of white phosphorous, will in all probability dictate that this AOC will never be utilized for any but ordnance disposal related activities, and almost certainly would never be released to the public.

ODA2 is classified as Restricted Access-Authorized Personnel Only. The area is closed to all normal training and administrative activities. Surveying, sampling, and other essential security, safety, natural resources management, and other directed activities may be conducted at ODA2 only after authorized personnel have been properly briefed on potential hazards/sensitive areas. Individuals unfamiliar with the hazards/restrictions are escorted by authorized personnel at all times while in the restricted area (USACE 2004).

There are no immediate plans for active re-use of ODA2; however, occasional demolition of MEC will continue at the RCRA unit. In the near term, limited material obtained during previous MEC removal activities may occasionally be detonated at the RCRA unit. This type of MEC demolition may occur approximately 1 week/year. The MEC material to be detonated is stored primarily in

Building 1501 (see Figure 1-5). Activity outside the RCRA unit would be limited to MEC technicians transporting material from storage to the RCRA unit for demolition.

6.3.2 Potentially Exposed Populations, Exposure Media, and Exposure Pathways

Potentially contaminated media at ODA2 are surface soil (0 to 1 feet bgs), subsurface soil (> 1 feet bgs), groundwater, surface water, and sediment.

Given the restricted access to ODA2, the most likely receptors will be individuals entering the area on an occasional basis to evaluate wildlife to meet the needs of natural resources management, or to check the status of the area for security or safety reasons and MEC technicians transporting material from storage to the RCRA unit. ODA2 is located in the central portion of RVAAP/RTLS and access is controlled through restrictive rules rather than with fencing or other physical barriers. The only access road is blocked by a locked gate thus preventing vehicle access; however, no physical barriers exist to prevent pedestrial access. Visitors to RVAAP/RTLS (e.g., OHARNG trainees, hunters, and contractors) are instructed as to where they are and are not allowed to go. Based on this information, the Security Guard/Maintenance Worker scenario outlined in the FWHHRAM (USACE 2004) is protective of potential current and future receptors at ODA2 because of land use restrictions in place due to MEC concerns and intended future land use. This scenario assumes a Security Guard/Maintenance Worker patrols ODA2 every day for one hour. Security patrols occur daily across the installation but not within ODA2 and patrolmen usually remain within their vehicles during these patrols. Although the security guard is not currently exposed to contaminated media at ODA2 on a daily basis, the potential exposure of this receptor is considered protective of receptors with more irregular exposure (e.g., a wildlife ecologist who spends a several days at the site once every few years, security personnel who may periodically evaluate the site, or UXO technicians who may periodically transport materials to the RCRA unit). Therefore, as a worst-case assumption, it is assumed that a security guard visits ODA2 and leaves his or her vehicle on a daily basis.

If additional MEC removal is conducted along Sand Creek, physical and chemical hazards associated with short-term activity will be addressed by worker protection programs in place for MEC removal.

The Security Guard/Maintenance Worker is assumed to be exposed to surface soil (0 to 1 feet bgs) only. Because of MEC issues, there will be no intrusive activities; therefore, subsurface soil is not evaluated in the quantitative HHRA. The access and digging restrictions at ODA2 are in place because of the presence of MEC and not as a result of exposure to chemical contaminants in soil. This restriction must remain in place to ensure receptors are protected. Other potential receptors (including exposure to subsurface soil by a resident farmer) would need to be evaluated before these restrictions could be removed. This receptor is not involved in recreational or training activities that would result in exposure to surface water or sediment. Because ODA2 will not be routinely used, no potable water will be available there; therefore, exposure to groundwater is not evaluated.

Exposures to contaminants in surface soil at ODA2 are evaluated for soil ingestion, dermal contact with soil, and inhalation of soil particles and volatile organic compounds.

6.3.3 Exposure Point Concentrations

This HHRA for ODA2 evaluates the reasonable maximum exposure (RME). The RME is an estimate of the highest exposure reasonably expected to occur at the site. Because of the uncertainty associated with any estimate of exposure concentration, the UCL_{95} for either a normal or lognormal distribution is the recommended statistic for evaluating the RME. In cases where the UCL_{95} exceeds the MDC, the maximum concentration is used as an estimate of the RME.

EPCs are calculated using equations from USEPA guidance*, Supplemental Guidance to RAGS: Calculating the Concentration Term* (USEPA 1992). The data are tested using the Shapiro-Wilk test to determine distribution, normal or lognormal, of the concentrations. This guidance notes that environmental data are often lognormally distributed but does not give specific guidance for data sets with unknown distributions.

For ODA2 the UCL_{95} on the mean is calculated using the normal distribution equation (see Equation 6-1) when the concentrations are normally distributed, when concentrations are not judged to be normally or lognormally distributed, when the data set contains fewer than five detections, or when the frequency of detection is less than 50%. For these situations, the UCL_{95} on the mean is calculated using the following equation:

$$UCL_{95}(normal) = \bar{x}_n + \frac{(t)(s_x)}{\sqrt{n}} \qquad \textbf{(6-1)}$$

where

$\bar{x}_n$ = mean of the untransformed data,
t = student-t statistic,
s_x = standard deviation of the untransformed data,
n = number of sample results available.

USEPA guidance *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA 2002c) provides several methods for calculating the UCL_{95} for data sets that are neither normally nor lognormally distributed. All of the methods in this guidance are based on the assumption of random sampling. Sampling at ODA2 was biased toward areas with the greatest potential for contamination. The reason for defaulting to the t-distribution (i.e., assumption of normality) when the distribution cannot be determined is that this method is simple and robust; even when the assumption that the underlying distribution is normal is violated, the estimate of the UCL_{95} is reasonably close to the true value.

For lognormally distributed concentrations, the UCL_{95} on the mean is calculated using the following equation:

$$UCL_{95}(lognormal) = e^{\left(\bar{x}_l + 0.5(s_l^2) + \frac{(S_l)(H)}{\sqrt{n-1}}\right)} \qquad \textbf{(6-2)}$$

where

e = constant (base of the natural log, equal to 2.718),
$\bar{x}_l$ = mean of the transformed data [$l = \log(x)$],
s_l = standard deviation of the transformed data,
H = H-statistic,
n = number of sample results available.

USEPA guidance (USEPA 2002c) notes that use of the H statistic may result in overestimating the true UCL_{95} on the mean if the data are not lognormal. Even small deviations from lognormality can greatly influence the results using the H-statistic, yielding upper bounds that are much too large (Singh et al., 1997).

6.3.4 Exposure Parameters and Calculations for Estimating Intakes

Standard intake equations from USEPA guidance (USEPA 1989) for ingestion, dermal contact, and inhalation of chemicals in soil (shown below) are used along with the exposure parameters shown in Table 6-3. Exposure parameters and intake equations are from the FWHHRAM (USACE 2004).

Table 6-3. Exposure Parameters for Security Guard/Maintenance Worker at ODA2

Parameter	Units	Value
Incidental Soil Ingestion		
Soil ingestion rate	kg/day	0.0001
Exposure time	hrs/day	1
Exposure frequency	days/year	250
Exposure duration	years	25
Body weight	kg	70
Carcinogen averaging time	days	25,550
Non-carcinogen averaging time	days	9,125
Fraction Ingested	unitless	1
Conversion factor	days/hr	0.042
Dermal Contact with Soil		
Skin area	m^2/event	0.33
Adherence factor	mg/cm^2	0.7
Absorption fraction	unitless	Chemical-specific (see Table 6-4)
Exposure frequency	events/year	250
Exposure duration	Years	25
Body weight	Kg	70
Carcinogen averaging time	Days	25,550
Non-carcinogen averaging time	Days	9,125
Conversion factor	$(kg\text{-}cm^2)/(mg\text{-}m^2)$	0.01

Table 6-3. Exposure Parameters for Security Guard/Maintenance Worker at ODA2 (continued)

Parameter	Units	Value
Inhalation of VOCs and Dust		
Inhalation rate	m^3/day	20
Volatilization factor (for VOCs only)	m^3/kg	chemical-specific (see Table 6-4)
Particulate emission factor	m^3/kg	9.24E+08 m^3/kg
Exposure time	hrs/day	1
Exposure frequency	days/year	250
Exposure duration	years	25
Body weight	kg	70
Carcinogen averaging time	days	25,550
Non-carcinogen averaging time	days	9,125
Conversion factor	days/hr	0.042

Incidental ingestion of soil is estimated for using Equation 6-3:

$$\text{Chemical Intake (mg/kg-day)} = \frac{C_S \times IR_S \times EF \times ED \times FI \times ET \times CF}{BW \times AT} \qquad \textbf{(6-3)}$$

where

C_s = chemical concentration in soil (mg/kg),
IR_s = ingestion rate (kg/day),
EF = exposure frequency (days/year),
ED = exposure duration (years),
FI = fraction ingested (value of 1, unitless),
ET = exposure time (hr/day),
CF = conversion factor for ET (day/hr),
BW = body weight (kg),
AT = averaging time (days) for carcinogens or noncarcinogens.

The dermally absorbed dose (DAD) from chemicals in soil is calculated using Equation 6-4.

$$\text{Chemical DAD (mg/kg-day)} = \frac{C_S \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}, \qquad \textbf{(6-4)}$$

where

C_s = chemical concentration in soil (mg/kg),
CF = conversion factor [$(10^{-6}$ kg/mg$) \times (10^4$ cm^2/m$^2)$],
SA = skin surface area exposed to soil (m^2/event),
AF = soil to skin adherence factor (1 mg/cm^2),
ABS = chemical-specific absorption factor (unitless; see Table 6-4),
EF = exposure frequency (events/year),
ED = exposure duration (years),

BW = body weight (kg),
AT = averaging time (days) for carcinogens or noncarcinogens.

Table 6-4. Chemical-Specific Exposure Parameters

COPC	Dermal Absorption Factor[a] (Unitless)	Volatilization Factor[b] (m^3/kg)
Inorganics		
Aluminum	0.001	N/A
Arsenic	0.03	N/A
Cadmium	0.001	N/A
Chromium, hexavalent	0.001	N/A
Copper	0.001	N/A
Manganese	0.001	N/A
Mercury	0.001	N/A
Nitrate/Nitrite	0.001	N/A
Organics		
2,4,6-Trinitrotoluene	0.1	N/A

[a] Chemical-specific absorption factor values from USEPA Region 5 (USEPA 2000a). When chemical-specific values are not available the following default values are used: semivolatile organic compounds = 0.1, VOCs = 0.01, inorganics = 0.001 per USEPA Region 4 Supplemental Guidance to RAGS (USEPA 2000b).
[b] Volatilization factors (VFs) calculated using the 1996 USEPA Soil Screening Guidance Methodology, using site-specific parameter values for Cleveland, Ohio. Only used for VOCs; since there are no VOCs that are COPCs, no VF values are shown.
N/A = Not applicable.

Inhalation of soil is calculated using Equation 6-5:

$$\text{Chemical Intake (mg/kg- day)}=\frac{C_S \times IR_a \times EF \times ED \times \left(VF^{-1} + PEF^{-1}\right) \times ET \times CF}{BW \times AT}, \qquad \textbf{(6-5)}$$

where

C_s = chemical concentration in soil (mg/kg),
IR_a = inhalation rate (m^3/day),
EF = exposure frequency (days/year),
ED = exposure duration (years),
VF = chemical-specific volatilization factor (m^3/kg; see Table 6-4),
PEF = particulate emission factor (m^3/kg),
ET = exposure time (hr/day)
CF = conversion factor for ET (day/hr),
BW = body weight (kg),
AT = averaging time (days) for carcinogens or noncarcinogens.

6.4 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to evaluate the potential for COPCs to cause adverse health effects in exposed individuals. Where possible, it provides an estimate of the relationship between the intake and dose of a COPC and the likelihood or severity of adverse health effects as a result of that exposure. Toxic effects have been evaluated extensively by USEPA. This section provides the results of the USEPA evaluation of the chemicals identified as COPCs at ODA2.

6.4.1 Toxicity Information and USEPA Guidance for Non-Carcinogens

Non-carcinogenic effects are evaluated by comparing an exposure or intake/dose with a reference dose (RfD) or reference concentration (RfC). The RfD and RfCs are determined using available dose-response data for individual chemicals. Scientists determine the exposure concentration or intake/dose below which no adverse effects are seen and add a safety factor (from 10 to 1,000) to determine the RfD or RfC. RfDs and RfCs are identified by scientific committees supported by USEPA. The RfDs available for the COPCs present in the surface soil at ODA2 are listed in Table 6-5 (USEPA 1997b 2004). In this HHRA, RfCs, measured in milligrams per cubic meter, were converted to RfDs expressed in units of milligrams per kilogram body weight per day by using the default adult inhalation rate and body weight [i.e., (RfC × 20 m^3/d)/70 kg = RfD] (USEPA 1989).

Chronic RfDs are developed for protection from long-term exposure to a chemical (from 7 years to a lifetime); subchronic RfDs are used to evaluate short-term exposure (from 2 weeks to 7 years) (USEPA 1989). Since the one potential receptor at ODA2 is not considered to have short-term exposure, only chronic RfDs are used in this HHRA.

Toxic effects are diverse and measured in various target body organs (e.g., they range from eye irritation to kidney or liver damage). USEPA is currently reviewing methods for accounting for the difference in severity of effects; however, existing RfDs do not address this issue.

6.4.2 Toxicity Information and USEPA Agency Guidance for Carcinogens

For carcinogens, risks are estimated as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as excess or incremental cancer risk, which is cancer occurrence in addition to normally expected rates of cancer development. Excess cancer risk is estimated using a cancer slope factor (CSF). The CSF is defined as a plausible upper-bound estimate of the probability of a response (i.e., cancer) per unit intake of a chemical over a lifetime (USEPA 1989).

USEPA expresses inhalation cancer potency as the unit risk based on the chemical concentration in air (i.e., risk per microgram [μg] of m^3 of ambient air). These unit risks were converted to CSFs expressed in units of risk per mg of chemical per kg body weight per day by using the default adult inhalation rate and body weight (i.e., [Unit Risk × 70 kg × 1,000 μg/mg]/20 m^3/d).

CSFs used in the evaluation of risk from carcinogenic COPCs are listed in Table 6-6 (USEPA 1997b 2004).

6.4.3 Estimated Toxicity Values for Dermal Exposure

Oral and inhalation RfDs and CSFs are currently available. Dermal RfDs and CSFs are estimated from oral toxicity values using chemical-specific gastrointestinal absorption factors (GAFs) to calculate total absorbed dose. This conversion is necessary because most oral RfDs and CSFs are expressed as the amount of chemical administered per time and body weight; however, dermal exposure is expressed as an absorbed dose. Dermal toxicity factors are calculated from oral toxicity factors as shown below (USEPA 2002a):

$$\mathrm{RfD_{dermal}} = \mathrm{RfD_{oral}} \times \mathrm{GAF} \qquad \textbf{(6-6)}$$

$$\mathrm{CSF_{dermal}} = \mathrm{CSF_{oral}}/\mathrm{GAF} \qquad \textbf{(6-7)}$$

Per FWHHRAM, dermal CSFs and RfDs are estimated from the oral toxicity values using chemical-specific GAFs to calculate the total absorbed dose only for chemicals with GAF values < 0.5. Chemical-specific GAF values available from USEPA (2002a) are used whenever possible. Not all COPCs have specific GAF values. When quantitative data are insufficient, a default GAF is used. A default value of 1.0 for organic and inorganic chemicals is used (USEPA 2002a). The GAF and resulting dermal toxicity values used in this HHRA are listed in Tables 6-5 and 6-6.

6.4.4 Assumptions Used in the Toxicity Assessment

One special assumption is made in assigning toxicity values for COPCs at ODA2: nitrate/nitrite is evaluated using the toxicity values for nitrite, which has more conservative toxicity values as compared to nitrate.

6.4.5 Chemicals Without USEPA Agency Toxicity Values

No RfDs or CSFs are available for some detected chemicals at ODA2 because the non-carcinogenic and/or carcinogenic effects of these chemicals have not yet been determined. Although these chemicals may contribute to health effects from exposure to contaminated media at ODA2, their effects cannot be quantified at the present time. COPCs without RfDs and CSFs are sulfide; 2-amino-4,6-DNT; and 4-amino-2,6-DNT.

Table 6-5. Non-carcinogenic Reference Doses for ODA2 COPCs

Analyte	Oral Chronic RfD (mg/kg-day)	Confidence Level	% GI Absorption[a]	Dermal Chronic RfD (mg/kg-day)	Inhalation Chronic RfD (mg/kg-day)	RfD Basis (Vehicle)	Critical Effect	Uncertainty/ Modifying Factor
Inorganics								
Aluminum	1.0E+00	NA	1	1.0E+00	1.4E-03	NA	NA	(O) UF = 10
Arsenic	3.0E-04	Medium (O)	0.95	3.0E-04	--	Oral, oral-water	Hyperpigmentation and keritosis and possible vascular complication	(O) UF = 3
Cadmium	1.0E-03	High	0.025	2.5E-05	--	Oral, oral-water	Renal toxicity, osteomalacia, osteoporosis, and significant proteinuria	(O) UF = 1,000
Chromium, hexavalent	3.0E-03	Low (O)	0.025	7.5E-05	2.9E-05	NA	NA	(O) UF = 300 (O) MF = 3 (I) UF = 300
Copper	4.0E-02	NA	1	4.0E-02	--	NA	NA	
Manganese	4.6E-02	NA	0.04	1.8E-03	1.4E-05	Oral: water, inhalation	(O) Lethargy, tremors, mental disturbance, muscle tonus, and central nervous system effects	(O) UF = 1 (O) MF = 3 (I) UF = 1,000
Mercury	3.0E-04	Low (O)	0.07	2.1E-05	--	Oral: diet (mouse)	(O) None	(O) UF = 300
		Medium (I)				Inhalation: (human)	(I) Neurotoxicity (human)	(I) UF = 30
Nitrate/Nitrite	1.0E-01		1	1.0E-01				
Organics								
2,4,6-Trinitrotoluene	5.0E-04	Medium	1	5.0E-04	--	Oral (dog)	Liver effects	UF = 1,000

[a] % gastrointestinal absorption (GI) values from USEPA 2002a.
(O) indicates oral, (I) indicates inhalation.
COPC = Constituent of potential concern.
MF = Modifying factor (the default modifying factor is 1).
NA = Not available.
RfD = Reference dose.
UF = Uncertainty factor.
-- = No value available.

Table 6-6. Cancer Slope Factors for ODA2 COPCs

COPC	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	% GI Absorption[a]	Dermal Slope Factor $(mg/kg\text{-}day)^{-1}$	Inhalation Slope Factor $(mg/kg\text{-}day)^{-1}$	USEPA Class	Type of Cancer
Inorganics						
Arsenic	1.5E+00	0.95	1.5E+00	1.5E+01	A	Respiratory system tumors
Cadmium	--	0.025	--	6.3E+00	B1	Respiratory tract and lung tumors
Chromium, hexavalent	--	0.025	--	4.2E+01	A	Lung tumors
Organics						
2,4,6-Trinitrotoluene	3.0E-02	1	3.0E-02	--	C	Bladder transitional cell papilloma

[a] % gastrointestinal absorption (GI) values from USEPA 2002a.

-- = No value available.

6.5 RISK CHARACTERIZATION

The purpose of the risk characterization is to evaluate the information obtained through the exposure and toxicity assessments to estimate potential risks and hazards. Potential carcinogenic effects are characterized by using projected intakes and chemical-specific, dose-response data (i.e., CSFs) to estimate the probability that an individual will develop cancer over a lifetime. Potential non-carcinogenic effects are characterized by comparing projected intakes of contaminants to toxicity values (i.e., RfDs). The numerical risk and hazard estimates presented in this section must be interpreted in the context of the uncertainties and assumptions associated with the risk assessment process and with the data upon which the risk estimates are based.

6.5.1 Methodology

Risk characterization integrates the findings of the exposure and toxicity assessments to estimate the potential for receptors to experience adverse effects as a result of exposure to contaminated media at ODA2.

6.5.1.1 *Risk Characterization for Carcinogens*

For carcinogens, risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as the incremental lifetime cancer risk (ILCR), or the increased chance of cancer above the normal background rate of cancer. In the United States, the background chance of contracting cancer is a little more than 3 in 10, or 3×10^{-1} (American Cancer Society 2003). The calculated ILCRs are compared to the range specified in the National Oil and Hazardous Substances Pollution Contingency Plan of 10^{-6} to 10^{-4}, or 1-in-1 million to 1-in-10,000 exposed persons developing cancer (USEPA 1990). ILCRs below 10^{-6} are considered acceptable; ILCRs above 10^{-4} are considered unacceptable. The range between 10^{-6} and 10^{-4} is of concern, and any decisions to address ILCRs further in this range, either through additional study or engineered control measures, should account for the uncertainty in the risk estimates.

The ILCR is calculated using the equation below (USEPA 1989):

$$\mathrm{ILCR} = \mathrm{I} \times \mathrm{CSF} \qquad \textbf{(6-8)}$$

where

I = chronic daily intake or DAD calculated in the exposure assessment (mg/kg-day),
CSF = cancer slope factor $(\text{mg/kg-day})^{-1}$.

For a given exposure pathway, the total risk to a receptor exposed to several carcinogenic COPCs is the sum of the ILCRs for each carcinogen, as shown in Equation 6-9 below:

$$\mathrm{ILCR}_{\mathrm{total}} = \Sigma \mathrm{ILCR}_{\mathrm{i}} \qquad \textbf{(6-9)}$$

where

$ILCR_{total}$ = total probability of cancer incidence associated with all carcinogenic COPCs,
$ILCR_i$ = ILCR for the i^{th} COPC.

In addition to summing risks across all carcinogenic COPCs, risks are summed across all exposure pathways for a given environmental medium (e.g., ingestion, inhalation, and dermal contact with surface soil). Per USEPA (1989) guidance, “there are two steps required to determine whether risks or hazard indices for two or more pathways should be combined for a single exposed individual or group of individuals. The first is to identify reasonable exposure pathway combinations. The second is to examine whether it is likely that the same individuals would consistently face the reasonable maximum exposure (RME) by more than one pathway.” It is reasonable to assume the same individual may be exposed at the RME by multiple pathways to a given exposure medium. For example, a Security Guard/Maintenance Worker present at ODA2 can reasonably be assumed to both ingest surface soil and to inhale contaminated dust from the same area.

6.5.1.2 Risk Characterization for Non-Carcinogens

In addition to developing cancer from exposure to contaminants, an individual may experience other toxic effects. The term “toxic effects” is used here to describe a wide variety of systemic effects ranging from minor irritations, such as eye irritation and headaches, to more substantial effects, such as kidney or liver disease and neurological damage. The risks associated with toxic (i.e., non-carcinogenic) chemicals are evaluated by comparing an estimated exposure (i.e., intake or dose) from site media to an acceptable exposure expressed as an RfD. The RfD is the threshold level below which no toxic effects are expected to occur in a population, including sensitive subpopulations. The ratio of intake over the RfD is the HQ (USEPA 1989) and is calculated as:

$$HQ = I/RfD \qquad \textbf{(6-10)}$$

where

I = daily intake or DAD of a COPC (mg/kg-day),
RfD = reference dose (mg/kg-day).

The HQs for each COPC are summed to obtain a hazard index (HI), as shown below:

$$HI = \Sigma HQ_i \qquad \textbf{(6-11)}$$

where

HI = hazard index for all toxic effects,
HQ_i = hazard quotient for the i^{th} COPC.

An HI greater than 1 has been defined as the level of concern for potential adverse non-carcinogenic health effects (USEPA 1989). This approach differs from the probabilistic approach used to evaluate carcinogens. An HQ of 0.01 does not imply a 1-in-100 chance of an adverse effect but indicates only that the estimated intake is 100 times less than the threshold level at which adverse health effects may occur.

In addition to summing hazards across all COPCs, hazards are summed across all exposure pathways for a given environmental medium.

6.5.1.3 Identification of COCs

COCs are defined for the surface soil medium as those contaminants that have an ILCR greater than 1×10^{-6} and/or an HI greater than 1 for the one receptor in this HHRA.

6.5.2 Results

Estimated risks for ODA2 are evaluated for the Security Guard/Maintenance Worker exposed to surface soil (the only receptor/medium combination applicable at ODA2). Surface soil data are defined as coming from 0 to 1 foot bgs.

The EU is evaluated to provide an estimate of risk from a RME. The RME incorporates a reasonable estimate of the concentration to which a receptor may be exposed (UCL_{95} on the mean). The use of the UCL_{95} on the mean as the EPC implies that a receptor may come into contact with contaminants throughout the EU.

Detailed hazard and risk results for the Security Guard/Maintenance Worker's direct contact with COPCs in surface soil are presented in Tables 6-7 and 6-8. The total HI is 0.051, which is below the threshold of 1.0; thus, no non-carcinogenic COCs are identified at ODA2. The total risk across all COPCs is 5.3E-06, coming predominantly from arsenic. The only carcinogenic COC identified is arsenic, as the total cancer risk from exposure to this chemical is 5.3E-06.

Table 6-7. ODA2 Surface Soil Non-Carcinogenic Hazards

COPC	EPC (mg/kg)	Daily Intake (mg/kg-day)			Hazard Quotient			Total HI Across All Pathways	COC [a]
		Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation		
Receptor = Security Guard/Maintenance Worker									
Aluminum	1.2E+04	4.8E-04	2.7E-04	1.0E-07	4.8E-04	2.7E-04	7.3E-05	8.3E-04	
Arsenic	1.4E+01	5.6E-07	9.3E-06	1.2E-10	1.9E-03	3.1E-02	--	3.3E-02	
Cadmium	1.5E+00	6.3E-08	3.5E-08	1.4E-11	6.3E-05	1.4E-03	--	1.5E-03	
Chromium, hexavalent	1.6E+01	6.5E-07	3.6E-07	1.4E-10	2.2E-04	4.8E-03	4.9E-06	5.0E-03	
Copper	1.5E+02	6.0E-06	3.3E-06	1.3E-09	1.5E-04	8.3E-05	--	2.3E-04	
Manganese	6.0E+02	2.4E-05	1.3E-05	5.3E-09	5.3E-04	7.3E-03	3.7E-04	8.2E-03	
Mercury	1.3E+00	5.4E-08	3.0E-08	1.2E-11	1.8E-04	1.4E-03	--	1.6E-03	
Nitrate/Nitrite	3.7E+00	1.5E-07	8.4E-08	3.3E-11	1.5E-06	8.4E-07	--	2.3E-06	
Inorganics Pathway Total					3.5E-03	4.6E-02	4.5E-04	5.0E-02	
2,4,6-Trinitrotoluene	2.3E-01	9.6E-09	5.3E-07	2.1E-12	1.9E-05	1.1E-03	--	1.1E-03	
Organics Pathway Total					1.9E-05	1.1E-03	--	1.1E-03	
Pathway Total - Chemicals					3.5E-03	4.7E-02	4.5E-04	5.1E-02	

[a] COPCs are identified as COCs if the total HI across all pathways is > 1 (denoted as H). As seen, no non-carcinogenic COCs are identified.

-- No hazard could be quantified, based on lack of approved toxicity value.

Table 6-8. ODA2 Surface Soil Carcinogenic Risks

COPC	EPC (mg/kg)	Daily Intake (mg/kg-day)			Risk			Total Risk Across All Pathways	COC[a]
		Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation		
Receptor = Security Guard/Maintenance Worker									
Arsenic	1.4E+01	2.0E-07	3.3E-06	4.3E-11	3.0E-07	5.0E-06	6.5E-10	5.3E-06	R
Cadmium	1.5E+00	2.2E-08	1.2E-08	4.8E-12	--	--	3.1E-11	3.1E-11	
Chromium, hexavalent	1.6E+01	2.3E-07	1.3E-07	5.0E-11	--	--	2.1E-09	2.1E-09	
Inorganics Pathway Total					3.0E-07	5.0E-06	2.8E-09	5.3E-06	
2,4,6-Trinitrotoluene	2.3E-01	3.4E-09	1.9E-07	7.4E-13	1.0E-10	5.7E-09	--	5.8E-09	
Organics Pathway Total					1.0E-10	5.7E-09	--	5.8E-09	
Pathway Total - Chemicals					3.0E-07	5.0E-06	2.8E-09	5.3E-06	

[a] COPCs are identified as COCs if the total risk across all pathways is > 10^{-6} (denoted as R). As seen, no non-carcinogenic COC (arsenic) is identified.

-- No risk could be quantified, based on lack of approved toxicity value.

The EPC for arsenic is 13.8 mg/kg, which is below its background soil concentration of 15.4 mg/kg. Thus, the cancer risk related to arsenic at ODA2 does not exceed the cancer risk for arsenic estimated from facility-wide background.

6.6 UNCERTAINTY ANALYSIS

This section identifies the uncertainties associated with each step of the risk assessment process, where possible. Uncertainties are not mutually exclusive.

6.6.1 Uncertainties Associated with the Data Evaluation

Although the data evaluation process used to select COPCs adheres to established procedures and guidance, it also requires making decisions and developing assumptions on the basis of historical information, disposal records, process knowledge, and best professional judgment about the data. Uncertainties are associated with all such assumptions. The background concentrations and PRGs used to screen analytes are also subject to uncertainty.

Another area of uncertainty involves the qualitative evaluation (and elimination from further consideration) of essential nutrients, many of which have no available toxicity values. In addition, the toxicity values used in the derivation of PRGs are subject to change, as additional information becomes available from scientific research. These periodic changes in toxicity values may cause the PRG values to change as well.

Representative exposure concentrations are calculated in this HHRA based on the assumption that the samples collected from the EU are truly random samples. This assumption may not be met for ODA2. Sample locations may be biased to identify areas of highest contaminant concentrations.

In addition, in the evaluation of the various media, environmental concentrations are assumed to be constant (i.e., concentrations are not reduced by loss due to natural removal processes such as volatilization, leaching, and/or biodegradation). Since the source of contamination (i.e., detonation and burning) no longer exists at ODA2 (outside the RCRA unit), this assumption is a source of uncertainty.

Some unavoidable uncertainty is associated with the contaminant concentrations detected and reported by the analytical laboratory. The quality of the analytical data used in the risk assessment depends on the adequacy of the set of procedures that specifies how samples are selected and handled and how strictly these procedures are followed. Quality assurance/QC procedures within the laboratories are used to minimize uncertainties; however, sampling errors, laboratory analysis errors, and data analysis errors can occur.

Some current analytical methods are limited in their ability to achieve detection limits at or below risk-based screening levels (i.e., PRG concentrations). Under these circumstances, it is uncertain whether the true concentration is above or below the PRGs, which are protective of human health. When analytes are on the COPC list and have a mixture of detected and non-detected concentrations, risk calculations may be affected by these detection limits. Risks may be overestimated as a result of some sample concentrations being reported as non-detected at the method detection limit (MDL), which may be greater than the PRG concentration (when the actual concentration may be much smaller than the MDL). Risks may also be underestimated because some analytes that are not detected in any sample are removed from the COPC list. If the concentrations of these analytes are below the MDL but are above the PRG, the risk from these analytes would not be included in the risk assessment results.

In the data assessment process, elevated levels of common laboratory contaminants [e.g., bis(2-ethylhexyl)phthalate] can be evaluated to see if the detected concentrations are likely to be “false positives” (i.e., at high concentrations due to laboratory interference). This process involves a check against the concentrations detected in the associated laboratory method blank.

6.6.2 Uncertainties Associated with the Exposure Assessment

Uncertainty is also introduced through the process of estimating representative exposure concentrations in the analyzed exposure media. Analytical results are used to calculate a mean concentration and the UCL_{95} on the mean concentration. The smaller of the MDC and the UCL_{95} concentration is used as the EPC for this HHRA. This method may underestimate the EPC for small data sets from areas with a high degree of variability in contaminant concentrations.

Moderate uncertainty can be introduced in the data aggregation process for estimating a representative exposure concentration in the exposure media. A statistical test (the Shapiro-Wilk test) is performed to determine whether the concentration data are best described by a normal or lognormal distribution. Each COPC’s mean and UCL_{95} on the mean concentrations are calculated using both detected values and one-half of the reported detection limit for samples without a detected concentration. The EPC is the smaller of the MDC or the calculated UCL_{95}. This method may moderately overestimate the exposure concentration. In addition, when the resulting individual contaminant risks are summed to provide a total ILCR or HI, the compounding conservatism of this method for estimating EPCs will likely result in an overestimate of the total risk.

At best, quantification of exposure provides an estimate of the chemical intake for various exposure pathways identified at the site. Several uncertainties associated with the various components of the exposure assessment include uncertainties about the exposure pathway equations, exposure parameters, land use scenarios, representative exposure concentrations, and sampling and analysis of the media.

For each primary exposure pathway chosen for analysis in this HHRA, assumptions are made concerning the exposure parameters (e.g., amount of contaminated media a receptor can be exposed to and intake rates for different routes of exposure) and the routes of exposure. In the absence of site-specific data, the assumptions used are consistent with Ohio EPA-approved default values, which are assumed to be representative of potentially exposed populations (USACE 2004). All contaminant exposures are assumed to be from site-related exposure media (i.e., no other sources contribute to the receptor's health risk).

Note that for the dermal contact with soil and sediment pathway, no exposure time is included in the equation. This is based on the assumption that the receptor may not bathe (i.e., remove the soil in contact with the skin surface) for 24 hrs following the initial exposure; therefore, the receptor is actually exposed to soil contaminants for 24 hrs/day. This may overestimate the risk associated with dermal contact with soil or sediment. This fact is especially important when the dermal pathway is the major contributor to the risks and/or hazards.

Most exposure parameters have been selected so that errors occur on the side of conservatism. When several of these upper-bound values are combined in estimating exposure for any one pathway, the resulting risks can be in excess of the 99th percentile and, therefore, outside of the range that may be reasonably expected. Therefore, the consistent conservatism employed in the estimation of these parameters generally leads to overestimation of the potential risks.

Only one receptor (security guard/maintenance worker) is evaluated for exposure to COPCs in surface (0 to 1 feet) soil. Other receptors and exposure to soil >1 feet bgs are not evaluated because of access and digging restrictions at ODA2. These restrictions are in place because of the presence of MEC. This restriction must remain in place to ensure receptors are protected. Other potential receptors (including exposure to subsurface soil by a resident farmer) would need to be evaluated before these restrictions could be removed.

6.6.3 Uncertainties Associated with the Toxicity Assessment

The methodology used to develop a non-carcinogenic toxicity value (RfD or RfC) involves identifying a threshold level below which adverse health effects are not expected to occur. The RfD and RfC values are generally based on studies of the most sensitive animal species tested (unless adequate human data are available) and the most sensitive endpoint measured. Uncertainties exist in the experimental dataset for such animal studies. These studies are used to derive the experimental exposure representing the highest dose level tested at which no adverse effects are demonstrated [i.e., the no-observed-adverse-effect level (NOAEL)]; in some cases, however, only a lowest-observed-adverse-effect level (LOAEL) is available. The RfD and/or RfC is derived from the NOAEL (or LOAEL) for the critical toxic effect by dividing the NOAEL (or LOAEL) by uncertainty factors. These factors usually are in multipliers of 10, with each factor representing a specific area of uncertainty in the extrapolation of the data. For example, an uncertainty factor of 100 is typically used when extrapolating animal studies to humans. Additional uncertainty factors are sometimes necessary when other experimental data limitations are found. Because of the large uncertainties (10 to 10,000) associated with some RfD or RfC toxicity values, exact safe levels of exposure for humans are not known. For non-carcinogenic effects, the amount of human variability in physical characteristics is important in determining the risks that can be expected at low exposures and in determining the NOAEL (USEPA 1989).

The uncertainty associated with the toxicity factors for non-carcinogens is measured by the uncertainty factor, the modifying factor, and the confidence level. The toxicological data (CSFs and RfDs) for dose-response relationships of chemicals are frequently updated and revised, which can lead to overestimation or underestimation of risks. These values are often extrapolations from animals to humans, and this can also cause uncertainties in toxicity values because differences can exist in chemical absorption, metabolism, excretion, and toxic response between animals and humans.

USEPA considers differences in body weight, surface area, and pharmacokinetic relationships between animals and humans to minimize the potential to underestimate the dose-response relationship; as a result, more conservatism is usually incorporated into these steps. In particular, toxicity factors that have high uncertainties may change as new information is evaluated. Therefore, a number of the COCs—particularly those with high uncertainties—may be subject to change. Finally, the toxicity of a contaminant may vary significantly with the chemical form present in the exposure medium. For example, risks from metals may be overestimated because they are conservatively assumed to be in their most toxic forms.

The carcinogenic potential of a chemical can be estimated through a two-part evaluation involving (1) a WOE assessment to determine the likelihood that a chemical is a human carcinogen, and (2) a slope factor assessment to determine the quantitative dose-response relationship. Uncertainties occur with both assessments. Chemicals fall into one of five groups on the basis of WOE studies of humans and laboratory animals (USEPA 2004): (1) Group A – known human carcinogen; (2) Group B – probable human carcinogen based on limited human data or sufficient evidence in animals, but inadequate or no evidence in humans; (3) Group C – possible human carcinogens; (4) Group D – not classified as to human carcinogenicity; and (5) Group E – evidence of no carcinogenic effects in humans. Two COPCs identified at ODA2 are Group A carcinogens (arsenic and hexavalent chromium), one is a Group B carcinogen (cadmium), and one is classified as Group C (2,4,6-TNT).

The CSF for a chemical is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. It is used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. The slope factor is derived by applying a mathematical model to extrapolate from a relatively high, administered dose to animals to the lower exposure levels expected for humans. The slope factor represents the UCL_{95} on the linear component of the slope (generally the low-dose region) of the tumorigenic dose-response curve. A number of low-dose extrapolation models have been developed, and USEPA generally uses the linearized multistage model in the absence of adequate information to support other models.

For several analytes, no toxicity information for either the non-carcinogenic or carcinogenic health effects to humans is available in USEPA's IRIS (USEPA 2004) or HEAST (USEPA 1997b).

Therefore, until and unless additional toxicity information allows the derivation of toxicity factors, potential risk from certain chemicals cannot be quantified. COPCs falling into this category include sulfide; 2-amino-4,6-DNT; and 4-amino-2,6-DNT.

Uncertainties are associated with the GAF values used to modify the oral toxicity values to evaluate dermal toxicity. Similar uncertainties are associated with the toxicity equivalency factor values used to estimate risks from exposure to polycyclic aromatic hydrocarbons. Many potential uncertainties are associated with the toxicity data used in this HHRA and can affect the risk, hazard, and COC determinations.

6.6.4 Uncertainties Associated with the Risk Characterization

Risk assessment, as a scientific activity, is subject to uncertainty. This is true even though the methodology used in this HHRA follows USEPA guidelines. As noted previously, the risk evaluation in this report is subject to uncertainty pertaining to sampling and analysis, selection of COPCs, exposure estimates, and availability and quality of toxicity data.

Uncertainties related to the summation of HQs and ILCRs across chemicals and pathways are a primary uncertainty in the risk characterization. In the absence of information on the toxicity of specific chemical mixtures, it is assumed that ILCRs and HQs are additive (i.e., cumulative) (USEPA 1989). The limitations of this approach for non-carcinogens are (1) the effects of a mixture of chemicals are generally unknown; it is possible that the interactions could be synergistic, antagonistic, or additive; (2) the RfDs have different accuracy and precision and are not based on the same severity or effect; and (3) HQ or intake summation is most properly applied to compounds that induce the same effects by the same mechanism. Therefore, the potential for occurrence of non-carcinogenic effects can be overestimated for chemicals that act by different mechanisms and on different target organs.

Limitations of the additive risk approach for multiple carcinogens are (1) the chemical-specific slope factors represent the upper 95th percentile estimate of potency; therefore, summing individual risks can result in an excessively conservative estimate of total lifetime cancer risk; and (2) the target organs of multiple carcinogens may be different, so the risks would not be additive. In the absence of data, additivity for ILCRs and HQs is assumed for this HHRA. However, because total risks and HIs are usually driven by a few chemicals, segregation of risks and HIs by target organ would most likely not have resulted in significantly different outcomes.

Additional uncertainty can be associated with the method of selection of COCs. For this HHRA, COCs are selected for a given medium/land use scenario as chemicals with individual ILCRs ≥ 1.0E-06 and/or individual HQs ≥ 1.0 for any medium/land use scenario.

Potential risks and hazards are not determined for the three COPCs (sulfide; 2-amino-4,6-DNT; and 4-amino-2,6-DNT) that could not be evaluated quantitatively due to the lack of toxicity information and/or values. This results in uncertainty that could underestimate the total risk/hazard to human health.

6.7 REMEDIAL GOAL OPTIONS

To support the remedial alternative selection process, RGOs are developed for the one chemical identified as a COC (arsenic) in the direct exposure pathways for this HHRA. RGOs are calculated using the methodology presented in RAGS Part B (USEPA 1991) while incorporating site-specific exposure parameters applicable to ODA2. RGOs are risk-based concentrations that may be considered in an FS to define the extent of contamination that must be remediated and help cost various alternatives. RGOs are media- and chemical-specific concentrations and are calculated for the one COC identified for the Security Guard/Maintenance Worker exposed to surface soil. The RGOs presented in this document are for protection of human health and may or may not be protective of ecological receptors. The process for calculating RGOs for this HHRA is a rearrangement of the cancer risk or non-cancer hazard equations, with the goal of obtaining the concentration that will produce a specific risk or hazard level. For example, the RGO for arsenic at the cancer risk level of 10^{-5} for the Security Guard/Maintenance Worker is the concentration of arsenic that produces a risk of 10^{-5} when using the exposure parameters specific to the Security Guard/Maintenance Worker receptor.

As discussed in Section 6.5.1, the cancer risk and non-cancer hazard are calculated as

$$\text{Risk} = (\text{Intake}) \times (\text{CSF}) \qquad \textbf{(6-12)}$$

$$\text{Hazard} = (\text{Intake}) / (\text{RfD}). \qquad \textbf{(6-13)}$$

The pathway-specific (e.g., soil ingestion) equations for intake are provided in Section 6.3.4. Note that all of the intake equations shown in Section 6.3.4 include a concentration term multiplied by several other exposure parameters.

To obtain the RGO for a specific risk level (e.g., 10^{-5}), the risk equation is rearranged so that the equation is solved for C, the concentration term. Similarly, to obtain the RGO for a specific hazard level (e.g., 1.0), the hazard equation is rearranged so that the equation is solved for the concentration term.

To demonstrate the soil ingestion pathway, note that by using the soil ingestion intake equation from Section 6.3.4 (Equation 6-3) and the general risk equation from Section 6.5.1, the risk from ingestion of soil is calculated as

$$\text{Risk}_{\text{ing(soil)}} = (C_s \times IR_s \times EF \times ED \times FI \times ET \times CF \times CSF) / (BW \times AT) \qquad \textbf{(6-14)}$$

To obtain the RGO at the 10^{-5} risk level for the ingestion of soil, a value of 10^{-5} is substituted in the equation above for $\text{Risk}_{\text{ing(soil)}}$, and the equation is rearranged to solve for C_s. Thus, the general RGO equation at the 10^{-5} risk level for the ingestion of soil is calculated as

$$\text{RGO}_{\text{ing(soil)}} \text{ at } 10^{-5} = (10^{-5} \times BW \times AT) / (IR_s \times EF \times ED \times FI \times ET \times CF \times CSF) \qquad \textbf{(6-15)}$$

A similar rearrangement of the ingestion of soil hazard equation is made, producing the general RGO equation at the 1.0 hazard level for this pathway/medium:

$$\mathrm{RGO}_{ing(soil)} \text{ at } 1.0 = (1.0 \times BW \times AT \times RfD) / (IR_s \times EF \times ED \times FI \times ET \times CF) \quad \textbf{(6-16)}$$

Thus, to obtain the ingestion of soil RGO at the 10^{-5} risk level for the Security Guard/Maintenance Worker exposed to arsenic, the parameter values for the Security Guard/Maintenance Worker (from Table 6-3) and the chemical-specific oral CSF (from Table 6-6) for arsenic are used:

$$\mathrm{RGO}_{ing(soil)} \text{ at } 10^{-5} \text{ for arsenic} = [(10^{-5})(70)(25550)] / (0.0001)(250)(25)(1)(1)(0.042)(1.5)] = 458 \text{ mg/kg } \textbf{(6-16)}$$

In this example, the RGO calculated is 458 mg/kg, which will produce a soil ingestion risk of 10^{-5} for the Security Guard/Maintenance Worker exposed to arsenic in the surface soil. This example is based on the ingestion of soil; however, RGOs calculated for ODA2 include exposure by ingestion, dermal contact, and inhalation.

Note that if a calculated RGO is not physically possible (e.g., more than the pure chemical), then the RGO is adjusted accordingly. For example, if the calculated RGO is 5.5E+06 mg/kg, then the RGO is adjusted downward to 1.0E+06 mg/kg.

For this HHRA, RGOs are calculated for each exposure route (e.g., ingestion), as well as for the total chemical risk or hazard across all appropriate exposure routes. Carcinogenic RGOs are calculated and presented in this HHRA at a target risk (TR) level of 10^{-5}. To obtain the carcinogenic RGO at another risk level, one should adjust the RGO at 10^{-5} accordingly, taking care to check the resulting concentration against the physical limits discussed above (e.g., 1.0E+06 mg/kg). For example, to obtain the RGO at the 10^{-4} risk level, one should multiply the RGO at the 10^{-5} risk level by 10 (and then check the result to ensure that the concentration is physically possible). Non-carcinogenic RGOs are calculated and presented in this HHRA for a target hazard index (THI) level of 1.0. To find the non-carcinogenic RGO at another hazard level, one should adjust the RGO at the 1.0 hazard level accordingly, taking care to check the resulting concentration against the physical limits discussed above (e.g., 1.0E+06 mg/kg). For example, to obtain the RGO at the 3.0 hazard level, one should multiply the RGO at the 1.0 hazard level by 3 (and then check the result to ensure that the concentration is physically possible).

Exposure to multiple COCs may require downward adjustment of the TR and hazard used to calculate final remedial levels. The TR and THI are dependent on several factors, including the number of carcinogenic and non-carcinogenic COCs and the target organs and toxic endpoints of these COCs. For ODA2, only one COC (arsenic) is identified, so no downward adjustment of the TR and THI is required.

RGOs for arsenic in surface soil are provided in Table 6-9. It is noted that the EPC for arsenic at ODA2 (13.8 mg/kg) is smaller than the most conservative (i.e., smallest) RGO across all pathways (the RGO based on a TR of 10^{-5} is 26 mg/kg). This EPC is also smaller than the arsenic surface soil background concentration for RVAAP (15.4 mg/kg).

Table 6-9. RGOs for Surface Soil COCs at ODA2

COC	Ingestion RGO HQ = 1.0	Ingestion RGO Risk = 10^{-5}	Dermal RGO HQ = 1.0	Dermal RGO Risk = 10^{-5}	Inhalation RGO HQ = 1.0	Inhalation RGO Risk = 10^{-5}	Total RGO[a] HI = 1.0	Total RGO[a] Risk = 10^{-5}
Receptor = Security Guard/Maintenance Worker								
Arsenic	7,358	458	442	27.5	--	210,728	417	26.0

[a] Total RGO is the RGO across all pathways (ingestion, dermal, and inhalation). All RGOs are in mg/kg.
-- No hazard-based RGO could be quantified for inhalation, based on lack of approved toxicity value.

6.8 SUMMARY AND CONCLUSIONS

This HHRA was conducted to evaluate risks and hazards associated with contaminated media at the RVAAP ODA2 AOC for one potential receptor (Security Guard/Maintenance Worker) exposed to one medium (surface soil, from a depth interval of 0 to 1 feet bgs). Results have been presented for all exposure scenarios and pathways. The following steps were used to generate conclusions regarding human health risks and hazards associated with contaminated surface soil at ODA2:

- identification of COPCs;
- calculation of risks and hazards;
- identification of COCs; and
- calculation of RGOs.

Risks and hazards were evaluated and RGOs calculated for the Security Guard/Maintenance Worker. Results are summarized below.

Potential human health risks/hazards were evaluated for exposure to COPCs in surface soil at one EU (all of ODA2 except for the 2.5-acre RCRA unit within the 25-acre CERCLA unit). Direct contact (i.e., ingestion, dermal contact, and inhalation) with surface soil was evaluated for the OHARNG Security Guard/Maintenance Worker. While the future MMRP has yet to determine basic parameters for this AOC, the vast amount of already unearthed and suspected large amounts of buried MEC, including burial of white phosphorous, will in all probability dictate that this AOC will never be utilized for any but ordnance disposal related activities, and almost certainly would never be released to the public.

For all COPCs in the EU, ILCRs were calculated to estimate cancer risk to the Security Guard/Maintenance Worker at ODA2. ILCRs below 10^{-6} are considered acceptable; ILCRs above 10^{-4} are considered unacceptable. HI values were also calculated to estimate overall non-carcinogen health risks. An HI greater than 1 is defined as the level of concern for potential adverse non-carcinogenic health effects. COCs are defined for the surface soil EU as those contaminants that have an ILCR greater than 1×10^{-6} and/or an HI greater than 1 for one receptor in the HHRA.

One metal (arsenic) was identified as a COC for the Security Guard/Maintenance Worker at ODA2. The total HI is 0.051, which is below the threshold of 1.0. Therefore, no non-carcinogenic COCs are identified at ODA2. The only carcinogenic COC identified is arsenic, with a total cancer risk from exposure to this chemical of 5.3 x 10^{-6}.

Risk-based RGOs were computed for arsenic at a TR of 10^{-5} and a THI of 1; however, the EPC used in this HHRA for arsenic (13.8 mg/kg) was smaller than the most conservative risk-based RGO (26 mg/kg, based on a TR of 10^{-5}), as well as the surface soil background concentration for RVAAP (15.4 mg/kg).

7.0 SCREENING ECOLOGICAL RISK ASSESSMENT

An ERA defines the likelihood of harmful effects on plants and animals as a result of exposure to chemical constituents. There are two types of ERAs: screening and baseline. A SERA depends on available site data and is conservative in all regards. A baseline ERA (BERA) requires even more site-specific exposure and effects information, including such measurements as body burden measurements and bioassays, and often uses less conservative assumptions. A SERA or equivalent is needed to evaluate the possible risk to plants and wildlife from current and future exposure to contamination at ODA2. The need for and nature of a BERA will be assessed following completion of the SERA.

The initial regulatory guidance for an ERA is contained in the USEPA's *RAGS, Volume II, Environmental Evaluation Manual* (USEPA 1989a) and in a subsequent document (USEPA 1991). Further discussion on the scientific basis for assessing ecological effects and risk is presented in *Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document* (USEPA 1989b). Other early 1990s guidance is provided in the *Framework for Ecological Risk Assessment* (USEPA 1992). A second generation of guidance consists of the *Procedural Guidance for Ecological Risk Assessments at U.S. Army Exposure Units* (Wentsel et al. 1994) and in its replacement, the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al. 1996). In addition, the more recently published *Ecological Risk Assessment Guidance* (USEPA 1997, 1998) supersedes *RAGS, Volume II* (USEPA 1989a). This latter guidance makes the distinction between the interrelated roles of screening and baseline ERAs. Briefly, SERAs utilize conservative assumptions for exposures and effects, while a BERA means increasingly unit-specific, more realistic (and generally less conservative) exposures and effects. More recently, published USEPA guidance (USEPA 1997) was used because it provided the clearest information on preliminary or screening ERAs. The Army also has the RVAAP Facility-wide Ecological Work Plan (USACE 2003) to guide the work at ODA2. Additionally, the Ohio EPA has guidance, and that too is being used, especially for the hierarchy for ecological screening values (ESVs) (Ohio EPA 2003). The Ohio EPA guidance identifies four levels of ERA: Level I Scoping, Level II Screening, Level III Baseline, and Level IV Field Baseline. This SERA for ODA2 includes the equivalent of Ohio EPA's Level I Scoping and Level II Screening ERA.

These documents discuss an overall approach to considering ecological effects and to identifying sources of information necessary to perform ERAs. However, they do not provide all the details. Thus, professional knowledge and experience are important in ERAs to compensate for this lack of specific guidance and established methods. This professional experience comes from a team of risk scientists, who are representatives from RVAAP, USACE, Ohio EPA, and Science Applications International Corporation (SAIC).

The following sections present the scope and objectives (Section 7.1); the procedural framework (Section 7.2); and the four steps to complete the screening work, hereafter referred to as the SERA, with emphasis on problem formulation (Section 7.3). The results are presented in Section 7.4. Finally, there is a recommendations section (Section 7.5) and a summary (Section 7.6).

7.1 SCOPE AND OBJECTIVES

The scope of the SERA is to characterize, in a preliminary way, the risk to plant and animal populations at ODA2, including its aquatic environments, from analytes that are present in the surface soil, sediment, and surface water. This is done for current conditions. Unlike the HHRA which focuses on individuals, the SERA focuses on populations or groups of interbreeding individuals. In the SERA process, individuals are addressed only if they are protected under the Endangered Species Act (ESA).

The SERA used site-specific analyte concentration data for surface soil, sediment, and surface water from various geographical parts of ODA2. Risks to ecological receptors were evaluated by performing a multi-step screening process in which, after each step, the detected analytes in the media were either deemed to pose negligible risk and eliminated from further consideration or carried forward to the next step in the screening process to a final conclusion of being a chemical of potential ecological concern (COPEC). COPECs are analytes whose concentrations are great enough to pose potential adverse effects to ecological receptors. The screening steps are described in detail in Section 7.3.3. COPECs are usually the starting point for more definitive BERAs.

The objective of the SERA was to identify whether any of the detected analytes in surface soil, sediment, and surface water at ODA2 posed sufficient potential risk to ecological receptors to warrant the analytes being classified as COPECs. This was done for the most important pathways involving soil, sediment, and surface water and receptors that would be exposed to the media. Deep groundwater is not a medium of concern for ecological receptors. However, shallow groundwater is expected to flow into the drainage ditches and ponds on ODA2. Groundwater is treated as surface water once it surfaces and mixes with existing surface water. In addition, the section contains an ecological SCM, selection of receptor, definition of exposure pathways, and selection of assessment endpoints and measures.

7.2 PROCEDURAL FRAMEWORK

According to the *Framework for Ecological Risk Assessment* (USEPA 1992), the SERA process consists of three interrelated phases: problem formulation, analysis (composed of exposure assessment and ecological effects assessment), and risk characterization. In conducting the SERA for ODA2, these three phases were partially completed by performing four interrelated steps. Each has the following parts:

- **Problem Formulation:** Problem formulation establishes the goals, breadth, and focus of the SERA and provides a characterization (screening step) of chemical stressors (chemicals that restrict growth and reproduction or otherwise disturb the balance of ecological populations and systems) present in the various habitats at the site. The problem formulation step also includes a preliminary characterization of the components, especially the receptor species, in the ecosystem likely to be at risk. It can also include the selection of assessment and measurement endpoints as a basis for developing a conceptual model of stressors, components, and effects (Section 7.3).

- **Exposure Assessment:** Exposure assessment defines and evaluates the concentrations of the chemical stressors. It also describes the ecological receptors and defines the route, magnitude, frequency, duration, and spatial pattern of the exposure of each receptor population to a chemical stressor (Section 7.4).

- **Effects Assessment:** Effects assessment evaluates the ecological response to chemical stressors in terms of the selected assessment and measurement endpoints. The effects assessment results in a profile of the ecological response of populations of plants and animals to the chemical concentrations or doses and to other types and units of stress to which they are exposed. Data from both field observations and controlled laboratory studies are used to assess ecological effects (Section 7.4).

- **Risk Characterization:** Risk characterization integrates exposure and effects or the response to chemical stressors on receptor populations using HQs, which are ratios of exposure to effect. The results are used to define the risk from contamination at ODA2, in contrast to background (naturally occurring) risk. In the present scope, it is an exceedance of an ESV that is an equivalent of being in harm's way.

The SERA is organized by the four interrelated steps of the USEPA framework. Section 7.3 covers problem formulation. Section 7.4 details results and discussion from an exposure/effects/risk viewpoint. Section 7.5 provides the recommendations regarding potential next steps. Finally, Section 7.6 provides the summary.

7.3 PROBLEM FORMULATION

The first step of USEPA's approach to the SERA process, problem formulation (data collection and evaluation), includes:

- descriptions of habitats, biota, and threatened and endangered species (T&E) (Section 7.3.1);
- selection of EUs (Section 7.3.2); and
- identification of preliminary COPECs (Section 7.3.3).

7.3.1 Description of Habitats and Populations

This section provides a description of the ecological resources at ODA2. Habitats and communities are discussed in Section 7.3.3.1, animals are discussed in Section 7.3.3.2, aquatic habitats are discussed in Section 7.3.3.3, and protected species are discussed in Section 7.3.3.4. All of this information shows that Level I in the Ohio EPA guidance is met. There are ecological resources present in the form of vegetation and animal life in both terrestrial and aquatic ecosystems. Thus, Level II was justified.

7.3.1.1 Terrestrial Habitats and Plant Communities

The ODA2 AOC occupies a total area of about 25 acres (Table 7-1). This area includes forests and woodlands, shrublands, grasslands, wetlands, old railroad beds, and paved and unpaved roads. Information on plant communities at ODA2 was gleaned from the plant community survey for the RVAAP (SAIC 1999). The vegetated areas provide habitat for the many plants and animals at RVAAP/RTLS.

Table 7-1. Plant Communities and Other Habitat Recorded at ODA2

Plant Community Type	Acres	% Area
Beech-Oak-Maple Forest Alliance	2.2	8.9
Mixed-Deciduous Successional Forest	0.5	2.0
Green Ash-American Elm-Hackberry Temporarily Flooded Forest Alliance	9.6	38.2
Dry Mid-Successional Cold – Deciduous Shrubland	1.4	5.7
Dry Early Successional Herbaceous Field	11.3	45.2
Total	25.0	100.0

Beech-Oak-Maple Forest Alliance

The Beech-Oak-Maple forest alliance describes a forest community that is an intermediate between upland and lowland and contains species common to both wet and dry environments. Characteristic species include American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), northern red oak (*Quercus rubra*), yellow-poplar (*Liriodendron tulipifera*), white oak (*Quercus alba*), swamp white oak (*Quercus bicolor*), pin oak (*Quercus palustris*), green ash (*Fraxinus pennsylvanica*), hackberry (*Celtis occidentalis*), Sugarberry (C. laevigata), and American elm (Ulmus Americana). This alliance is similar to the Beech – Sugar maple – (Yellow-poplar) Forest Alliance, but is characterized by the greater abundance of red maple and the presence of wetland species such as swamp white oak, pin oak, American elm, and green ash. In addition, this alliance often contains a denser understory of woody and herbaceous species. This community occurs between the northern part of ODA2 and Winklepeck Burning Grounds covering ~ 2.2 acres or 8.9% of the total area of the AOC (Table 7-1).

Mixed-Deciduous Successional Forest

This transitional forest community is fairly abundant at RVAAP/RTLS and is indicative of a late stage of recovery following significant disturbance (e.g., clear-cutting). A mixture of pioneer species forms the somewhat open canopy. Common species include white ash, wild black cherry, red maple, black locust (*Robinia pseudoacacia*), quaking aspen (*Populus tremuloides*), and bigtooth aspen (*Populus grandidentata*). Generally, thick shrub and herbaceous layers are present characterized by old-field species such as gray dogwood *(Cornus racemosa*), northern arrowwood (*Viburnum recognitum*, syn. *dentatum*), blackberry (*Rubus allegheniensis*), hawthorn (*Crataegus* spp.), goldenrod, sheep sorrel (*Rumex acetosella*), and fescue grasses (*Festuca* spp., mostly *Festuca arundinacea*). An example of this community at ODA2 is located in the northwest part of the AOC between Sand Creek and Greenleaf Road. This community covers ~0.5 acres or 2.0% of the total area of the AOC (Table 7-1).

Green Ash-American Elm-Hackberry Temporarily Flooded Forest Alliance

This forest alliance is associated with floodplains near streams and rivers and other temporarily flooded areas. Characteristic tree species include green ash, American elm, hackberry, and red maple. Black walnut (*Juglans nigra*), white ash, swamp white oak, cottonwood (*Populus deltoids*), and black willow (*Salix nigra*) also are present. Sycamore (*Platanus occidentalis*) and silver maple (*Acer saccharinum*), two species often associated with floodplain forests, generally are not abundant at RVAAP/RTLS. The understory and shrub layers are dense and include species such as American elm, northern arrowwood, silky dogwood (*Cornus amomum*), elderberry (*Sambucus canadensis*) and willows (*Salix* spp.). Herbaceous species include wingstem (*Verbesina alternifolia*), jewelweed (*Impatiens biflora* and *I. Pallida*), false nettle (*Boehmeria cylindrica*), jack-in-the-pulpit (*Arisaema triphyllum*), smartweeds (*Polygonum* spp.), sedges (*Carex* spp.), and many others. This community occurs along the Sand floodplain. This community covers ~9.6 acres or 38.2% of the total area of the AOC (Table 7-1).

Dry Mid-Successional Cold-Deciduous Shrubland

The dry mid-successional cold-deciduous shrubland community describes a plant grouping at RVAAP/RTLS that is frequently encountered in previously disturbed areas (e.g., former agricultural fields) that have had sufficient recovery time for invasion by shrub species. This community is present throughout RVAAP/RTLS covering large (>10 acres) as well as smaller areas (<1 acre). It is characterized by shrub species covering more than 50% of the area with relatively few large trees (>7 m or ~20 ft in height). Common shrub species include gray dogwood, northern arrowwood, blackberry, hawthorn, and multiflora rose (*Rosa multiflora*). Typical pioneer tree species include red maple, wild black cherry, white ash, and black locust. A dense herbaceous community is present with common species such as goldenrod, dogbane, self-heal or heal-all, yarrow (*Achillea millefolium*), strawberry (*Fragaria virginiana*), black-eyed Susan (*Rudbeckia hirta*), sheep sorrel (*Rumex acetosella*), and fescue grasses. An example of this community at ODA2 is located east of Greenleaf Road near the southern border of RVAAP/RTLS. It is also commonly referred to as an Old Field Community. This community covers ~1.4 acres or 5.7% of the total area of the AOC (Table 7-1).

Dry Early Successional Herbaceous Field

This community describes a frequent plant grouping at RVAAP/RTLS that is present in recently disturbed areas that have not had sufficient recovery time for significant invasion by shrub species. It is characterized by a dense herbaceous community with common species, including goldenrod, clasping-leaf dogbane, self-heal or heal-all, yarrow, strawberry, black-eyed Susan, sheep sorrel, and fescue grasses. Young shrubs frequently are present, but cover less than 50% of the area. Trees are rare. Common shrub species include gray dogwood, northern arrowwood, blackberry, and multiflora rose. An example of this community is located in the central part of ODA2 on both sides of Sand Creek. This area was maintained in its present state by frequent mowing over the last several years.

The most recent disturbance to this area was associated with the ordnance disposal activities from 1999 to 2000. This community covers ~11.3 acres or 45.2% of the total area of the AOC (Table 7-1).

7.3.1.2 *Forestry Resources and Management*

ODA2 is occasionally used for the demolition of unexploded ordnance found in conjunction with the environmental restoration program (OHARNG 2001, Morgan 2004). After detonations, the area is leveled and seeded with an approved grass seed mix. Mowing is done occasionally to prevent the growth of woody vegetation (OHARNG 2001).

ODA2 is categorized as a semi-improved area. General grounds maintenance in semi-improved areas includes maintaining existing drainage; vegetation management using mowing, brush cutting, and herbicides; soil stabilization and erosion control; and repair, as needed (OHARNG 2001).

ODA2 is within Forest Management Compartment 5 (which has a total area of 2,826 acres), 1 of the 10 forest management compartments designated within RVAAP/RTLS. While each compartment is further subdivided into cutting units, the cutting unit boundaries reflect topographic features (e.g., creeks and roads) rather than forest types. Of Compartment 5's forested area (2,310 acres), 950 acres are in saw timber, 950 acres are in pole timber, and timber stands considered being of adequate regeneration cover 410 acres. Regeneration cover refers to ground vegetation that reduces erosion. Specific timber stand improvement prescriptions currently in place for Forest Management Compartment 5 call for the control of grapevines on about 170 acres. The timber harvest schedule for RVAAP/RTLS forests shows Forest Management Compartment 5 being harvested during 2006 with an expected allowable harvest of 589,000 board feet (Doyle Rule) (OHARNG 2001).

7.3.1.3 *Special Management Considerations*

Riparian Areas

Sand Creek flows through ODA2 and supports significant riparian habitat. Forest Management Compartment 5 is scheduled to be harvested during 2006. Special guidelines are followed when conducting forest management operations in riparian areas (OHARNG 2001). These guidelines include the establishment of buffer zones around riparian areas, exclusion of main skid trails from buffer zones, crossing of drainage ways, creeks and streams at right angles using culverts and/or bridging, use of single-tree selective harvesting within riparian buffer zones, retention of standing dead trees and trees with exfoliating or loose bark whenever possible, and the exclusion of leaving any slash and logging debris 6 in. or greater in diameter in any drainage channels.

Sensitive Habitats and Special Interest Areas

The Ohio Department of Natural Resources (ODNR) and the U. S. Fish and Wildlife Service did not identify any sensitive habitats on or near ODA2 during their natural heritage data searches (ODNR 1993). No Special Interest Areas have been designated within ODA2 (OHARNG 2001, Morgan

2004). Special Interest Areas include communities that host state-listed species, are representative of historic ecosystems, or are otherwise noteworthy (OHARNG 2001).

Jurisdictional Wetlands

Two jurisdictional delineations have been performed in recent years to support the National Environmental Policy Act (NEPA) requirements of specific project proposals. All of these maps and delineations are on file in the RTLS Environmental Office (OHARNG 2001). No additional wetland delineations have been performed on RVAAP/RTLS (Morgan 2003). However, it is probable that jurisdictional wetlands would be found within ODA2 along Sand Creek if a jurisdictional delineation were to be performed (Morgan 2004). Jurisdictional wetlands would signify an ecological resource of value.

Floodplains

Sand Creek is identified as having a 100-year floodplain by the Federal Emergency Management Agency (FEMA) and is reflected in the FEMA Flood Insurance Rate Map for Portage County (OHARNG 2001). The surface drainage provided by Sand Creek and the other numerous streams at RVAAP/RTLS is capable of efficiently draining the site; therefore, flooding has not been a problem (OHARNG 2001).

Executive Order 11988, *Floodplain Management,* requires all federal agencies to provide leadership and take action to reduce the risk of flood loss, minimize the impacts of flooding, and restore and preserve the natural and beneficial values of floodplains when acquiring, managing, or disposing of federal lands (OHARNG 2001).

7.3.1.4 *Animal Populations*

The plant communities at RVAAP/RTLS provide habitat that supports many species of animals. Results of 1992 and 1993 ODNR surveys at RVAAP/RTLS included 27 mammals, 154 birds, 12 reptiles, 19 amphibians, 47 fish (including 6 hybrids), 4 crayfish, 17 mussels and clams, 11 aquatic snails, 26 terrestrial snails, 37 damselflies and dragonflies, 58 butterflies, and 485 moths. Several game species, such as deer, are managed through hunts scheduled during the fall months (ODNR 1997).

The plant communities within ODA2 also provide habitats that support many species of animals. About 9% of ODA2 is forested, about 2% is in successional forest, 38% is in flooded forest, 6% is dry shrubland, and 45% is dry early successional herbaceous field.

Woodland bird species, such as the very (*Catharus fuscescens*) and wood thrush (*Hylocichla mustlina*), may be found within the beech-oak-maple stands. These woodlands likely provide habitat for migrant species such as the red-eyed vireo (*Vireo olivaceous*), yellow-throated vireo (*Vireo flavifrons*), Eastern wood-pewee (*Contopus virens*) and Acadian flycatcher (*Empidonax virescens*) in addition to permanent residents typified by the tufted titmouse (*Parus bicolor*), black-capped chickadee (*Parus atricapillus*), American crow (*Corvus brachyrhynchos*), bluejay (*Cyanocitta *cristata*), and red-bellied (*Melanerpes carolinus*) and downy (*Picoides pubescens*) woodpeckers (ODNR 1993).

Common bird species that use the successional forest and shrubland habitats include the song sparrow (*Melospiza melodia*), field sparrow (*Spizella pusilla*), common yellowthroat (*Geothylpis trichas*), gray catbird (*Dumetella carolinensis*), rufous-sided towhee (*Pipilo erythrophthalmus*), American goldfinch (*Carduelis tristis*), and blue-winged warbler (*Vermivora pinus*).

Large mammals that likely use all of the habitats include white-tailed deer (*Odocoileus virginianus*) and raccoon (*Procyon lotor*), while eastern cottontail (*Sylvilagus floridanus*), white-footed mouse (*Peromyscus leucopus*), short-tailed shrew (*Blarina brevicauda*), and meadow vole (*Microtus pennsylvanicus*) are small mammals that may be found in all of these habitats (ODNR 1993).

Sand Creek and its associated riparian habitat support additional animal species. Common wetland birds found are red-winged blackbirds (*Agelaius phoeniceus*), great blue herons (*Ardea herodias*), tree swallows (*Tachycineta bicolor*), wood ducks (*Aix sponsa*), and mallards (*Anas platyrhynchos*). Muskrat (*Ondatra zibethicus*) are likely inhabitants of most ponds (ODNR 1993).

7.3.1.5 Aquatic Habitats

Special Status Waters

Sand Creek bisects ODA2 as it flows west to east. Boundary to boundary (using a ODA2 boundary map provided by SpecPro), Sand Creek meanders about 1.2 miles through ODA2. Sand Creek, being a tributary of Eagle Creek, is designated as a State Resource Waters. With this designation, a stream and its tributaries fall under the state anti-degradation policy. These waters are protected from any action that would degrade the existing water quality (OHARNG 2001).

Streams

Sand Creek flows west-to-east through ODA2. This stream will be evaluated as part of the facility surface water investigation. The facility surface water investigation is intended to systematically document the presence/absence of Ravenna site-specific contaminants at specific locations and any movement of those contaminants from AOCs to other locations, including off-site.

The fish communities at RVAAP/RTLS were surveyed by ODNR in the early 1990s (ODNR 1993). Two survey sites from this study can be used to describe the fish community in Sand Creek above and below ODA2. Site 18 (upstream of ODA2) was located in Sand Creek on Newton Falls Road 0.25 mile east of Greenleaf Road. Site 17 (downstream of ODA2) was located in Sand Creek at George Road downstream from the bridge. Thirteen fish species were found upstream of ODA2 at Site 18 and 12 fish species were found downstream of ODA2 at Site 17. Species included Northern hog sucker (*Hypentelium nigricans*), white sucker (*Catostomus commersoni*), blacknose dace (R*hinichthys atratulus*), grass pickerel (*Esox americanus vermicula*), creek chub (*Semotilus atromaculatus*), stoneroller (*Campostoma anomalum*), redbelly dace (*Phoxinus erythrogaster*), rock bass (*Ambloplites* *rupestris*), striped shiner (*Luxilus chrysocephalus*), silverjaw minnow (*Notropis buccatus*), bluntnose minnow (*Pimephales notatus*), green sunfish (*Lepomis cyanellus*), Johnny darter (*Etheostoma nigrum*), and fantail darter (*Etheostoma flabellare*). The grass pickerel and rock bass were found only upstream of ODA2, while the Northern hog sucker only appeared downstream of the site. All other species were collected at both locations.

7.3.2 USACE/Ohio EPA Surface Water Study

A facility-wide surface water investigation was made by USACE with the cooperation of the Ohio EPA (USACE 2005). Sandy Creek near ODA2 was among the locations samples with results as follows.

A total of 7.5 miles of Sand Creek were assessed in 2003. This includes a stretch in ODA2. Based on the performance of the biological communities, the entire 7.5 miles of Sand Creek were in full attainment of the Warmwater Habitat aquatic life use. None of the chemicals measured in the surface water of Sand Creek exceeded criteria protective of the Warmwater Habitat aquatic life use. Aside from one chemical, all organic parameters tested (explosives, SVOCs, pesticides, and PCBs) in the water were reported as non-detect. Nutrients, metals and dissolved solids were at low levels in Sand Creek surface water, and were largely reflective of the undeveloped condition of the watershed. Metals in sediments were below Ohio sediment reference values and organic compounds were either non-detect or at low levels. Stream physical habitat conditions were good to excellent. Qualitative Habitat Evaluation Index (QHEI) scores for Sand Creek averaged 75.2, demonstrating the potential to support WWH biological communities. Mountain brook lamprey, a state endangered fish, and the caddisfly *Psilotreta indecisa*, a state threatened insect, were collected from Sand Creek. Based on sampling results from Sand Creek, no biological impairment associated with chemical contaminants was observed. Fish communities in Sand Creek were assessed by ODNR during 1999 and 1993. Results of those collections were generally comparable to the 2003 results, with a majority of sites attaining the Warmwater Habitat biocriterion.

7.3.2.1 T&E Species

The relative isolation and protection of habitat at RVAAP/RTLS has created an important area of refuge for a number of plant and animal species considered rare by the state of Ohio. To date, 54 state-listed species are confirmed to be on the RVAAP/RTLS property. None of these are known to exist within ODA2 (OHARNG 2001, Morgan 2004). See Table 7-2 for a list of T&E species at RVAAP/RTLS.

Federal

No known federally listed threatened or endangered species have been documented on RVAAP/RTLS (OHARNG 2001, Morgan 2004). A site-wide bat survey was performed in 1999. The federally endangered Indiana bat (*Myotis sodalis*) was not identified in this or any other survey and does not occur on RVAAP/RTLS (OHARNG 2001), although this bat has been documented nearby (Morgan 1996).

Several species listed as under Federal Observation (formerly Federal Candidate Species, Category 2) occur on RVAAP/RTLS. These species include the Cerulean warbler (*Dendroica cerulea*), Henslow's sparrow (*Ammodramus henslowii*), and the butternut tree (*Juglans cinerea*) (ODNR 1997). None of these species has been documented at ODA2 (Morgan 2004).

State

State-listed endangered species include three birds (Northern Harrier [*Circus cyaneus*], common barn owl [*Tyto alba*], and yellow-bellied Sapsucker [*Sphyrapicus varius*]), a lamprey (Mountain Brook Lamprey [*Ichthyomyzon greeleyi*]), and a butterfly (Graceful Underwing [*Catocala graciliZ*]) (ODNR 1997). None of these species has been documented at ODA2 (Morgan 2004).

A number of species that occur on RVAAP/RTLS are listed as state potentially threatened. These species include two trees (the gray birch [*Betula populifolia*] and the butternut [*Juglans cinerea*]), four woody species (Northern rose azalea [*Rhododendron nudiflorum* var. *roseum*], large cranberry [*Vaccinium macrocarpon*], hobblebush [*Viburnum alnifolium*], and fox grape [*Vitus labrusca*]), and four herbaceous species (round-leaved sundew [*Drosera rotundifolia*], closed gentian [*Gentiana clausa*], blunt mountain-mint [*Pychanthemum muticum*], and woodland horsetail [*Equisetum sylvaticum*]). Two additional plant species that are suspected to occur on RVAAP/RTLS are the long beech fern (*Phegopteris connectilis*) and eel-grass (*Vallisneria americana*) (ODNR 1993). None of these species has been documented at ODA2 (Morgan 2004).

Table 7-2. Rare Species Recorded at RVAAP/RTLS

Common Name	Scientific Name
State Endangered Species	
American bittern	*Botaurus lentiginosus(migrant)*
Northern harrier	*Circus cyaneus*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Golden-winged warbler	*Vermivora chrysoptera*
Osprey	*Pandion haliaetus (migrant)*
Trumpeter swan	*Cygnus buccinator (migrant)*
Mountain Brook Lamprey	*Ichthyomyzon greeleyi*
Graceful Underwing	*Catocala gracilis*
Ovate Spikerush	*Eleocharis ovata(Blunt spike-rush)*
Tufted Moisture-loving Moss	*Philonotis Fontana var. caespitosa*
Bobcat	*Felis rufus*
State Threatened Species	
Barn owl	*Tyto alba*
Dark-eyed junco	*Junco hyemalis (migrant)*
Hermit thrush	*Catharus guttatus (migrant)*
Least bittern	*Ixobrychus exilis*
Lest flycatcher	*Empidonax minimus*
	Psilotreta indecisa (caddisfly)
Simple willow-herb	*Epilobium strictum*
Woodland Horsetail	*Equisetum sylvaticum*

Table 7-2. Rare Species Recorded at RVAAP/RTLS (continued)

Common Name	Scientific Name
State Potentially Threatened Plants	
Pale sedge	*Carex pallescens*
Gray Birch	*Betula populifolia*
Butternut	*Juglans cinerea*
Northern rose azalea	*Rhododendron nudiflorum var. roseum*
Hobblebush	*Viburnum alnifolium*
Long Beech Fern	*Phegopteris connectilis*
Straw sedge	*Carex straminea*
Water avens	*Geum rivale*
Tall St. John's wort	*Hypericum majus*
Swamp oats	*Sphenopholis pensylvanica*
Shining ladies-tresses	*Spiranthes lucida*
Arbor Vitae	*Thuja occidentalis*
American Chestnut	*Castanea dentata*
State Species of Concern	
Pygmy shrew	*Sorex hovi*
Star-nosed mole	*Condylura cristata*
Woodland jumping mouse	*Napaeozapus insignis*
Sharp-shinned hawk	*Accipiter striatus*
Marsh wren	*Cistothorus palustris*
Henslow's sparrow	*Ammodramus henslowii*
Cerulean warbler	*Dendroica cerulea*
Prothonotary warbler	*Protonotaria citrea*
Bobolink	*Dolichonyx oryzivorus*
Northern bobwhite	*Colinus virginianus*
Common moorhen	*Gallinula chloropus*
Great egret	*Casmerodius albus*
Sora	*Porzana corolina*
Virginia Rail	*Rallus limicola*
Creek heelsplitter	*Lasmigona compressa*
Eastern box turtle	*Terrapene carolina*
Four-toed salamander	*Hemidactylium scutatum*
	Stenoema ithica (mayfly)
	Apamea mixta (moth)
Brachylomia algens (moth)	

Table 7-2. Rare Species Recorded at RVAAP/RTLS (continued)

Common Name	Scientific Name
State Special Interest Species	
Canada warbler	*Wilsonia canadensis (migrant)*
Little blue heron	*Egretta caerulea*
Magnolia warbler	*Dendroica magnolia*
Northern waterthrush	*Seiurus noveboracensis*
Winter wren	*Troglodytes troglodytes*
Back-throated blue warbler	*Dendroica caerulescens*
Brown creeper	*Certhia americana*
Morning warbler	*Oporornis philadelphia*
Pine siskin	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
Red-breasted nuthatch	*Sitta Canadensis*
Golden-crowned kinglet	*Regulus satrapa*
Blackburnian warbler	*Dendroica fusca*
Blue grosbeak	*Guiraca caerulea*
Common snipe	*Gallinago gallinago*
American wigeon	*Anas americaca*
Gadwall	*Anas strepera*
Green-winged teal	*Anas crecca*
Northern shoveler	*Anas clypeata*
Redheaded duck	*Aythya americana*
Ruddy duck	*Oxyura jamaicensis*
	Pohlia elongate var. elongate *(No common Name, Bryophyte)*

ODNR = Ohio Department of Natural Resources.
RVAAP/RTLS = Ravenna Army Ammunition Plant/Ravenna Training and Logistics Site.

Species that are state-listed as of special concern (listed either by the Ohio Department of Wildlife [ODOW] or the Heritage Program [Heritage]) include the woodland jumping mouse (*Napaeozapus insignis*) (ODOW), four birds (the Solitary Vireo [*Vireo solitarius*] [Heritage], Sharp-shinned Hawk [*Accipiter striatus*] [ODOW], Sora [*Porzana Carolina*] [ODOW], and Virginia Rail [*Rallus limicola*] [ODOW]), and two herpetiles (the four-toed salamander [*Hemidactylium scutatum*] [ODOW] and the smooth green snake [*Opheodrys vernalis*] [Heritage]) (ODNR 1997). None of these species has been documented at ODA2 (Morgan 2004).

7.3.3 Selection of Exposure Units

From the ecological assessment viewpoint, an EU is the area where ecological receptors potentially are exposed to the site constituents. Thus, the EU is defined on the basis of the historical use of various processes. Although some ecological receptors are likely to gather food, seek shelter, reproduce, and move around, spatial boundaries of the ecological EUs are the same as the spatial boundaries of aggregates defined for nature and extent, fate and transport, and the HHRA. Chemical data from the RCRA unit are excluded from the surface soil and subsurface soil data aggregations. These proposed EUs for ODA2 are as follows:

Terrestrial EU:

- Soil at ODA2.

Sediment EUs:

- Upstream at Sand Creek; and
- Downstream at Sand Creek.

Surface water EUs:

- Upstream at Sand Creek; and
- Upstream at Sand Creek.

The distinction between EUs is based on location and history of the units. Each of the EUs is spatially separated. The exact history of waste applications and spills at each EU is uncertain. This uncertainty regarding waste applications and spills provides further justification for the distinction between the EUs.

7.3.4 Identification of COPECs

In Level I Screening in Ohio EPA's Ecological Risk Assessment Guidance Document (Ohio EPA 2003), it is shown that there are natural resources present that could, in turn, be affected (negatively) by the likely or established presence of chemically contaminated soils, sediments, and surface water (chemicals of interest [COIs]). Thus, there is justification to proceed to Level II.

COPECs were identified by using methods described for Level II Screening in Ohio EPA's *Ecological Risk Assessment Guidance Document* (Ohio EPA 2003). Identification of COPECs entailed a multi-step process that began with the detected COIs that were identified in the Level I Scoping and included a data evaluation, media evaluation, and media screening as part of the Level II Screen. These three are described below in Sections 7.3.3.1, 7.3.3.2, and 7.3.3.3, respectively.

7.3.4.1 *Data Evaluation*

The data evaluation of COIs entailed two components: a frequency of detection analysis and an evaluation of common laboratory contaminants. The purpose of the frequency of detection analysis was to eliminate from further consideration any COIs that were detected in 5% or less of the samples for a given medium. However, COIs that were present in multiple media, or deemed to be persistent, bioaccumulative, and toxic (PBT) were not eliminated, even if they failed the frequency of detection evaluation. PBT compounds included four inorganics (cadmium, lead, mercury, and zinc) because of their bioaccumulative potential, as well as any organic compound whose log K_{ow} was greater than or equal to 3.0. Table N-1 lists the Log K_{ow} values for organic compounds.

Common laboratory contaminants included acetone, 2-butanone(methylethylketone), carbon disulfide, methylene chloride, toluene, and phthalate esters. If blanks contained detectable concentrations of these contaminants, then the sample results were considered positive results if the sample concentrations exceeded 10-fold the maximum amount detected in any blank.

7.3.4.2 Media Evaluation

The media evaluation was performed after the frequency of detection and common laboratory contaminant evaluation, using the COIs that were not eliminated during those two steps. The purpose of the media evaluation was to determine whether site-related chemicals have impacted media associated with the site. The evaluation methods were media-specific, and included comparison against background concentrations for all media and comparison against Ohio-specific sediment reference values (SRVs) for sediment. Because the sediments associated with ODA2 (Sand Creek) were from lotic (flowing) surface water bodies, Ohio-specific SRVs were also used for acceptable background values whenever available. The SRVs were derived by Ohio EPA (Ohio EPA 2003) to be used in lieu of or in addition to on-site sediment background values.

Next, MDCs of COIs in soil, sediment, and surface water were compared to selected background concentrations and eliminated from further consideration in the Level II Screen if the maximum concentrations were less than background values (or SRVs) and the COIs were not PBT compounds. If the MDCs of COIs exceeded background values or SRVs, and/or the COIs were PBT compounds, the COIs were deemed COPECs and were carried forward to the media screening step.

7.3.4.3 Media Screening

The media screening step proceeded after the data/media evaluations, using the inputted COPECs identified in those two steps, assuming a decision was made to proceed with the ERA process instead of selecting a removal action. The media screening process was media-specific (Ohio EPA 2003). For example, MDCs of the COPECs for surface soil, subsurface soil, and sediment were compared against media-specific ESVs recommended by Ohio EPA (Ohio EPA 2003). The ESVs are conservative toxicological benchmarks that represent concentrations, which if not exceeded, should cause no adverse effects to most ecological receptors exposed to the media. For surface water, average concentrations of COPECs that were identified during the data and media evaluations were compared against Ohio Administrative Code (OAC) water quality criteria (WQC) pursuant to OAC 3745-1 and an updated summary (per December 30, 2002) of criteria posted on the Ohio EPA website (http://www.epa.state.oh.us/dws/wqc/criteria.html). Each COPEC was considered separately. The soil and sediment ESVs, as well as the OAC WQC that were used for the media screening, are presented in Tables N-2 through N-4.

For the media screening, any inputted soil or sediment COPEC that was not a PBT compound and whose MDC did not exceed the ESV was not retained as a COPEC and was eliminated from further consideration in the Level II Screen. For surface water, any inputted COPEC that was not a PBT compound and whose average concentration did not exceed the OAC WQC was also eliminated from further consideration. If no COPECs were retained in any medium, that medium was eliminated from further ecological risk evaluation (Ohio EPA 2003). However, any inputted COPECs whose concentrations exceeded ESVs or OAC WQC, or that did not have ESVs or OAC WQC, and/or were PBT compounds, were retained as COPECs.

The sources and screening hierarchy of soil and sediment screening benchmarks were specified by Ohio EPA (2003) as follows.

Soil Screening Hierarchy

For soils, the MDC of each COPEC was compared to soil screening values. The hierarchy of sources of soil screening values, in order of preference, (Ohio EPA 2003) was as follows:

- Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones, 1997a. *Preliminary Remediation Goals for Ecological Endpoints.* ES/ER/TM-162/R2.

- Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997b. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision*. ES/ER/TM-126/R2.

- Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997c. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision*. ES/ER/TM-85/R3.

- The fourth stated source is *Ecological Data Quality Levels (EDQLs), U.S. EPA, Region 5, Final Technical Approach for Developing EDQLs for RCRA Appendix IX Constituents and Other Significant Contaminants of Concern, 1999* (USEPA 1999). However, that reference has been superceded by *Region 5 Corrective Action, Ecological Screening Levels (2003),* http://www.epa.gov/reg5rcra/ca/edql.htm.

Sediment Screening Hierarchy

For sediments, the stream must have an Aquatic Life Habitat Use Designation. If there is full attainment of biological criteria for that designation, sediment is dismissed from further evaluation. If there is not full attainment of biological criteria, the MDCs of COPECs are to be compared to sediment screening values. The hierarchy for sediment screening values (Ohio EPA 2003), in order of preference, was as follows:

- Consensus-based threshold effects concentrations values (MacDonald, Ingersoll, and Berger 2000).

- *Ecological Data Quality Levels (EDQL), U.S. EPA, Region 5, Final Technical Approach for Developing EDQLs for RCRA Appendix IX Constituents and Other Significant Contaminants* *of Concern, 1999* (USEPA 1996). However, this reference has been superceded by *Region 5 Corrective Action, Ecological Screening Levels (2003),* http://www.epa.gov/reg5rcra/ca/edql.htm.

Surface Water Hierarchy

For surface water, one uses the chemical criteria pursuant to OAC 3745-1 for the Erie Ontario Lake Plain coercion (Ohio EPA 2002). The guidance (Ohio EPA 2003) specifies that samples averaged over a 30-day period are to be compared to "outside mixing zone average" criteria for human health, aquatic life, and wildlife. In addition, biological criteria for the aquatic life habitat designation, warm-water habitat, pursuant to AOC 3745-1-07 for the Lake Erie basin coercion, must be met. To ensure a conservative screen, outside mixing zone average values were used as criteria in the general screen.

7.4 RESULTS AND DISCUSSION

This section presents the findings or results of the comparisons of various exposure measurements (e.g., maximum concentrations) and various effects measurements (e.g., ESVs). These comparisons are done at each of the EUs and their applicable media to identify COPECs. In addition, the results and discussion section contains the preliminary SCM, site-specific receptors, and other information pertaining to Level III.

7.4.1 Data and Media Evaluation Results

Tables showing the results of the data and media evaluation screening to initially identify COPECs for surface soil, subsurface soil, downstream and upstream sediment, and downstream and upstream surface water are presented in Tables N-2 through N-7, respectively. A summary of these results of the data and media evaluation screening is provided below.

7.4.1.1 Surface Soil

Forty-one detected COIs, including 25 inorganics (includes total and hexavalent chromium), nine explosives, one pesticide, three SVOCs, and three VOCs were inputted to the data and media evaluation for surface soil (Table N-2). Two inorganics (antimony and silver) and seven explosives were eliminated from being COPECs due to a frequency of detection less than 5% and not being PBT compounds. Thus, 32 of the COIs were deemed to be COPECs because they met one or more of the following criteria: they were PBTs and/or their frequency of detection exceeded 5%, and/or their MDC exceeded the background value (or there was not a reported background value). The COPECs were carried forward to the media screening step, which is discussed in Section 7.4.2.

7.4.1.2 Subsurface Soil

Thirty-eight detected COIs, including 24 inorganics (includes total and hexavalent chromium), nine explosives, two SVOCs, and three VOCs were inputted to the data and media evaluation for subsurface soil (Table N-3). Eleven inorganics and five explosives were eliminated from being

COPECs. Ten of the 11 inorganics were eliminated because they all had MDCs less than the background values and they were not PBTs. One inorganic (sodium) was eliminated from being a COPEC because its frequency of detection was less than 5% and it was not a PBT compound. The five explosives that were eliminated all had frequency of detections less than 5%, were not PBTs, and had no background values. Thus, 22 of the inputted COIs were deemed to be COPECs because they met one or more of the following criteria: they were PBTs and/or their frequency of detection exceeded 5%, and/or their MDC exceeded the background value (or there was not a reported background value). The COPECs were carried forward to the media screening, which is discussed in Section 7.4.2.

7.4.1.3 Downstream Sediment

Twenty-six detected COIs, including 22 inorganics (includes total and hexavalent chromium), one pesticide, and three VOCs were inputted to the data and media evaluation for Sand Creek downstream sediment (Table N-4). Thirteen inorganics were eliminated from being COPECs because their MDCs did not exceed the Ohio EPA SRVs and they were not PBTs. Thus, 13 of the inputted COIs were deemed to be COPECs because they met one or more of the following criteria: they were PBTs and/or their frequency of detection exceeded 5%, and/or their MDC exceeded the SRV or background value (or there was not a reported SRV or background value). The COPECs were carried forward to the media screening, which is discussed in Section 7.4.2.

7.4.1.4 Upstream Sediment

Twenty-five detected COIs, including 21 inorganics, three SVOCs, and one VOC were inputted to the data and media evaluation for Sand Creek upstream sediment (Table N-5). Thirteen inorganics were eliminated from being COPECs, 12 of which had MDCs that did not exceed the Ohio EPA SRVs and they were not PBTs. One inorganic COI (sodium) was eliminated from being a COPEC because its MDC did not exceed the background value, it was not a PBT, and it did not have a SRV. Thus, 12 of the inputted COIs were deemed to be COPECs because they met one or more of the following criteria: they were PBTs and/or their frequency of detection exceeded 5%, and/or their MDC exceeded the SRV or background value (or there was not a reported SRV or background value). The COPECs were carried forward to the media screening, which is discussed in Section 7.4.2.

7.4.1.5 Downstream Surface Water

Fifteen detected COIs, including 11 inorganics, one explosive, one SVOC, and two VOCs were inputted to the data and media evaluation for Sand Creek downstream surface water (Table N-6). Six of the inorganics were eliminated from being COPECs because their MDCs did not exceed the background value and they were not PBTs. Thus, nine of the inputted COIs were deemed to be COPECs because they met one or more of the following criteria: they were PBTs and/or their frequency of detection exceeded 5%, and/or their MDC exceeded the background value (or there was not a reported background value). The COPECs were carried forward to the media screening, which is discussed in Section 7.4.2.

7.4.1.6 Upstream Surface Water

Thirteen detected COIs, including 11 inorganics, one explosive, and one VOC were inputted to the data and media evaluation for Sand Creek upstream surface water (Table N-7). Six of the inorganics were eliminated from being COPECs because their MDCs did not exceed the background value and they were not PBTs. Thus, seven of the inputted COIs were deemed to be COPECs because they met one or more of the following criteria: their frequency of detection exceeded 5% and/or their MDC exceeded the background value (or there was not a reported background value). The COPECs were carried forward to the media screening, which is discussed in Section 7.4.2.

7.4.2 Media Screening Results

Tables providing the screening values and chemical criteria for these comparisons are found in Appendix N, Tables N-8 through N-10. Tables showing the results of the media screening for surface soil, subsurface soil, downstream and upstream sediment, and downstream and upstream surface water are presented in Tables N-11 through N-16, respectively. Summary results of the retained COPECs following the media screening are presented in Tables 7-3 through 7-8 and are in the following sections.

7.4.2.1 Surface Soil Media Screening

The media screening for surface soil is shown in Table N-11. A summary of surface soil COPECs that were retained following the media screening is presented in Table 7-3.

Thirty-two COPECs were inputted into the media screening from the data and media evaluation, including 23 inorganics (includes total and hexavalent chromium), two explosives, one pesticide, three SVOCs, and three VOCs (Table N-11). Six of the inputted COPECs were not retained because their maximum detects were below their ESVs and they were not PBT compounds. The six eliminated COPECs included two inorganics (barium and beryllium), one explosive (2,4,6-TNT), and three VOCs (acetone, 2-butanone, and PCE). Thus, 26 COPECs were retained, which included 21 inorganics, one explosive, one pesticide, and three SVOCs.

Of the 26 retained COPECs, 16 had maximum detects that exceeded their ESV (all inorganics), six had no ESVs, (five inorganics and one explosive) and four were COPECs solely due to being PBT compounds (the pesticide and all three SVOCs) (Table 7-3). Four of the retained COPECs (cadmium, lead, mercury, and zinc) had maximum detects that exceeded the ESV and were also PBT compounds.

Table 7-3. Summary of Surface Soil COPECs for ODA2 and Rationale for Retention

Retained COPEC	Rationales for COPEC Retention		
	Maximum Detect > ESV	**PBT Compound**	**No ESV**
Inorganics			
Aluminum	X		
Arsenic	X		
Cadmium	X	X	
Calcium			X
Chromium	X		
Chromium, hexavalent	X		
Cobalt	X		
Copper	X		
Iron	X		
Lead	X	X	
Magnesium			X
Manganese	X		
Mercury	X	X	
Nickel	X		
Nitrate/nitrite			X
Potassium			X
Selenium	X		
Sodium			X
Sulfide	X		
Vanadium	X		
Zinc	X	X	
Organics			
Explosives			
Tetryl			X
Pesticides/PCBs			
4,4’-DDD		X	
Semi-Volatiles			
Bis(2-ethylhexyl)phthalate		X	
Di-n-butylphthalate		X	
N_Nitrosodiphenylamine		X	

COPEC = Constituent of potential ecological concern.
DDD = Dichlorodiphenyldichloroethane.
ESV = Ecological screening value.
PBT = Persistent, bioaccumulative, and toxic.
PCB = Polychlorinated biphenyl.
“X” = COPEC was retained based on this rationale.

Table 7-4. Summary of Subsurface Soil COPECs for ODA2 and Rationale for Retention

Retained COPEC	**Rationales for COPEC Retention**		
	Maximum Detect > ESV	**PBT Compound**	**No ESV**
Inorganics			
Arsenic	X		
Barium	X		
Cadmium	X	X	
Chromium, hexavalent	X		
Copper	X		
Iron	X		
Lead	X	X	
Magnesium			X
Mercury	X	X	
Nitrate/nitrite			X
Selenium	X		
Sulfide	X		
Zinc	X	X	
Organics			
Explosives			
2-Amino-4,6-dinitrotoluene			X
4-Amino-2,6-dinitrotoluene			X
Tetryl			X
Semi-Volatiles			
Bis(2-ethylhexyl)phthalate		X	
Di-n-butylphthalate		X	

COPEC = Constituent of potential ecological concern.
ESV = Ecological screening value.
PBT = Persistent, bioaccumulative, and toxic.
“X” = COPEC was retained based on this rationale.

Table 7-5. Summary of Sand Creek Downstream Sediment COPECs for ODA2 and Rationale for Retention

Retained COPEC	Rationales for COPEC Retention		
	Maximum Detect > ESV	**PBT Compound**	**No ESV**
Inorganics			
Cadmium	X	X	
Copper	X		
Lead		X	
Mercury	X	X	
Nitrate/nitrite			X
Sulfide			X
Zinc	X	X	
Organics			
Pesticides/PCBs			
Dieldrin		X	
Volatiles			
Chloromethane			X

COPEC = Constituent of potential ecological concern.
ESV = Ecological screening value.
PBT = Persistent, bioaccumulative, and toxic.
PCB = Polychlorinated biphenyl.
"X" = COPEC was retained based on this rationale.

Table 7-6. Summary of Sand Creek Upstream Sediment COPECs for ODA2 and Rationale for Retention

Retained COPEC	Rationales for COPEC Retention		
	Maximum Detect > ESV	**PBT Compound**	**No ESV**
Inorganics			
Barium			X
Cadmium	X	X	
Copper	X		
Lead		X	
Mercury		X	
Nitrate/nitrite			X
Sulfide			X
Zinc	X	X	
Organics			
Semi-Volatiles			
Bis(2-ethylhexyl)phthalate		X	
Di-n-butylphthalate		X	
Fluoranthene		X	

COPEC = Constituent of potential ecological concern.
ESV = Ecological screening value.
PBT = Persistent, bioaccumulative, and toxic.
"X" = COPEC was retained based on this rationale.

Table 7-7. Summary of Sand Creek Downstream Surface Water COPECs for ODA2 and Rationale for Retention

Retained COPEC	Rationales for COPEC Retention		
	Maximum Detect > OAC WQC	**PBT Compound**	**No OAC WQC**
Inorganics			
Calcium			X
Magnesium			X
Nitrate/nitrite			X
Sulfide			X
Zinc		X	
Organics			
Explosives			
Nitrocellulose			X
Semi-Volatiles			
Bis(2-ethylhexyl)phthalate		X	

COPEC = Constituent of potential ecological concern.
OAC WQC= Ohio Administrative Code Water Quality Criteria.
PBT = Persistent, bioaccumulative, and toxic.
"X" = COPEC was retained based on this rationale.

Table 7-8. Summary of Sand Creek Upstream Surface Water COPECs for ODA2 and Rationale for Retention

Retained COPEC	Rationales for COPEC Retention		
	Maximum Detect > OAC	**PBT Compound**	**No OAC WQC**
Inorganics			
Calcium			X
Magnesium			X
Nitrate/nitrite			X
Organics			
Explosives			
Nitrocellulose			X

COPEC = Constituent of potential ecological concern.
OAC WQC= Ohio Administrative Code Water Quality Criteria.
PBT = Persistent, bioaccumulative, and toxic.
"X" = COPEC was retained based on this rationale.

7.4.2.2 Subsurface Soil Media Screening

The media screening for subsurface soil is shown in Table N-12. A summary of subsurface soil COPECs that were retained following the media screening is presented in Table 7-4.

Twenty-two COPECs were inputted into the media screening from the data and media evaluation, including 13 inorganics (includes total and hexavalent chromium), four explosives, two SVOCs, and three VOCs (Table N-12). Four of the inputted COPECs were not retained because their maximum detects were below their ESVs and they were not PBT compounds. The four eliminated COPECs included one explosive (2,4,6-TNT) and the three volatiles (2-butanone, PCE, and toluene). Thus, 18 COPECs were retained, which included 13 inorganics, three explosives, and two SVOCs.

Of the 18 retained COPECs, 11 had maximum detects that exceeded their ESV (all inorganics), five had no ESVs, (two inorganics and three explosives), and two were COPECs solely due to being PBT compounds (SVOCs) (Table 7-4). Four of the retained COPECs (cadmium, lead, mercury, and zinc) had maximum detects that exceeded the ESV and were also PBT compounds.

7.4.2.3 Downstream Sediment Media Screening

The media screening for Sand Creek downstream sediment is shown in Table N-13. A summary of downstream sediment COPECs that were retained following the media screening is presented in Table 7-5.

Thirteen downstream sediment COPECs were inputted into the media screening from the data and media evaluation, including nine inorganics, one pesticide, and three VOCs (Table N-13). Four of the inputted COPECs were not retained because their maximum detects were below their ESVs. The four eliminated COPECs included two inorganics (hexavalent chromium and nickel) and two VOCs (2-butanone and PCE). Thus, nine COPECs were retained, which included seven inorganics, one pesticide, and one VOC.

Of the nine retained COPECs, four had maximum detects that exceeded their ESV (four inorganics), three had no ESVs (nitrate/nitrite, sulfide, and chloromethane), and two were COPECs solely due to being PBT compounds (lead and dieldrin) (Table 7-5). Three of the retained COPECs (cadmium, mercury, and zinc) had maximum detects that exceeded the ESV and were also PBT compounds.

7.4.2.4 Upstream Sediment Media Screening

The media screening for Sand Creek upstream sediment is shown in Table N-14. A summary of upstream sediment COPECs that were retained following the media screening is presented in Table 7-6.

Twelve upstream sediment COPECs were inputted into the media screening from the data and media evaluation, including eight inorganics, three SVOCs, and one VOC (Table N-14). Only one of the inputted COPECs (2-butanone) was not retained because its maximum detect was below its ESV. Thus, 11 COPECs were retained, which included eight inorganics and the three SVOCs.

Of the 11 retained COPECs, three had maximum detects that exceeded their ESV (cadmium, copper, and zinc), three had no ESVs (barium, nitrate/nitrite, and sulfide), and five were COPECs solely due to being PBT compounds (lead, mercury, bis[2-ethylhexyl]phthalate, di-n-butylphthalate, and fluoranthene) (Table 7-6). Two of the retained COPECs (cadmium and zinc) had maximum detects that exceeded the ESV and were also PBT compounds.

7.4.2.5 Downstream Surface Water Media Screening

The media screening for Sand Creek downstream surface water is shown in Table N-15. A summary of downstream surface water COPECs that were retained following the media screening is presented in Table 7-7.

Nine downstream surface water COPECs were inputted into the media screening from the data and media evaluation, including five inorganics, one explosive, one SVOC, and two VOCs (Table N-15). Two of the inputted COPECs (carbon disulfide and chloroform) were not retained because their maximum detects were below their OAC WQC. Thus, seven COPECs were retained, which included five inorganics, one explosive, and one SVOC.

Of the seven retained COPECs, five had no OAC WQC (calcium, magnesium, nitrate/nitrite, sulfide, and nitrocellulose) and two were COPECs solely due to being PBT compounds [zinc and bis(2-ethylhexyl)phthalate] (Table 7-7). None of the retained COPECs for downstream surface water had a maximum detect exceeding the OAC WQC.

7.4.2.6 Upstream Surface Water Media Screening

The media screening for Sand Creek upstream surface water is shown in Table N-16. A summary of upstream surface water COPECs that were retained following the media screening is presented in Table 7-8.

Seven upstream surface water COPECs were inputted into the media screening from the data and media evaluation, including five inorganics, one explosive, and one VOC (Table N-16). Three of the inputted COPECs were not retained because their maximum detects were below their OAC WQC. The three eliminated COPECs included two inorganics (chromium and nickel) and the one VOC (chloroform). Thus, four COPECs were retained, which included three inorganics and the one explosive.

All four of the retained COPECs had no OAC WQC (calcium, magnesium, nitrate/nitrite, and nitrocellulose) (Table 7-8). None of the retained COPECs for Sand Creek upstream surface water had a maximum detect exceeding the OAC WQC, nor were they PBT compounds.

7.4.3 Ecological Conceptual Site Models

Ecological conceptual site models (ECSMs) depict and describe the known and expected relationships among the stressors, pathways, and assessment endpoints that are considered in the risk assessment, along with a rationale for their inclusion. Two ECSMs are presented for this Level II Screen. One ECSM is associated with the media screening of the Level II Screen (Figure 7-1). The other ECSM (Figure 7-2) represents the Level III Baseline. The ECSMs for the ODA2 site were developed using the available site-specific information and professional judgment. The contamination mechanism, source media, transport mechanisms, exposure media, exposure routes, and ecological receptors for the ECSMs are described below.

7.4.3.1 Contamination Source

The contamination source includes releases from historic site operations. Chapter 2.0 describes the types of historical operations that take place at the site.

7.4.3.2 Source Media

The source medium is soil. For the SERA, surface soil is defined as 0 to 2 ft bgs. Contaminants released from historic site operations went directly into the surrounding soil, making soil the source medium.

7.4.3.3 Transport Mechanisms

Transport mechanisms at the site include volatilization into the air, biota uptake, erosion to surface water and sediment, and leaching to groundwater. Biota uptake is a transport mechanism because some of the site contaminants are known to accumulate in biota, and those biota are free to move around. The deposition of eroded soils containing site contaminants into surface water and sediment is also a valid transport mechanism for both ECSMs.

7.4.3.4 Exposure Media

Sufficient time (over 10 years) has elapsed for contaminants in the source media to have migrated to potential exposure media, resulting in possible exposure of plants and animals that come in contact with these media. Potential exposure media include air, surface soil, subsurface soil, food chain, surface water, and sediment. Groundwater is not considered an exposure medium because ecological receptors are unlikely to contact groundwater at a depth of greater than 5 feet bgs. Groundwater could outcrop into surface water as a seep or spring, but is not considered an exposure medium until it does so. Soil, surface water, sediment, and food chain are the four principal exposure media for the ODA2 site.

7.4.3.5 Exposure Routes

Exposure routes are functions of the characteristics of the media in which the sources occur, and how both the released chemicals and receptors interact with those media. For example, chemicals in surface water may be dissolved or suspended as particulates and be very mobile, whereas those same constituents in soil may be much more stationary. The ecology of the receptors is important because it dictates their home range, whether the organism is mobile or immobile, local or migratory, burrowing or above ground, plant eating, animal eating, or omnivorous.

For the Level II Screen, specific exposure routes were not identified because it is not receptor-specific and only focuses on comparison of MDCs of chemicals in the exposure media against published ecological toxicological benchmark concentrations derived for those media. However, the Level III Baseline ECSM (Figure 7-2) will identify specific exposure routes and indicates whether the exposure routes from the exposure media to the ecological receptors are major or minor. Major exposure routes are evaluated quantitatively, whereas minor routes are evaluated qualitatively. The Level III

Baseline ECSM (Figure 7-2) shows a major exposure route of soil to terrestrial plants and animals and an incomplete exposure route of upper groundwater to terrestrial and aquatic plants and animals. Groundwater is assumed not to be directly contacted by ecological receptors.

The major exposure routes for chemical toxicity from surface soil include ingestion (for terrestrial invertebrates, rabbits, voles, shrews, robins, foxes, and hawks) and direct contact (for terrestrial plants and invertebrates). The ingestion exposure route for rabbits, voles, shrews, robins, foxes, and hawks includes soil, as well as plant and/or animal food (i.e., food chain), that was exposed to the surface soil. Minor exposure routes for surface soil include direct contact and inhalation of fugitive dust (for rabbits, voles, shrews, robins, foxes, and hawks). The major exposure routes for chemical toxicity from subsurface soil (0.6 to 1.2 m [2 to 4 ft]) include ingestion (for terrestrial invertebrates, rabbits, voles, shrews, and robins) and direct contact (for terrestrial plants and invertebrates). The ingestion exposure route for terrestrial vertebrates includes soil, as well as plant and/or animal food (food chain) that was exposed to the subsurface soil. Minor exposure routes for subsurface soil include direct contact and inhalation of fugitive dust (for rabbits, voles, and shrews). The major exposure routes for surface water include ingestion (for aquatic biota, muskrats, ducks, mink, and herons) and direct contact (for aquatic biota and benthic invertebrates). Minor exposure pathways for surface water and sediment include direct contact and inhalation (for muskrats, ducks, mink, and herons). The major exposure routes for sediment include ingestion (for aquatic biota, muskrats, ducks, mink, and herons) and direct contact (for aquatic biota and benthic invertebrates). The ingestion exposure routes for aquatic biota (including vertebrate mammals and birds) include sediment and surface water (as applicable), as well as plant and/or animal food (food chain) that was exposed to the sediment or surface water.

Exposure to groundwater is an incomplete pathway for all terrestrial and aquatic ecological receptors because groundwater is too deep beneath ground level for there to be direct exposure to any of the receptors. If the groundwater outcrops via seeps or springs into wetlands or ditches, it becomes part of the surface water and would be evaluated in the surface water pathway.

7.4.3.6 *Ecological Receptors*

For the Level II screen, specific ecological receptors were not identified, but terrestrial and aquatic biota were each considered as a whole. However, for the Level III Baseline, terrestrial and aquatic ecological receptors, as well as riparian receptors, would be identified in the ECSM (Figure 7-2). The terrestrial receptors include plants, terrestrial invertebrates (earthworms), rabbits, voles, shrews, robins, foxes, and hawks. The aquatic receptors include benthic invertebrates and aquatic biota. Aquatic herbivore receptors are represented by the muskrat and the mallard duck. The riparian carnivores include mink and herons. These receptors are discussed in more detail in Section 7.4.4.

7.4.4 Selection of Site-Specific Ecological Receptor Species

The selection of ecological receptors for the site-specific analysis screen was based on plant and animal species that do or could occur in the terrestrial and aquatic habitats at the site. Three criteria were used to identify the site-specific receptors.

1. **Ecological Relevance**: The receptor has or represents a role in an important function such as energy fixation (e.g., plants), nutrient cycling (e.g., earthworms), and population regulation (e.g., hawks). Receptor species were chosen to include representatives of all applicable tropic levels identified by the ECSM for the site. These species were selected to be predictive of assessment endpoints (including protected species/species of special concern and recreational species).

2. **Susceptibility**: The receptor is known to be sensitive to the chemicals detected at the site, and given their food and habitat preferences, their exposure is expected to be high. The species have a likely potential for exposure based upon their residency status, home range size, sedentary nature of the organism, habitat compatibility, exposure to contaminated media, exposure route, and/or exposure mechanism compatibility. Ecological receptor species were also selected based on the availability of toxicological effects and exposure information.

3. **Management Goals**: Valuable roles in erosion control (e.g., plants), societal values (e.g., trapping for fur [mink] and small game hunting [rabbits]), and regulatory protection (e.g., Migratory Bird Act [robins, hawks, mallards, and herons] and Migratory Bird Hunting Stamp Act [mallards]). The ecosystem functions of the ecological receptor species (foodweb interactions, keystone species, vital to ecosystem function, dominant species or tolerant/intolerant species) were considered during the selection process.

At ODA2, the following types of ecological receptors are likely to be present: terrestrial plants, terrestrial invertebrates, cottontail rabbits (*Sylvilagus floridanus*), meadow voles (*Microtus pennsylvanicus*), short-tailed shrews (*Blarina brevicauda*), American robins (*Turdus migratoris*), red foxes (*Vulpes vulpes*), red-tailed hawks (*Buteo jamaicensis*), sediment-dwelling biota, aquatic biota, muskrats (*Ondatra zibenthicus*), mallard ducks (*Anas platyrhynchos*), mink (*Mustella vison*), and great blue herons (*Ardea herodias*). Each of these receptors is described in Section 7.4.4.1 (for terrestrial exposures) or 7.4.4.2 (for aquatic and riparian exposures).

7.4.4.1 Terrestrial Exposure Classes and Receptors

Terrestrial exposures, receptors, and justification for their selection for the site-specific analysis screen are presented below.

Terrestrial Vegetation Exposure to Soil

Terrestrial vegetation exposure to soil is applicable to the ODA2 site. Terrestrial plants have ecological relevance because they represent the base of the food web and are the primary producers that turn energy from the sun into organic material (plants) that provides food for many animals. There is sufficient habitat present for them at the site. In addition, plants are important in providing shelter and nesting materials to many animals, thus, plants are a major component of habitat. Plants provide natural cover and stability to soil and stream banks, thereby reducing soil erosion.

Terrestrial plants are susceptible to toxicity from chemicals. Plants have roots that are in direct contact with surface soil, which provides them with direct exposure to contaminants in the soil. They also can have exposure to contaminants via direct contact on the leaves. There are published toxicity benchmarks for plants (Efroymson et al. 1997c), and there are management goals for plants because of their importance in erosion control. Thus, there is sufficient justification to warrant plants as a receptor for the ODA2 site.

Terrestrial Invertebrate Exposure to Soil

Terrestrial invertebrate exposure to soil is applicable to soils for the ODA2 site. Earthworms represent the receptor for the terrestrial invertebrate class, and there is sufficient habitat present for them on-site. Earthworms have ecological relevance because they are important for decomposition of detritus and for energy and nutrient cycling in soil (Efroymson et al. 1997b). Earthworms are probably the most important of the terrestrial invertebrates for promoting soil fertility because they process much soil.

Earthworms are susceptible to exposure to, and toxicity from, COPECs in soil. Earthworms are nearly always in contact with soil and ingest soil, which results in constant exposure. Earthworms are sensitive to various chemicals. Toxicity benchmarks are available for earthworms (Efroymson et al. 1997b). Although management goals for earthworms are not immediately obvious, the important role of earthworms in soil fertility cannot be overlooked. Thus, there is sufficient justification to warrant earthworms as a receptor for the ODA2 site.

Mammalian Herbivore Exposure to Soil

Mammalian herbivore exposure to soil is applicable to the ODA2 site. Cottontail rabbits and meadow voles represent mammalian herbivore receptors, and there is suitable habitat present for them at the site. Both species have ecological relevance by consuming vegetation, which helps in the regulation of plant populations and in the dispersion of some plant seeds. Small herbivorous mammals such as cottontail rabbits and voles are components of the diet of terrestrial top predators.

Both cottontail rabbits and meadow voles are susceptible to exposure to, and toxicity from, COPCs in soil and vegetation. Herbivorous mammals are exposed primarily through ingestion of plant material and incidental ingestion of contaminated surface soil containing chemicals. Exposures by inhalation of COPCs in air or on suspended particulates, as well as exposures by direct contact with soil were assumed to be negligible. Dietary toxicity benchmarks are available for many COPCs for mammals (Sample et al. 1996), and there are management goals for rabbits because they are an upland small game species protected under Ohio hunting regulations. There are no specific management goals for meadow voles at ODA2. However, because of the management goals for rabbits, plus the ecological relevance and susceptibility to contamination for both species, there is sufficient justification to warrant cottontail rabbits and meadow voles as receptors for the ODA2 site.

Insectivorous Mammal and Bird Exposure to Soil

Insectivorous mammal and bird exposure to soil is applicable to the ODA2 site. Short-tailed shrews and American robins represent the receptors for the insectivorous mammal and bird terrestrial exposure class, respectively. There is sufficient, suitable habitat present at the site for these receptors.

Both species have ecological relevance because they help to control aboveground invertebrate community size by consuming large numbers of invertebrates. Shrews and robins are a prey item for terrestrial top predators.

Both short-tailed shrews and American robins are susceptible to exposure to, and toxicity from, COPCs in soil, as well as contaminants in vegetation and terrestrial invertebrate. Insectivorous mammals such as short-tailed shrews and birds such as American robins are primarily exposed by ingestion of contaminated prey (e.g., earthworms, insect larvae, and slugs), as well as ingestion of soil. In addition, shrews ingest a small amount of leafy vegetation, and the robin's diet consists of 50% each of seeds and fruit. Dietary toxicity benchmarks are available for mammals and birds (Sample et al. 1996). Both species are recommended as receptors because there can be different toxicological sensitivity between mammals and birds exposed to the same contaminants. There are management goals for robins because they are federally protected under the Migratory Bird Treaty Act of 1993, as amended. There are no specific management goals for shrews at the site. Based on the management goals for robins, plus the susceptibility to contamination and ecological relevance for both species, there is sufficient justification to warrant shrews and robins as receptors for the ODA2 site.

Terrestrial Top Predators

Exposure of terrestrial top predators is applicable to the ODA2 site. Red foxes and red-tailed hawks represent the mammal and bird receptors for the terrestrial top predator exposure class, respectively, and there is a limited amount of suitable habitat present for them at the site. Both species have ecological relevance because as representatives of the top of the food chain for the site terrestrial EUs, they control populations of prey animals such as small mammals and birds.

Both red foxes and red-tailed hawks are susceptible to exposure to, and toxicity from, COPECs in soil, vegetation, and/or animal prey. Terrestrial top predators feed on small mammals and birds that may accumulate constituents in their tissues following exposure at the site. There is a potential difference in toxicological sensitivity between mammals and birds exposed to the same COPCs so it is prudent to examine a species from each taxon (Mammalia and Aves, respectively). Red foxes are primarily carnivorous but consume some plant material. The red-tailed hawk consumes only animal prey. The foxes may incidentally consume soil.

There are management goals for both species. Laws (Ohio trapping season regulations for foxes, and federal protection of raptors under the Migratory Bird Treaty Act) also protect these species. In addition, both species are susceptible to contamination and have ecological relevance as top predators in the terrestrial ecosystem. Thus, there is sufficient justification to warrant these two species as receptors for the ODA2 site.

7.4.4.2 Aquatic and Riparian Exposure Receptors

The aquatic exposures, receptors, and justification for why they are relevant for the ODA2 site are presented below.

Exposure of Aquatic Biota to Water

Exposure of aquatic biota to water is applicable to the ODA2 site. Aquatic biota (e.g., aquatic plants, invertebrates, and fish) represent the ecological receptors for the aquatic biota exposure class, and there is habitat for them at this site. Aquatic biota have ecological relevance because they represent the range of living organisms in the aquatic ecosystem and they provide food for various predators.

Aquatic biota are susceptible to exposure to and toxicity from, COPECs in surface water. The exposure concentration for aquatic biota is assumed to be equal to the measured environmental concentration because the biota have constant contact with water and the aquatic toxicity benchmarks that are used are expected to protect aquatic life from all exposure pathways, including ingestion of surface water, contaminated plants, and animals. Toxicity benchmarks are available for aquatic biota (Suter and Tsao 1996), but Ohio state WQC for surface water must also be met.

There are management goals for aquatic biota in laws that specify Ohio water quality standards to support designated uses (e.g., survival and propagation of aquatic life) for waters of the state. In addition, aquatic biota are susceptible to contamination by virtue of continual exposure in water, and they have ecological relevance for biota within the aquatic and terrestrial ecosystems. Thus, there is sufficient justification to warrant aquatic biota as a receptor for the ODA2 site.

Exposure of Sediment-Dwelling Biota to Sediment

Sediment-dwelling biota exposure to sediment is applicable to the site-specific analysis. Benthic invertebrates such as aquatic insect larvae, like caddisflies (Trichoptera), mayflies (Ephemeroptera), and midges (Chironomidae), as well as non-insects such as crayfish (Decapoda), snails (Gastropoda), and clams and bivalves (Pelycypoda) represent the receptors for the sediment-dwelling biota aquatic exposure class. These biota have ecological relevance because they provide food for many aquatic species and also for some terrestrial mammals and birds such as raccoons, mallards, and herons.
Benthic invertebrates are susceptible to exposure to, and toxicity from, COPECs in sediment. These biota have direct contact with sediment and sediment pore water. Toxicity benchmarks are available for benthic invertebrates (Jones, Suter, and Hull 1997).

There are management goals for sediment-dwelling biota because the condition of these biological communities is linked to assessment of Ohio water quality use attainment in streams. These biota are susceptible to contamination by virtue of continual exposure in sediment, and they have ecological relevance as a major food source for aquatic biota. Thus, there is sufficient justification to warrant sediment-dwelling biota as a receptor for the Level III Baseline.

Herbivore Exposure to Water, Sediment, and the Aquatic/Sediment Food Web

Aquatic herbivores like muskrats and mallard ducks are exposed to water and sediment so these exposures are applicable to the ODA2 site. There is also suitable habitat for them at the site. Muskrats eat aquatic vegetation. Mallard ducks are surface-feeding ducks that obtain much of their food by dabbling in shallow water and filtering through soft mud with their beaks. Their food consists mostly of seeds of aquatic plants, as well as aquatic invertebrates (USEPA 1993). Animal matter accounts for approximately 67 to 90% of the diet for breeding female ducks during the spring and summer, but decrease to less than 10% of the diet during the winter. Mallards have ecological relevance as important components of the aquatic food web. As aquatic herbivores, muskrats and mallards help maintain the size and composition of the aquatic vegetation community.

Muskrats and mallards are susceptible to exposure to, and toxicity from, COPECs in surface water and aquatic vegetation. The potential for exposure to contaminants is high because they consume aquatic and sediment-dwelling plants that can accumulate high concentrations of some chemicals from water. In addition, these species can have further exposure via ingestion of contaminants in surface water that they use for a drinking water source and incidentally ingested sediment. Since there is a potential difference in the toxicological sensitivity of mammals and birds exposed to the same COPECs, one mammal and one bird were examined for exposure to water, sediment, and the aquatic food chain. Dietary toxicity benchmarks for many inorganic and some organic substances are available for mammals and birds (Sample et al. 1996).

There are management goals for muskrats and mallards. For example, there are Ohio trapping season regulations for muskrats, and mallards are federally protected under the Migratory Bird Treaty Act of 1993, as amended. Mallard ducks are also federally protected as a game species under the Migratory Bird Hunting and Conservation Stamp Act of 1934, as amended. Both species are susceptible to COPECs, especially via ingestion exposure, and they have ecological relevance. Thus, there is sufficient justification to warrant these receptors for the ODA2 site.

Riparian Carnivores

Exposure of predators to aquatic biota is applicable to the ODA2 site because PBT chemicals are present at the site. There is also suitable habitat for these receptors at the site. Exposure evaluation for piscivores (fish-eating predators) is required by Ohio EPA (Ohio EPA 2003) when a PBT compound or a COPEC with no screening benchmark is found in surface water or sediment. Mink and great blue herons are riparian carnivores chosen to represent mammalian and bird receptors for the fish-eating predator exposure class, respectively. Riparian carnivores feed predominantly in and along the banks of streams. Both species have ecological relevance because as piscivorous riparian carnivores, they are important components of the aquatic food web representing the top predators. As top predators, they help limit the population size for some aquatic and some sediment-dwelling biota communities.

Both species are susceptible to exposure to, and toxicity from, COPECs in surface water, aquatic biota, and sediment-dwelling biota. The potential for exposure to COPECs is high for these two species because they consume fish, which can accumulate high concentrations of some chemicals from water. In addition, both species can have further exposure via ingestion of COPECs in surface water that is used for a drinking water source. Dietary toxicity benchmarks are available for mammals and birds (Sample et al. 1996). There can be differences in toxicological sensitivity between mammals and birds exposed to the same COPEC, so both species are appropriate.

There are management goals for both species because regulations protect both species. For example, mink are regulated by Ohio trapping regulations because they are fur-bearing mammals. Great blue herons are federally protected under the Migratory Bird Treaty Act of 1993, as amended. Both species are susceptible to contamination, especially via ingestion exposure routes, and they have ecological relevance as predators. Thus, there is sufficient justification to warrant these two receptors for the ODA2 site.

7.4.5 Relevant and Complete Exposure Pathways

Relevant and complete exposure pathways for the ecological receptors at ODA2 were described in Section 7.4.3 on the ECSMs. As previously discussed, there are relevant and complete exposure pathway for various ecological receptors including terrestrial vegetation and invertebrates, aquatic and sediment-dwelling biota, and terrestrial and aquatic herbivores, insectivores, and carnivores. Thus, these types of receptors could be exposed to COPECs in abiotc media at the ODA2 site.

7.4.6 Candidate Ecological Assessment Endpoints and Measures

The protection of ecological resources, such as habitats and species of plants and animals, is a principal motivation for conducting SERAs. Key aspects of ecological protection are presented as management goals, which are general goals established by legislation or agency policy and based on societal concern for the protection of certain environmental resources. For example, environmental protection is mandated by a variety of legislation and governmental agency policies (e.g., CERCLA and NEPA). Other legislation includes the ESA (16 U.S. Code 1531-1544, 1993, as amended) and the Migratory Bird Treaty Act (16 U.S. Code 703-711, 1993, as amended). To evaluate whether a management goal has been met, assessment endpoints, measures of effects, and decision rules were formulated. The management goals, assessment endpoints, measures of effects, and decision rules are discussed below.

There are two management goals for ODA2. However, the assessment endpoints differ between the general screen and the site-specific analysis screen. The management goals for the SERA are:

- Management Goal 1: Protect terrestrial plant and animal populations from adverse effects due to the release or potential release of chemical substances associated with past site activities.

- Management Goal 2: Protect aquatic plant and animal populations and communities from adverse effects due to the release or potential release of chemical substances associated with past site activities.

Ecological assessment endpoints are selected to determine whether these management goals are met at the unit. An ecological assessment endpoint is a characteristic of an ecological component that may be affected by exposure to a stressor (e.g., COPEC). Assessment endpoints are "explicit expressions of the actual environmental value that is to be protected" (USEPA 1992). Assessment endpoints often reflect environmental values that are protected by law, provide critical resources, or provide an ecological function that would be significantly impaired if the resource was altered.

Unlike the HHRA process, which focuses on individual receptors, the SERA focuses on populations or groups of interbreeding non-human, non-domesticated receptors. Accordingly, assessment endpoints generally refer to characteristics of populations and communities. In the screening level ERA process, risks to individuals are assessed only if they are protected under the ESA or other species-specific legislation, or if the species is a candidate for listing as a T&E species.

Given the diversity of the biological world and the multiple values placed on it by society, there is no universally applicable list of assessment endpoints. Therefore, Ohio EPA's *Ecological Risk Assessment Guidance Document* (Ohio EPA 2003) was used to select assessment endpoints.

For the Level II Screen, the assessment endpoints are any potential adverse effects on ecological receptors, where receptors are defined as any plant or animal population, communities, habitats, and sensitive environments (Ohio EPA 2003). Although the assessment endpoints for the Level II Screen are associated with Management Goals 1 and 2, specific receptors are not identified with the assessment endpoints.

For the Level III Baseline, the assessment endpoints would be more specific and stated in terms of types of specific ecological receptors associated with each of the two management goals. Assessment endpoints 1, 2, 3, and 4 entail the growth, survival, and reproduction of terrestrial receptors such as vegetation and terrestrial invertebrates, herbivorous mammals, worm-eating/insectivorous mammals and birds, and carnivorous top predator mammals and birds, respectively. Assessment endpoints 1 through 4 are associated with Management Goal 1, protection of terrestrial populations and communities. Assessment endpoint 5 deals with the growth, survival, and reproduction of sediment-dwelling biota, which is associated with Management Goal 2, protection of aquatic populations and communities. Assessment endpoints 6, 7, and 8 are also associated with Management Goal 2, and deal with the growth, survival, and reproduction of aquatic biota, aquatic herbivores, and riparian carnivores, respectively.

Table 7-9 shows the management goals for terrestrial and aquatic resources, attendant assessment endpoints, measures of effect, and decision rule by assessment endpoint number. Further, the table provides definitions of Assessment Endpoints 1, 2, 3, and 4 (terrestrial receptors) and 5, 6, 7, and 8 (aquatic receptors). As stated, the assessment endpoint table includes a column about the conditions for making a decision depending on whether the HQ is less than or more than 1. If the HQ is greater than 1, the Scientific Management Decision Point (SMDP) options from Ohio EPA/Army COE guidance are provided: No further action, risk management, monitoring, remediation, or further investigation. These are the logical options, and the options fitted to the ODA2 circumstances are provided in Section 7.5.

Table 7-9. Management Goals, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified for the ODA2 During the Level II Screening

Management Goals	Assessment Endpoint	Measures of Effect	Decision Rule
Management Goal 1: The protection of terrestrial populations, communities, and ecosystems.	Assessment Endpoint 1: Growth, survival, and reproduction of plant and soil invertebrate communities and tissue concentrations of contaminants low enough such that higher trophic levels that consume them are not at risk. Receptors: plants and earthworms	Measures of Effect 1: Plant and earthworm soil toxicity benchmarks and measured RME concentrations of constituents in soil.	Decision Rule for Assessment Endpoint 1: If hazard quotients (HQs), defined as the ratios of COPEC RME concentrations in surface soil to toxicity reference value (TRV) benchmarks for adverse effects on plants and soil invertebrates, are less than or equal to 1, then Assessment Endpoint 1 has been met and plants and soil-dwelling invertebrates are not at risk. If the HQs are >1, a SMDP has been reached, at which it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage related COPECs and applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 2: Growth, survival, and reproduction of herbivorous mammal populations to low concentrations of contaminants in their tissues so that higher trophic level animals that consume them are not at risk. Receptor: cottontail rabbits	Measures of Effect 2: Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies.	Decision Rule for Assessment Endpoint 2: If HQs, based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface soil to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on herbivorous mammals are less than or equal to 1, Assessment Endpoint 2 is met, and the receptors are not at risk. If the HQs are >1, a SMDP has been reached, at which it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.

Table 7-9. Management Goals, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified for the ODA2 During the Level II Screening

Management Goals	Assessment Endpoint	Measures of Effect	Decision Rule
Management Goal 1: The protection of terrestrial populations, communities, and ecosystems (Continued).	Assessment Endpoint 3: Growth, survival, and reproduction of worm-eating and insectivorous mammal and bird populations and low enough concentrations of contaminants in their tissue so that predators that consume them are not at risk. Receptors: shrews and robins	Measures of Effect 3: Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies.	Decision Rule for Assessment Endpoint 3: If HQs based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface soil to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on worm-eating and insectivorous mammals and birds is less than or equal to 1, then Assessment Endpoint 3 is met, and these receptors are not at risk. If the HQs are >1, a SMDP has been reached, at which it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 4: Growth, survival, and reproduction of carnivorous mammal and bird populations. Receptors: red fox and red-tailed hawk	Measures of Effect 4: Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies.	Decision Rule for Assessment Endpoint 4: If HQs based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface soil to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on carnivorous mammals and birds are less than or equal to 1, then Assessment Endpoint 4 is met, and the receptors are not at risk. If the HQs are >1, a SMDP has been reached, at which it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.

Table 7-9. Management Goals, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified for the ODA2 During the Level II Screening

Management Goals	Assessment Endpoint	Measures of Effect	Decision Rule
Management Goal 2: The protection of aquatic populations, wetland communities, and ecosystems.	Assessment Endpoint 5: Survival, reproduction, and diversity of benthic invertebrate communities, as well as low enough concentrations of contaminants in their tissues so that higher trophic level animals that consume them are not at risk. Receptor: benthic invertebrates	Measures of Effect 5: Measured concentration of contaminants in sediment and sediment toxicity thresholds, e.g., Consensus-based Threshold Effects Concentrations (TECs), EPA Region 5 Ecological Screening Levels (ESLs), and Ohio EPA Sediment Reference Values.	Decision Rule for Assessment Endpoint 5: If HQs based on ratios of COPEC RME concentrations in sediment-to-sediment toxicity benchmarks are less than or equal to1, then Assessment Endpoint 5 is met and sediment-dwelling organisms are not at risk. If the HQs are > 1, a SMDP has been reached, at which it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 6: Growth, survival, and reproduction of aquatic biota (including fish, plants, invertebrates). Receptor: aquatic biota	Measures of Effect 6: Measured concentrations of contaminants in surface water and Ohio EPA Chemical Specific Water Quality Criteria found in OAC 3745.	Decision Rule for Assessment Endpoint 6: If HQs based on ratios of COPEC RME concentrations in surface water to aquatic biota toxicity benchmarks are less than or equal to 1, then Assessment Endpoint 6 is met and the receptors are not at risk. If the HQs are > 1, a SMDP has been reached, at which it will be necessary to decide what is needed: no further action, risk management of ecological resources, monitoring of the environment, remediation of any site-usage related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.

Table 7-9. Management Goals, Ecological Assessment Endpoints, Measures of Effect, and Decision Rules Identified for the ODA2 During the Level II Screening

Management Goals	Assessment Endpoint	Measures of Effect	Decision Rule
Management Goal 2: The protection of aquatic populations, wetland communities, and ecosystems (Continued).	Assessment Endpoint 7: Growth, survival, and reproduction of aquatic herbivores that ingest aquatic plants, surface water, and sediment. Receptors: muskrats and mallards	Measures of Effect 7: Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies.	Decision Rule 7: If HQs based on ratios of COPEC RME concentrations in surface water and sediment to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on aquatic herbivorous mammals and birds are less than or equal to 1, then Assessment Endpoint 7 is met and the receptors are not at risk. If the HQs are > 1, a SMDP has been reached, at which it will be necessary to decide what is needed: no further action, risk management of ecological receptors, monitoring of the environment, remediation of any site-usage related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.
	Assessment Endpoint 8: Growth, survival, and reproduction of riparian carnivorous mammal and bird communities that feed on aquatic organisms. Receptors: mink and herons	Measures of Effect 8: Estimates of receptor home range area, body weights, feeding rates, and dietary composition based on published measurements of endpoint species or similar species; modeled COPEC concentrations in food chain based on measured concentrations in physical media; chronic dietary NOAELs applicable to wildlife receptors based on measured responses of similar species in laboratory studies.	Decision Rule 8: If HQs based on ratios of estimated exposure concentrations predicted from COPEC RME concentrations in surface water to dietary limits corresponding to NOAEL TRV benchmarks for adverse effects on riparian carnivores is less than or equal to 1, then Assessment Endpoint 8 has been met these receptor populations are not at risk. If the HQs are > 1, a SMDP has been reached, at which it will be necessary to decide what is needed: no further action, risk management of ecological receptors, monitoring of the environment, remediation of any site-usage related COPECs in applicable media, or further investigation such as a Level III and Level IV Field Baseline.

The assessment endpoints would be evaluated through the use of "measures" (formerly named measurement endpoints). USEPA defines measures as ecological characteristics used to quantify and predict change in the assessment endpoints. They consist of measures of receptor and population characteristics, measures of exposure, and measures of effect. For example, measures of receptor characteristics include parameters such as home range, food intake rate, and dietary composition. Measures of exposure include attributes of the environment such as contaminant concentrations in soil, sediment, surface water, and biota. The measures of effect for the Level II Screen consist of the MDCs of each contaminant for soil or sediment (average concentrations for surface water), ESV benchmarks for COIs in soil and sediment, as well as the Ohio state WQC for surface water (see Section 7.3.3).

Appropriate measures of exposure relating to the assessment endpoints for the Level II and Level III ERAs include measured concentrations of chemicals in surface soil, sediment, and surface water. Additional measures of exposure for the Level III Baseline would include predicted concentrations of chemicals in vegetation and various receptor animals such as rabbits, shrews, American robins, and aquatic biota based on measured soil, sediment, and surface water concentrations. The measures for the site-specific analysis screen and their relationship to their corresponding assessment endpoints are summarized above.

In the Level II Screen, MDCs in soil or sediment at each EU were compared to default soil or sediment concentrations that are expected not to cause harm to ecological populations. Average concentrations in surface water were compared to Ohio state WQC. The Level II screen used Ohio EPA (Ohio EPA 2003) published guidelines for selection of screening values for soil and sediment, and OAC WQC for surface water.

COPECs that remained after the Level II Screen are subject to a Level III Baseline analysis with exposures that are more representative of the exposures expected for the representative receptors. Level III Baseline analysis includes evaluation of exposure of a variety of receptors to the reasonable maximum exposure concentrations of COPECs at each EU, using default dietary and uptake factors. The representative ecological receptors may not all be present at each EU. However, all representative receptors are evaluated at this step.

For the Level III Baseline, the decision rules for COPECs came from Ohio EPA's guidance for chemicals (Ohio EPA 2003). Briefly, for COPECs, the first decision rule is based on the ratio or HQ of the ambient exposure or exposure point concentration (numerator) of a given chemical to the ecological effects or toxicity reference value (denominator) of the same chemical. A ratio of 1 or smaller means that ecological risk is negligible while a ratio of greater than 1 means that ecological risk from that individual chemical is possible and that additional investigation should follow to confirm or refute this prediction. In addition, a sum of all the HQs [that is, the hazard index (HI)] for given groups of chemicals, (e.g., all inorganics, all organics, or all chemicals with a common mode of action) of 1 or less means that there is no concern, while a sum greater than 1 indicates that there may be a concern for that group of chemicals and that further investigation is needed. The second decision rule is that if "no other observed significant adverse effects on the health or viability of the local individuals or populations of species are identified" (Ohio EPA 2003) and the HI does not exceed 1, "the site is highly unlikely to present significant risks to endpoint species" (Ohio EPA 2003). There are three potential outcomes for the Level III Baseline: (1) no significant risks to endpoint species so no further analysis is needed, (2) conduct field baseline assessment to quantify adverse effects to populations of representative species that were shown to be potentially impacted based on hazard calculations in the Level III BERA, or (3) remedial action taken without further study.

7.5 RECOMMENDATION

Because this Level II SERA identified multiple COPECs in multiple abiotic media (surface and subsurface soil, sediment, and surface water), and identified site-specific receptors and the presence of relevant and complete exposure pathways for those receptors, the potential exists for ecological hazard so a recommendation is made to move to an SMDP.

There is sufficient information from the Level II risk assessment, and Facility-wide Biological and Water Quality Study 2003, Ravenna Army Ammunition Plant, all at ODA2, to clarify that there are few to no aquatic life resources that are in harm's way or experiencing risk, and likewise the terrestrial ecological resources appear to be healthy and functioning although exceedances of ESVs suggest some risk. There is no need for more studies, rather a strategy of how to best use that information.

The outcomes associated with the SMDP, in order of likelihood, for the ecological risk assessment, as mentioned in the assessment endpoint table, are:

1. Risk management of the ecological resources, especially as characterized by the Level II study that includes an ecological reconnaissance and the Facility Wide Biological and Water Quality Study 2003 at ODA2,

2. Remediation of some of the source material if land-use (assumed to be restricted access because of MEC) and other evidence, such as site-related usage COPECs, really warrant it, or

3. Conduct of more investigation, such as a Level III and Level IV Field Baseline, to further define COPECs when this would truly yield needed information to make a significantly better decision about the present and future role of ecological resources at ODA2.

Note that other logical outcomes, mentioned in the assessment endpoint table, are not recommended:

4. No further action because of the presence of ecological risk,

5. Monitoring because of the need to make other decisions (1, 2, or 3) prior to this.

A WOE approach to the COPECs involved at ODA2 would assist in defining the best outcome or decision. The WOE would use such topics and proposed purposes as follows:

1. Useful findings of the ecological screening level work (Level II) - those chemicals that exceed the ESVs,
2. ODA2-specific biological and water quality field work (from the study by the same name at RVAAP) - little to no appearance of impact to biological community both upstream and downstream,
3. Military land use - influences the land management practives and their priorities,
4. Degree of correlation of site usage or suspected usage COPECs (from step 4 of the RVAAP Facility-Wide Ecological Work Plan) - may delimit COPECs,
5. Possibility of remediation - letting status quo habitat remain likely has less negative impact than source removal, and
6. Other, including the need or lack of need for ecological RAO.

The WOE will be part of the FS.

Thus, this Level II SERA can be used by risk managers to assist in selecting a specific outcome of the SMDP.

7.6 SUMMARY

The ODA2 site contains sufficient terrestrial and aquatic (surface water and sediment) habitat to support various classes of ecological receptors. For example, terrestrial habitats at ODA2 include old fields, woodlots, and grassy areas. Various classes of receptors, such as vegetation, small and large mammals, and birds, have been observed at the site. The presence of suitable habitat and observed receptors at the site warrants a SERA. Thus, Ohio EPA protocol (Level I) was met and Level II was needed.

A Level II SERA was performed for ODA2 soils, sediment, and surface water using Ohio EPA guidance methods. The Level II Screen consisted of a media-specific data and media evaluation of detected COIs, as well as a media-specific media screen. The data and media evaluation was conducted to identify whether the chemicals could be initially eliminated from further consideration due to low frequency of detection (data evaluation) and whether the chemicals were site related and have impacted the site [media evaluation that included comparison of detected concentrations against background (and SRVs for sediment) and identification of PBT compounds]. Any input COIs that were not eliminated during the data and media evaluation were carried forward to the media screen. The media screen entailed comparing concentrations of inputted chemicals against ESVs (for soil and sediment) and OAC WQS for surface water. Chemicals whose concentrations exceeded or lacked the ESVs or OAC WQS, as well as chemicals that were PBT compounds, were retained as COPECs while all other chemicals were eliminated from further action.

For surface soil, 41 detected COIs were inputted into the data and media evaluations, wherein 9 were eliminated due to low frequency of detection and not being PBT compounds, and 32 were identified as COPECs and carried forward to the media screening. Of the 32 COPECs inputted into the media screening, 6 were eliminated because their concentrations did not exceed their ESVs and they were not PBT compounds, so 26 chemicals were retained as COPECs for surface soil.

For subsurface soil, 38 detected COIs were inputted into the data and media evaluations, wherein 16 were eliminated due either to concentrations below background, low frequency of detection, and not being PBT compounds. Thus, 22 of the 38 detected COIs were identified as COPECs and carried forward to the media screening. Of the 22 COPECs inputted into the media screening, 4 were eliminated because their concentrations did not exceed their ESVs and they were not PBT compounds, so 18 chemicals were retained as COPECs for subsurface soil.

For downstream sediment, 26 detected COIs were inputted into the data and media evaluations, wherein 13 were eliminated due their concentrations being less than the Ohio EPA SRVs and not being PBT compounds. Thus, 13 of the 26 detected COIs were identified as COPECs and carried forward to the media screening. Of the 13 COPECs inputted into the media screening, 4 were eliminated because their concentrations did not exceed their ESVs and they were not PBT compounds, so 9 chemicals were retained as COPECs for downstream sediment.

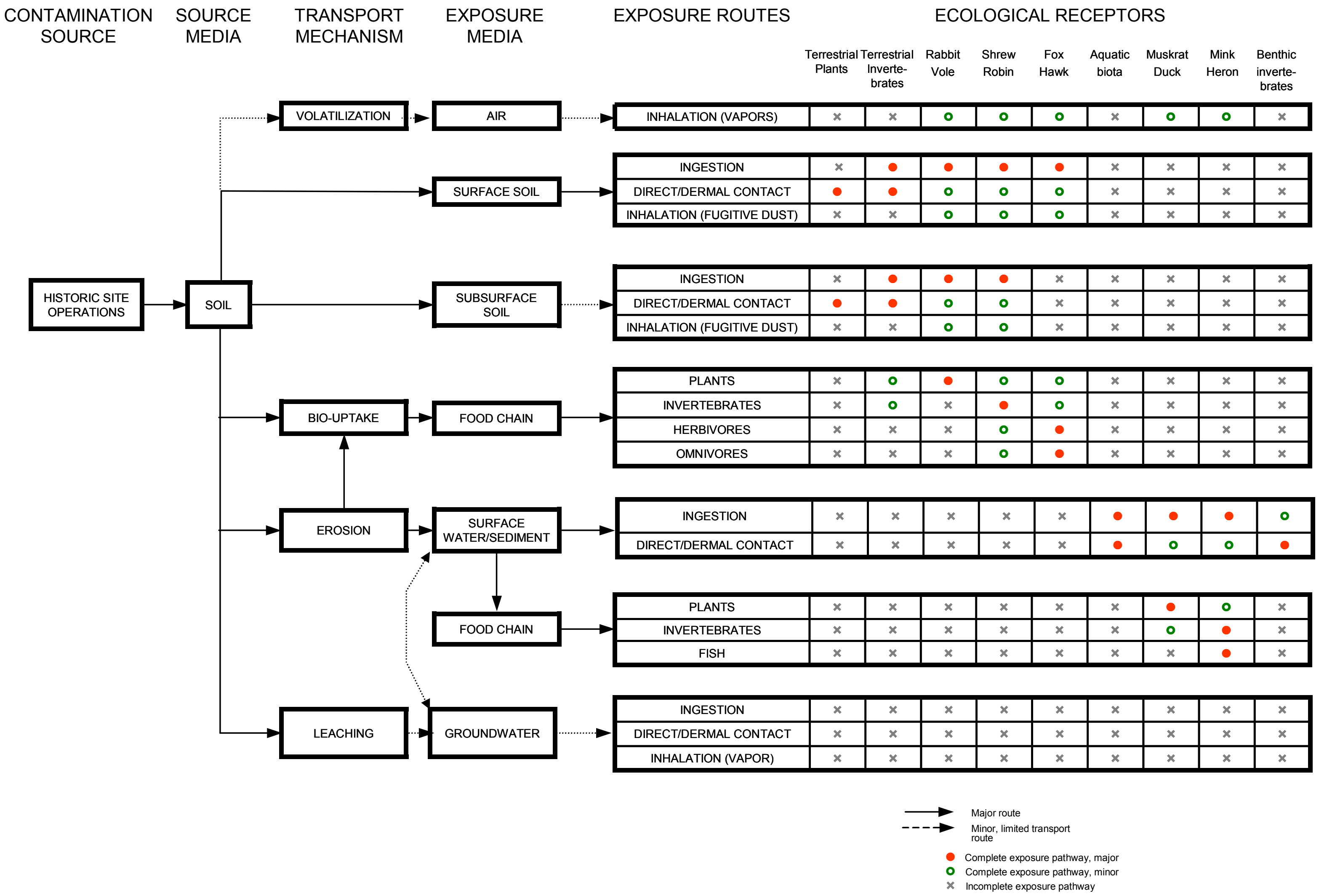
For upstream sediment, 25 detected COIs were inputted into the data and media evaluations, wherein 13 were eliminated because their concentrations either were less than the Ohio EPA SRVs or background and they were not PBT compounds. Thus, 12 of the 25 detected COIs were identified as COPECs and carried forward to the media screening. Of the 12 COPECs inputted into the media screening, only 1 was eliminated because its concentration did not exceed its ESV and it was not a PBT compound, so 10 chemicals were retained as COPECs for upstream sediment.

For downstream surface water, 15 detected COIs were inputted into the data and media evaluations, wherein 6 were eliminated due their concentrations being less than background and not being PBT compounds. Thus, 9 of the 15 detected COIs were identified as COPECs and carried forward to the media screening. Of the nine COPECs inputted into the media screening, two were eliminated because their concentrations did not exceed their ESVs and they were not PBT compounds, so seven chemicals were retained as COPECs for downstream surface water.

For upstream surface water, 13 detected COIs were inputted into the data and media evaluations, wherein 6 were eliminated due their concentrations being less than background and not being PBT compounds. Thus, 7 of the 13 detected COIs were identified as COPECs and carried forward to the media screening. Of the seven COPECs inputted into the media screening, three were eliminated because their concentrations did not exceed their ESVs and they were not PBT compounds, so four chemicals were retained as COPECs for upstream surface water.

Because COPECs were identified and retained for soil, sediment, and surface water, ESCMs were prepared, along with the identification of site-specific ecological receptors, relevant and complete exposure pathways, and candidate assessment endpoints. These types of information will be used to prepare a Level III Baseline if it is deemed necessary to conduct a Level III ERA.

Based on the presence of multiple COPECs in soil, sediment, and surface water, as well as the presence of site-specific ecological receptors and complete exposure pathways to those COPECs at the ODA2 site, a recommendation is made to move to a SMDP. The most likely outcomes, in order of likelihood, associated with the SMDP for the ecological risk assessment, as mentioned in the assessment endpoint table and Section 7.5, are in order of likelihood: 1) risk management of the ecological resources, 2) remediation of some of the source material, or 3) conduct of more investigation. In the FS, a weight-of-evidence approach to the COPECs involved at ODA2 would assist in defining the best outcome or decision. Thus, the information in this Level II SERA can be used to assist risk managers in making their decision associated with the SMDP.



EXPOSURE MEDIA	EXPOSURE ROUTES	Terrestrial Plants	Terrestrial Inverte-brates	Rabbit Vole	Shrew Robin	Fox Hawk	Aquatic biota	Muskrat Duck	Mink Heron	Benthic inverte-brates
AIR	INHALATION (VAPORS)	×	×	○	○	○	×	○	○	×
SURFACE SOIL	INGESTION	×	●	●	●	●	×	×	×	×
	DIRECT/DERMAL CONTACT	●	●	○	○	○	×	×	×	×
	INHALATION (FUGITIVE DUST)	×	×	○	○	○	×	×	×	×
SUBSURFACE SOIL	INGESTION	×	●	●	●	×	×	×	×	×
	DIRECT/DERMAL CONTACT	●	●	○	○	×	×	×	×	×
	INHALATION (FUGITIVE DUST)	×	×	○	○	×	×	×	×	×
FOOD CHAIN	PLANTS	×	○	●	○	○	×	×	×	×
	INVERTEBRATES	×	○	×	●	○	×	×	×	×
	HERBIVORES	×	×	×	○	●	×	×	×	×
	OMNIVORES	×	×	×	○	●	×	×	×	×
SURFACE WATER/SEDIMENT	INGESTION	×	×	×	×	×	●	●	●	○
	DIRECT/DERMAL CONTACT	×	×	×	×	×	●	○	○	●
FOOD CHAIN	PLANTS	×	×	×	×	×	×	●	○	×
	INVERTEBRATES	×	×	×	×	×	×	○	●	×
	FISH	×	×	×	×	×	×	×	●	×
GROUNDWATER	INGESTION	×	×	×	×	×	×	×	×	×
	DIRECT/DERMAL CONTACT	×	×	×	×	×	×	×	×	×
	INHALATION (VAPOR)	×	×	×	×	×	×	×	×	×

→ Major route
⇢ Minor, limited transport route

● Complete exposure pathway, major
○ Complete exposure pathway, minor
× Incomplete exposure pathway

Figure 7-1. ECSM for Level II Screen – Pathways for Ecological Exposure at ODA2

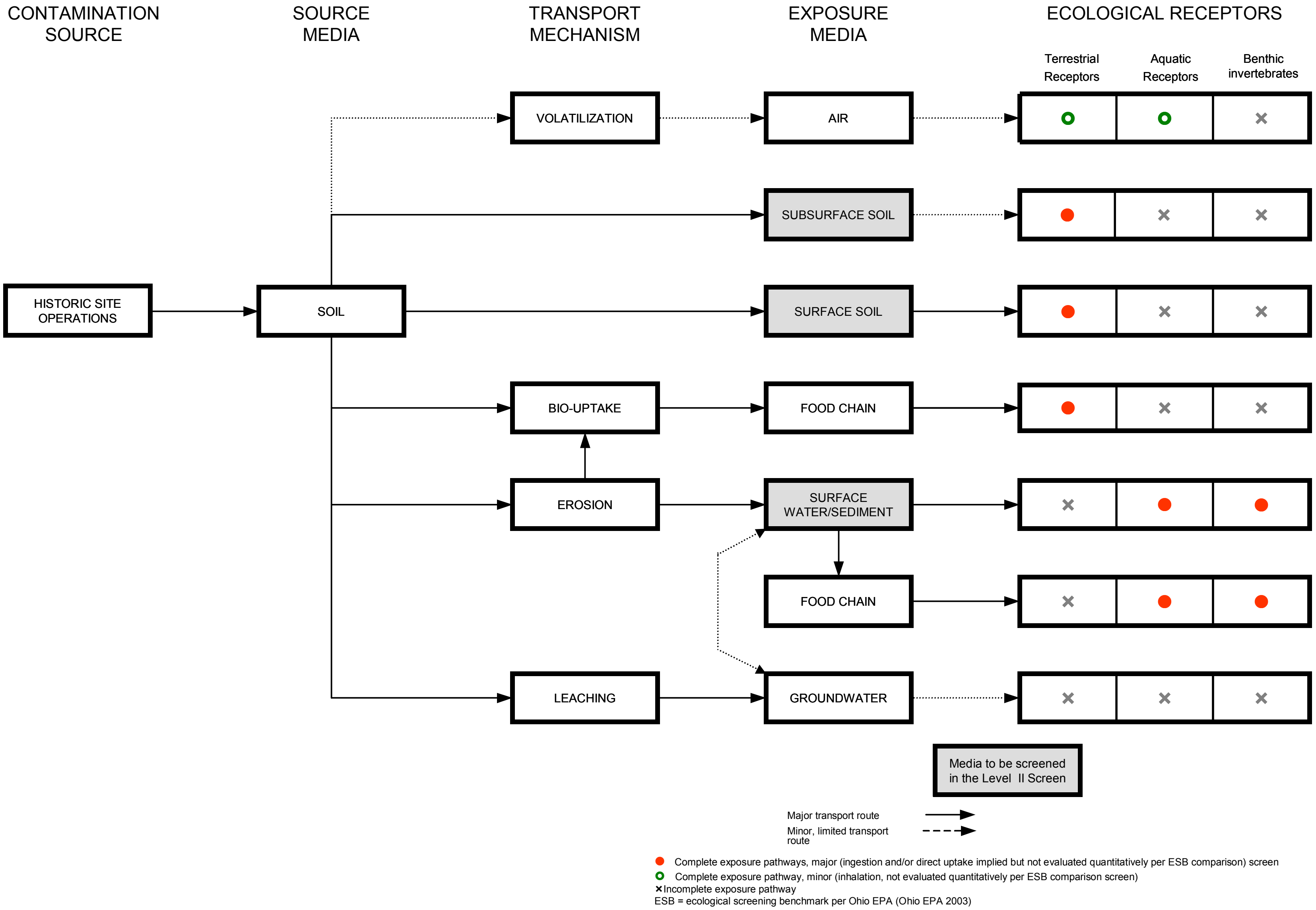


Figure 7-2. ECSM for Level III Baseline – Pathways for Ecological Exposure at ODA2

8.0 SUMMARY AND CONCLUSIONS

The ODA2 Phase II RI Report presents a detailed analysis of the environmental data collected during the Phase II RI field effort. The following sections present an overview of the major findings of the nature and extent of contamination, modeling of contaminant fate and transport, HHRA, and ERA. A revised SCM is presented to integrate results of the evaluations presented in this report. The SCM denotes, based on available data, where source areas occur, the mechanisms for contaminant migration from source areas to receptor media (e.g., streams and groundwater), and exit pathways from the AOC. The conclusions of the Phase II RI are presented by media with an emphasis on the degree of contamination and the potential risks to human receptors.

8.1 SUMMARY OF CONTAMINANT NATURE AND EXTENT

During the Phase II investigation at ODA2, 175 environmental samples were collected as follows: 66 surface soil samples, 66 subsurface soil samples, 15 sediment samples, 12 surface water samples, and 16 groundwater samples. The following text provides a summary of the results of the investigation.

8.1.1 Surface Soil

Based on the evaluation of the occurrence and distribution of contaminants in surface soil, SRCs are generally found in two areas of the AOC; the floodplain south of Sand Creek, and north of Sand Creek. The following observations can be made concerning SRCs in surface soil:

- Explosives and propellants are found at the highest concentration at sample locations DA2-053 (south of Sand Creek) and DA2-045 (north of Sand Creek). Explosives and propellants are found at 11 sampling locations south of Sand Creek, mostly in the floodplain adjacent to Sand Creek. These compounds are found at 10 sampling locations north of Sand Creek, mostly to the north and west. The limits of explosive and propellant occurrences in surface soil has been delineated in the floodplain south of Sand Creek. North of Sand Creek, occurrences of explosives and propellants are surrounded by few non-detects; however additional sampling will be conducted and reported in the FS.

- The following explosive and propellant compounds were detected in surface soil samples collected north of Sand Creek:
  - 1,3,5-Trinitrobenzene detected in DA2-044 (86 µg/kg);
  - 2,4,6-Trinitrotoluene detected in DA2-038 (3200 µg/kg), -039 (68 µg/kg), and –045 (87 µg/kg);
  - 2,4-DNTdetected in DA2-037 (210 µg/kg);
  - 2-Amino-4,6-Dinitrotoluene detected in DA2-045 (65 µg/kg);
  - 4-Amino-2,6-Dinitrotoluene detected in DA2-045 (56 µg/kg);
  - Nitroglycerine detected in DA2-045 (7200 µg/kg);
  - RDX detected in DA2-114 (150 µg/kg); and

  - Tetryl was detected in DA2-035 (810 µg/kg), -038 (590 µg/kg), -039 (18000 µg/kg), -040 (120 µg/kg), -044 (4200 µg/kg), -048 (3400 µg/kg), and –093 (1300 µg/kg).
- The following explosive and propellant compounds were detected in surface soil samples collected south of Sand Creek:
  - 2,4,6-Trinitrotoluene detected in DA2-053 (150 µg/kg), -072 (2100 µg/kg), and –111 (110 µg/kg);
  - 2,4-DNTdetected in DA2–112 (130 µg/kg);
  - 2-Amino-4,6-Dinitrotoluene detected in DA2-053 (260 µg/kg), -072 (87 µg/kg), and –111 (390 µg/kg);
  - 4-Amino-2,6-Dinitrotoluene detected in DA2-053 (180 µg/kg), -072 (140 µg/kg), and –111 (250 µg/kg);
  - HMX detected in DA2-067 (580 µg/kg) and –068 (120 µg/kg);
  - Nitroglycerine detected in DA2-053 (31000 µg/kg); and
  - Tetryl was detected in DA2-053, (200 µg/kg), -058 (480 µg/kg), -065 (240 µg/kg), -068 (520 µg/kg), -072 (710 µg/kg), -073 (560 µg/kg), -074 (2300 µg/kg), -077 (820 µg/kg), and -078 (2300 µg/kg).

- Metals exceeding background concentrations are found at surface soil sample locations throughout the AOC. The area north of Sand Creek has 8 surface soil sampling locations that have eight or more SRCs above background. These sample locations are generally centrally located in the AOC north of Sand Creek. The area south of Sand Creek has three surface soil sampling locations that have eight or more SRCs above background. These locations south of Sand Creek are in the floodplain adjacent to Sand Creek. The lateral extent of inorganic SRCs in surface soil have not been delineated based on the sampling results.

- The highest concentrations for the inorganic SRCs above background in the surface soil samples are as follows:

  North of Sand Creek
  - Aluminum – 23400 mg/kg at DA2-036;
  - Arsenic – 19.9 mg/kg at DA2-048 and DA2-084;
  - Beryllium – 1.5 mg/kg at DA2-042;
  - Cadmium – 9.5 mg/kg at DA2-046;
  - Chromium – 31.7 mg/kg at DA2-036;
  - Hexavalent chromium – 8 mg/kg at DA2-039;
  - Cobalt – 14.2 mg/kg at DA2-093;
  - Copper – 168 mg/kg at DA2-107;
  - Lead – 117 mg/kg at DA2-107;
  - Manganese – 1570 mg/kg at DA2-093;
  - Mercury – 0.41 mg/kg at DA2-035;
  - Nickel – 31.2 mg/kg at DA2-046;
  - Nitrate/Nitrite – 5.1 mg/kg at DA2-039;
  - Selenium – 1.5 mg/kg at DA2-044;

  - Vanadium – 38 mg/kg at DA2-036; and
  - Zinc – 557 mg/kg at DA2-107.

South of Sand Creek

  - Aluminum – 17900 mg/kg at DA2-110;
  - Arsenic – 16.7 mg/kg at DA2-055;
  - Beryllium – 0.98 mg/kg at DA2-068;
  - Cadmium – 3.8 mg/kg at DA2-077;
  - Chromium – 60.8 mg/kg at DA2-068;
  - Hexavalent chromium – 28 mg/kg at DA2-077 ;
  - Cobalt – 24.6 mg/kg at DA2-057;
  - Copper – 1210 mg/kg at DA2-067;
  - Lead – 218 mg/kg at DA2-069;
  - Manganese – 2140 mg/kg at DA2-057;
  - Mercury – 9.9 mg/kg at DA2-077;
  - Nickel – 28.8 mg/kg at DA2-074;
  - Nitrate/Nitrite – 4 mg/kg at DA2-054;
  - Selenium – 1.9 mg/kg at DA2-109;
  - Silver – 0.32 mg/kg at DA2-070; and
  - Zinc – 492 mg/kg at DA2-077.

- SVOCs, VOCs, pesticides, and PCBs are either not detected in surface soil, or detections are limited to low concentrations in a limited number of sample locations.

8.1.2 Subsurface Soil

Based on the evaluation of the occurrence and distribution of contaminants in subsurface soil at ODA2, the following observations can be made:

- Explosives and propellants are present in subsurface soil at 8 sampling locations north of Sand Creek. 2,4,6-TNT and tetryl are the most common explosive north of Sand Creek, with DA2-045 having the highest number (5) of explosives and propellants detected. South of Sand Creek, explosives and propellants were detected at 11 locations, with DA2-111 having the highest number detected (4). 2,4,6 Trinitrotoluene and tetryl were detected in subsurface soil at six sampling locations both north and south of Sand Creek.

- The following explosive and propellant compounds were detected at subsurface soil sampling locations north of Sand Creek:
  - Tetryl was detected in samples collected from DA2-045, -046, -084, and 086. The highest concentration was detected at DA2-046 (2.1 mg/kg);
  - 2,4,6-TNT was detected in samples collected from DA2-035, -044, -045, and -086. The highest concentration was detected in DA2-035 (200 ug/kg);
  - RDX was detected in DA2-044 (520 µg/kg) and DA2-082 (100 µg/kg).
  - 2,4-DNTwas detected at DA2-107 (58 µg/kg);

  - 2-Amino-4,6-Dinitrotoluene was detected at DA2-045, -047, and -086. The highest concentration was detected in DA2-086 (140 µg/kg);
  - 4-Amino-2,6-Dinitrotoluene was detected at DA2-045, -047, -053, -067, -086, and -111. The highest concentration was detected at station DA2-067 (110 µg/kg);
  - Nitroglycerine was detected at DA2-045 (26 mg/kg); and
  - o-Nitrotoluene was detected at station DA2-035 (430 µg/kg).

- The following explosive and propellant compounds were detected at subsurface soil sampling locations south of Sand Creek:
  - Tetryl was detected in samples collected from DA2-053, -072, -073, -077, -078, and 079. The highest concentration was detected in DA2-079 (4.4 mg/kg).
  - 2,4,6-TNT was detected in samples collected from DA2-067, -072, -073, -079, -081, and -111. The highest concentration was detected in DA2-111 (1.3 mg/kg).
  - RDX was detected in DA2-072 (410 µg/kg).
  - 2,4-DNTwas detected at DA2-067 (62 µg/kg) and DA2-111 (60 µg/kg).
  - 2-Amino-4,6-Dinitrotoluene was detected at DA2-053 (230 µg/kg) and DA2-111 (570 µg/kg).
  - 4-Amino-2,6-Dinitrotoluene was detected at DA2-053, -067, and -111. The highest concentration was detected at station DA2-067 (430 µg/kg).

- All subsurface samples had at least one SRC inorganic compound detected above the background levels for subsurface soil with the exception of DA2-058 and DA2-083. North of Sand Creek, DA2-044, -045, -046, and -084 had six or more SRCs detected at each sampling location. South of Sand Creek, DA2-068 and -074 has six or more SRCs detected at those sampling locations.

- The highest concentrations for the inorganic SRCs above background in the subsurface soil samples are as follows:
  North of Sand Creek

  - Arsenic – 32.6 mg/kg at DA2-036;
  - Barium – 700 mg/kg at DA2-045;
  - Beryllium – 1.2 mg/kg at DA2-084;
  - Cadmium – 4.7 mg/kg at DA2-045;
  - Hexavalent chromium – 23 mg/kg at DA2-084;
  - Copper – 152 mg/kg at DA2-086;
  - Lead – 78.6 mg/kg at DA2-107;
  - Mercury – 0.24 mg/kg at DA2-046;
  - Nitrate/Nitrite – 3.7 mg/kg at DA2-044;
  - Sulfide – 1,900 mg/kg at DA2-104; and
  - Zinc – 2770 mg/kg at DA2-045.

South of Sand Creek

- Antimony – 2.2 mg/kg at DA2-073;
- Arsenic – 26.4 mg/kg at DA2-055;
- Cadmium – 3.3 mg/kg at DA2-072;
- Hexavalent chromium – 16 mg/kg at DA2-068;
- Copper – 445 mg/kg at DA2-073;
- Lead – 147 mg/kg at DA2-073;
- Mercury – 18.1 mg/kg at DA2-072;
- Nitrate/Nitrite – 2 mg/kg at DA2-059;
- Selenium – 1.7 mg/kg at DA2-059;
- Sulfide – 530 mg/kg at DA2-074; and
- Zinc – 422 mg/kg at DA2-072.

- The VOCs toluene, tetrachloethylene, and 2-Butanone were detected in one of seven subsurface soil samples analyzed for VOCs at ODA2. SVOCs di-n-butyl phthalate, (four detects in seven samples), bis(2-ethyhexyl) phthalate (five detects in seven samples), and n-Nitrosodiphenylamine (one detect in seven samples) were also detected.

- Pesticides and PCBs were not detected in subsurface soil samples.

8.1.3 Sediment

The interpretation of chemical data obtained from ODA2 sediment is summarized as follows:

- The following inorganic SRCs (with the maximum concentration detected) occur in sediment above background levels:

    - Aluminum (17,300 mg/kg at DA2-100)
    - Barium (317 mg/kg at DA2-097)
    - Beryllium (1.2 mg/kg at DA2-100)
    - Cadmium (2.3 mg/kg at DA2-097)
    - Chromium (19.4 mg/kg at DA2-100)
    - Hexavalent chromium (6.1 mg/kg at DA2-099)
    - Cobalt (10.5 mg/kg at DA2-097)
    - Copper (62.3 mg/kg at DA2-091)
    - Lead (31.3 mg/kg at DA2-097)
    - Mercury (0.37 mg/kg at DA2-089)
    - Nickel (25.2 mg/kg at DA2-100)
    - Nitrate/Nitrite (9.1 mg/kg at DA2-100)
    - Sulfide (1,100 mg/kg at DA2-099)
    - Vanadium 30.9 mg/kg at DA2-100)

- SRCs in sediment above background levels that have migrated to the furthest downstream location east of the AOC (station DA2-103) include beryllium and cadmium.

- The sample locations that had the highest concentration of inorganic SRCs in sediment samples are as follows:

    - DA2-089 (downstream floodplain of Sand Creek) – mercury
    - DA2-091 (upstream floodplain south of Sand Creek) – copper
    - DA2-097 (ditch north of Sand Creek) – barium, cadmium, cobalt, and lead
    - DA2-099 (Sand Creek downstream) – hexavalent chromium and sulfide
    - DA2-100 (ditch upgradient of Sand Creek Disposal Area) – beryllium, chromium, nickel, nitrate/nitrite and vanadium

8.1.4 Surface Water

The interpretation of SRC data obtained from ODA2 surface water is summarized below:

- **July 9&10, 2000**: Carbon disulfide and sulfide were only detected above background in the downstream location (DA2-099). Nitrate/nitrite was detected above background in all three sampling locations, with the concentration remaining basically unchanged between all three locations.

- **September 9&10, 2002**: Nitrocellulose was detected at all three sample locations. Nitrate/nitrite was detected in the upstream sample (DA2-095) and the furthest downstream sample (DA2-102). Carbon disulfide was detected in the furthest downstream sample (DA2-102).

- **November 26, 2002**: Chloroform was detected above background at all three sampling locations. Nitrate/nitrite was detected above background at DA2-095 and DA2-099.

- **April 4, 2003**: Nickel and chromium were detected above background at DA2-095. Carbon disulfide was only detected at DA2-099. Bis(2-ethylhexyl) phthalate was only detected at DA2-102. Nitrate/nitrite was detected above background at DA2-095 and DA2-102.

8.1.5 Groundwater

The interpretation of chemical data obtained from ODA2 groundwater is summarized as follows:

- Groundwater in all monitoring wells contains site-related metals with the exception of DA2-110, DA2-112, and DA2-DET4. DA2-104, located in the northern portion of the AOC, contained the most inorganics at the maximum concentration detected in groundwater.
- Wells WBG-012 and WBG-013 contain explosives and/or propellants.

- Di-n-Butyl-Phthalate was detected at two wells (DA2-110 and DA2-113). Carbon Disulfide was detected at five wells (DA2-107, DA2-108, DET1, DET4, and WBG-012). No pesticides or PCBs were detected in any of the wells sampled.

8.2 SUMMARY OF CONTAMINANT FATE AND TRANSPORT

Metals and explosive residue were detected in surface/subsurface soil and groundwater beneath two areas of the site:

- Area A – area north of Sand Creek, not including the RCRA area; and
- Area B – floodplain area downgradient of Rocket Ridge and south of Sand Creek.

Contaminant fate and transport modeling performed as part of the Phase II RI included leachate modeling (SESOIL) and groundwater modeling (ATD123) of the two source areas. Fate and transport modeling indicates that metals and explosives may leach from soils to the groundwater beneath the source areas. Migration of many of the constituents, however, has been attenuated because of moderate to high retardation factors. Summaries of results for these models follows.

8.2.1 SESOIL Modeling

SESOIL modeling results indicate that beneath the source areas, the following CMCOPCS are predicted to leach to groundwater with concentrations exceeding the groundwater RBCs/MCLs beneath sampling points:

8.2.1.1 *Area A*

- Arsenic
- Barium
- Chromium
- Hexavalent Chromium
- Copper

8.2.1.2 *Area B*

- RDX
- Tetryl
- Antimony
- Chromium
- Hexavalent Chromium
- Copper
- Selenium

In addition the following compounds are observed in groundwater at the site at concentrations exceeding their respective RBCs/MCLs:

- Arsenic
- Hexavalent Chromium
- Manganese

The three compounds listed above were combined with the compounds identified in the SESOIL modeling as CMCOPCs as final CMCOPCs to be modeled for lateral migration using AT123D.

8.2.2 AT123D Modeling

All compounds except manganese that were identified as CMCOPCS in the SESOIL modeling were identified as CMCOCs based on AT123D modeling. The maximum groundwater concentrations of these compounds were predicted to exceed RBCs/MCLs at Sand Creek at the closest point downgradient of the source areas. Summary results of AT123D modeling including receptor concentration at Sand Creek are presented in Table 5-3.

8.3 SUMMARY OF THE HUMAN HEALTH RISK ASSESSMENT

The HHRA was conducted to evaluate risks and hazards associated with contaminated media at the RVAAP ODA2 AOC for one potential receptor (Security Guard/Maintenance Worker) exposed to one medium (surface soil, from a depth interval of 0 to 1 feet bgs). Results were presented in Section 6 for all exposure scenarios and pathways. The following steps were used to generate conclusions regarding human health risks and hazards associated with contaminated surface soil at ODA2:

- identification of COPCs;
- exposure assessment;
- calculation of risks and hazards;
- identification of COCs; and
- calculation of RGOs.

8.3.1 Identification of COPCs

The surface soil at ODA2 data were evaluated as a single EU. Data from the RCRA unit was not included within this HHRA. The 2.5-acre RCRA unit is located within the larger 25-acre CERCLA unit. The RCRA unit is not included within the closure of the ODA2 CERCLA unit. Soil contamination at the RCRA unit will be investigated and remediated, as needed, in accordance with RCRA or other applicable requirements. Twelve COPCs were identified for the surface soil EU. The 12 surface soil COPCs are:

- Nine inorganics (aluminum, arsenic, cadmium, hexavalent chromium, copper, manganese, mercury, nitrate/nitrite, and sulfide; and
- Three explosives (2,4,6-TNT, 2-amino-4,6-DNT, and 4-amino-2,6-DNT).

Risks and hazards cannot be quantified for three of the 12 surface soil COPCs listed above (2-amino-4,6-DNT, 4-amino-2,6-DNT, and sulfide) due to a lack of toxicity information.

8.3.2 Exposure Assessment

The objectives of the exposure assessment are to estimate the magnitude, frequency, and duration of potential human exposure to COPCs in the EU. The four primary steps of the exposure assessment are to:

- Identify current and future land use;
- Identify potentially exposed populations, exposure media, and exposure pathways;
- Calculate exposure point concentrations; and
- Estimate each receptor's potential intake of each COPC.

Based on the exposure assessment, the scenario of an OHARNG Security Guard/Maintenance Worker exposed to surface soil was selected for further evaluation of toxicity effects and risk characterization.

8.3.3 Identification of COCs

For all COPCs in the EU, ILCRs were calculated to estimate cancer risk to the Security Guard/Maintenance Worker at ODA2. ILCRs below 10^{-6} are considered acceptable; ILCRs above 10^{-4} are considered unacceptable. HI values were also calculated to estimate overall non-carcinogen health risks. An HI greater than 1 is defined as the level of concern for potential adverse non-carcinogenic health effects. COCs are defined for the surface soil EU as those contaminants that have an ILCR greater than 1×10^{-6} and/or an HI greater than 1 for one receptor in the HHRA.

One metal (arsenic) was identified as a COC for the Security Guard/Maintenance Worker at ODA2. The total HI is 0.051, which is below the threshold of 1.0. Therefore, no non-carcinogenic COCs are identified at ODA2. The only carcinogenic COC identified is arsenic, with a total cancer risk from exposure to this chemical of 5.3×10^{-6}.

Risk-based RGOs were computed for arsenic at a TR of 10^{-5} and a THI of 1; however, the EPC used in this HHRA for arsenic (13.8 mg/kg) was smaller than the most conservative risk-based RGO (26 mg/kg, based on a TR of 10^{-5}), as well as the surface soil background concentration for RVAAP (15.4 mg/kg).

8.4 SUMMARY OF THE SCREENING ECOLOGICAL RISK ASSESSMENT

The ODA2 site contains sufficient terrestrial and aquatic (surface water and sediment) habitat to support various classes of ecological receptors. For example, terrestrial habitats at ODA2 include old fields, woodlots, and grassy areas. Various classes of receptors, such as vegetation, small and large mammals, and birds, have been observed at the site. The presence of suitable habitat and observed receptors at the site warrants a SERA. Thus, Ohio EPA protocol (Level I) was met and Level II was needed.

A Level II SERA was performed for ODA2 soils, sediment, and surface water using Ohio EPA guidance methods. The Level II Screen consisted of a media-specific data and media evaluation of detected COIs, as well as a media-specific media screen. The data and media evaluation was conducted to identify whether the chemicals could be initially eliminated from further consideration due to low frequency of detection (data evaluation) and whether the chemicals were site related and have impacted the site (media evaluation that included comparison of detected concentrations against background [and SRVs for sediment] and identification of PBT compounds). Any input COIs that were not eliminated during the data and media evaluation were carried forward to the media screen. The media screen entailed comparing concentrations of inputted chemicals against ESVs (for soil and sediment) and OAC WQS for surface water. Chemicals whose concentrations exceeded or lacked the ESVs or OAC WQS, as well as chemicals that were PBT compounds, were retained as COPECs while all other chemicals were eliminated from further action.

For surface soil, 41 detected COIs were inputted into the data and media evaluations, wherein 9 were eliminated due to low frequency of detection and not being PBT compounds, and 32 were identified as COPECs and carried forward to the media screening. Of the 32 COPECs inputted into the media screening, 6 were eliminated because their concentrations did not exceed their ESVs and they were not PBT compounds, so 26 chemicals were retained as COPECs for surface soil.

For subsurface soil, 38 detected COIs were inputted into the data and media evaluations, wherein 16 were eliminated due either to concentrations below background, low frequency of detection, and not being PBT compounds. Thus, 22 of the 38 detected COIs were identified as COPECs and carried forward to the media screening. Of the 22 COPECs inputted into the media screening, 4 were eliminated because their concentrations did not exceed their ESVs and they were not PBT compounds, so 18 chemicals were retained as COPECs for subsurface soil.

For downstream sediment, 26 detected COIs were inputted into the data and media evaluations, wherein 13 were eliminated due their concentrations being less than the Ohio EPA SRVs and not being PBT compounds. Thus, 13 of the 26 detected COIs were identified as COPECs and carried forward to the media screening. Of the 13 COPECs inputted into the media screening, 4 were eliminated because their concentrations did not exceed their ESVs and they were not PBT compounds, so 9 chemicals were retained as COPECs for downstream sediment.

For upstream sediment, 25 detected COIs were inputted into the data and media evaluations, wherein 13 were eliminated because their concentrations either were less than the Ohio EPA SRVs or background and they were not PBT compounds. Thus, 12 of the 25 detected COIs were identified as COPECs and carried forward to the media screening. Of the 12 COPECs inputted into the media screening, only 1 was eliminated because its concentration did not exceed its ESV and it was not a PBT compound, so 10 chemicals were retained as COPECs for upstream sediment.

For downstream surface water, 15 detected COIs were inputted into the data and media evaluations, wherein 6 were eliminated due their concentrations being less than background and not being PBT compounds. Thus, 9 of the 15 detected COIs were identified as COPECs and carried forward to the media screening. Of the nine COPECs inputted into the media screening, two were eliminated because their concentrations did not exceed their ESVs and they were not PBT compounds, so seven chemicals were retained as COPECs for downstream surface water.

For upstream surface water, 13 detected COIs were inputted into the data and media evaluations, wherein 6 were eliminated due their concentrations being less than background and not being PBT compounds. Thus, 7 of the 13 detected COIs were identified as COPECs and carried forward to the media screening. Of the seven COPECs inputted into the media screening, three were eliminated because their concentrations did not exceed their ESVs and they were not PBT compounds, so four chemicals were retained as COPECs for upstream surface water.

Because COPECs were identified and retained for soil, sediment, and surface water, ESCMs were prepared, along with the identification of site-specific ecological receptors, relevant and complete exposure pathways, and candidate assessment endpoints. These types of information will be used to prepare a Level III Baseline if it is deemed necessary to conduct a Level III ERA. Another factor in this SMDP is that both upstream and downstream sampling stations in Sand Creek show healthy aquatic ecology and full attainment status according to Ohio EPA guidelines.

Based on the presence of multiple COPECs in soil, sediment, and surface water, as well as the presence of site-specific ecological receptors and complete exposure pathways to those COPECs at the ODA2 site, a recommendation is made to move to a SMDP. Possible outcomes of the SMDP could include (1) further evaluation by conducting a Level III BERA, (2) performing a remedial action to reduce ecological risks, or (3) determining that no further action is warranted because of military land-use or other reasons. The information in this Level II SERA can be used to assist risk managers in making their decision associated with the SMDP.

8.5 SITE-SPECIFIC CONCEPTUAL MODEL

The ODA2 SCM at the time of the Phase II RI field investigation was summarized in Section 2. A revised SCM is presented in this section using data obtained during the Phase II RI and computer models that assess the potential fate and transport of contaminants that leach from surface soil into the groundwater system and migrate to a potential receptor or exit point. Elements of the SCM include:

- primary contaminant source areas and release mechanisms based on Phase II RI soil data;
- contaminant migration pathways and exit points based on sediments, surface water; and geotechnical data; and
- data gaps and uncertainties.

8.5.1 Primary Contaminant Source and Release Mechanisms

Based on results of the Phase II RI soil sampling, the southern floodplain of Sand Creek downgradient from the Sand Creek Disposal Area, and the west/northwest area north of Sand Creek contain the greatest numbers and concentrations of contaminants. Metals and explosives are present in soil in these areas at concentrations greater than background or risk screening criteria. The majority of contamination is within the surface soil interval less than a depth of 0.3 meter (1.0 foot), but some explosives and metals were detected in subsurface soil in areas of high surface soil contamination.

The primary mechanism for release of contaminants from the source areas is leaching of constituents via infiltration of rainwater through surface and subsurface soils. Conservative modeling indicates several metals and explosives may leach from the contaminated surface soils to groundwater at concentrations exceeding MCLs/RBCs. Based on modeling results, maximum groundwater concentrations of arsenic, antimony, barium, chromium, hexavalent chromium, copper, selenium, RDX, and tetryl are predicted to reach Sand Creek from the groundwater at concentrations exceeding MCLs/RBCs.

8.5.2 Contaminant Migration Pathways and Exit Points

Migration of many constituents has been attenuated because of moderate to high soil retardation factors. In general, groundwater flow within the AOC flow is towards Sand Creek. The primary exit pathway from ODA2 is via surface water and groundwater flow to Sand Creek. The low concentrations of the metals and explosive SRCs detected in sediment and surface water at station DA2-103 suggest these processes are effective at attenuating constituents and restricting their migration beyond the site boundary. However, storm events may produce flushing of the surface water system and result in periodic transport beyond the site boundary. The off-site migration of contaminants from ODA2 was not confirmed by sampling during the Phase II RI.

8.5.3 Uncertainties

The SCM is developed based on available site characterization and chemical data. Uncertainties are inherent in the SCM where selected data do not exist or are sparse. The uncertainties within the SCM for ODA2 include the following:

- Groundwater flow directions shown on Figure 2-5 are based on groundwater elevation data collected from the ODA2 monitoring wells. The monitoring wells at ODA2 are predominantly clustered around Sand Creek near the center of the AOC. Chemical and groundwater elevation data from the fringes of the site are generally unknown. Monitoring wells in these areas would be needed to confirm whether groundwater SRCs were entering the site from outside the AOC, and to more accurately depict the groundwater flow directions.

- Soil and groundwater samples were not collected from an area of the site known as Rocket Ridge. This area was a disposal area for munitions and has not been cleared of MEC hazards. It was therefore unsafe at the time of the Phase II RI to collect samples from this area. It can be inferred from the contamination present downgradient of this area (Area B), that Rocket Ridge is a source of soil and groundwater contamination. Although this area is a likely source area for soil and groundwater SRCs, the presence or extent of contamination in this area is unknown.

- 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 ODA2 are uncertain.

8.6 CONCLUSIONS

The conclusions presented below, by medium, combine the findings of the contaminant nature and extent evaluation, fate and transport modeling, and the HHBRA and SERA.

8.6.1 Surface/Subsurface Soil

- 2,4,6-TNT; tetryl; arsenic; barium; cadmium; chromium; chromium (hexavalent); copper; mercury; nickel; and PCE were identified as initial CMCOPCs for Area A based on soil screening analysis.

- 2,4,6-TNT; 2,4-DNT; RDX; tetryl; antimony; barium; cadmium; chromium; chromium (hexavalent); copper; manganese; mercury; nickel; selenium; and PCE were identified as initial CMCOPCs for Area B based on soil screening analysis.

- Arsenic, barium, chromium, chromium (hexavalent), and copper were identified as final CMCOPCs for Area A based on source loading predicted by the SESOIL modeling.

- RDX, tetryl, antimony, chromium, chromium (hexavalent), copper, and selenium were identified as final CMCOPCs for Area B based on source loading predicted by the SESOIL modeling.

- One metal (arsenic) was identified as a COC for the Security Guard/Maintenance Worker at ODA2. Risk-based RGOs were computed for arsenic at a TR of 10^{-5} and a THI of 1; however, the EPC used in this HHRA for arsenic (13.8 mg/kg) was smaller than the most conservative risk-based RGO (26 mg/kg, based on a TR of 10^{-5}), as well as the surface soil background concentration for RVAAP (15.4 mg/kg).

- The lateral and vertical extent of SRCs in the surface/subsurface soil both north and south of Sand Creek has not been fully determined.

8.6.2 Sediment/Surface Water

- Nitrocellulose was detected in sediment at DA2-100 and in surface water at DA2-095, DA2-099, and DA2-102.

- Surface water at DA2-095 contain the most inorganic SRCs with concentrations above background levels. DA2-095 is located in the southwest corner of the AOC near where the stream flows into the AOC.

- SVOCs, VOCs, pesticides, and PCBs are either not detected in sediment, or detections are limited to low concentrations in a limited number of sample locations

8.6.3 Groundwater

- Groundwater in all monitoring wells contains site-related metals with the exception of DA2-110, DA2-112, and DA2-DET4. DA2-104, located in the northern portion of the AOC contained the most inorganics at the maximum concentration in groundwater.

- Wells WBG-012 and WBG-013 contain explosives and/or propellants.

- Arsenic, antimony, barium, chromium, chromium (hexavalent), copper, selenium, RDX, and tetryl were identified as CMCOCs based on AT123D modeling. The maximum groundwater concentrations of the constituents were predicted to exceed MCLs/RBCs at Sand Creek at the closest point downgradient of the source areas.

- The horizontal extent of SRCs in groundwater both north and south of Sand Creek has not been fully determined.

9.0 RECOMMENDATIONS

9.1 NATURE AND EXTENT OF CONTAMINATION

It is recommended that an FS be performed for ODA2. This study should be designed to provide the information necessary for decision-makers to consider possible remedial actions that may be used to reduce risks to the environment and potential receptors.

Future land uses for ODA2 should be determined prior to development of the FS and selection of a remedy. Identification of future land uses provides the basic information necessary to select the appropriate remedial response needed to achieve protection of human health and the environment, allows development of appropriate remedial action objectives, and allows finalization and application of RGOs for appropriate potential receptors. Upon finalization of RGOs, definitive delineation of source areas where RGOs are exceeded may then be performed. These factors directly determine the required extent and cost of remediation needed to achieve protection of the receptor. Identification of future land uses will also allow consideration of presumptive remedies and will be necessary for documentation in a Record of Decision and attendant Land Use Controls Assurance Plan.

The following uncertainties should be addressed in the FS to allow for a complete evaluation of possible remedial actions:

1. Determine the vertical and horizontal extent of soil SRCs both north and south of Sand Creek.

9.1.1 Human Health Risk Assessment

Only arsenic was identified as a COC for Security Guard/Maintenance Worker at ODA2. At least until a final remedial action is implemented, administrative controls should be put in place at ODA2 to protect likely human receptors. The EPC for arsenic (13.8 mg/kg) is less than surface soil background (15.4 mg/kg). It is recommended that the decision makers carefully consider the need for further investigation or remedial action based on the risk assessment results for this receptor.

9.1.2 Ecological Risk Assessment

The SERA identified the presence of multiple COPECs in soil, sediment, and surface water, as well as the presence of site-specific ecological receptors and complete exposure pathways to those COPECs at the ODA2 site, and a recommendation is made to move to a SMDP. The most likely outcomes associated with the SMDP (in order of likelihood) for the ecological risk assessment, as mentioned in Sections 7 and 8, are: 1) risk management of the ecological resources based on the military land-use or other reasons that may include development of RGOs or weight-of-evidence analysis that no RGOs are required, 2) remediation of some of the source material, if required, to reduce ecological risks, or 3) conduct of more investiagation, such as a Level III. In the FS, a weight-of-evidence approach to the COPECs involved at ODA2 would assist in defining the best outcome or decision.

The information in the Level II SERA presented in this report can be used to assist risk managers in making their decision associated with the SMDP.

10.0 REFERENCES

American Cancer Society 2003. *Cancer Facts & Figures 2003*, online: www.cancer.org.

Burrows, E.P., D.H. Rosenblatt, W.R. Mitchell, and D.L. Parmer 1989. "Organic Explosives and Related Compounds: Environmental and Health Considerations." U. S. Army Biomedical Research and Development Laboratory, Fort Detrick, Frederick, MD.

DoD (Department of Defense) 1999. *DoD Ammunition and Explosives Safety Standards* (DOD 6055.9-STD), Washington, DC.

Dragun, James 1988. *The Soil Chemistry of Hazardous Materials,* Hazardous Materials Control Research Institute, Silver Spring, MD.

Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones 1997a. *Preliminary Remediation Goals for Ecological Endpoints,* ES/ER/TM-162/R2, Lockheed Martin Energy Systems, Oak Ridge National Laboratory, Oak Ridge, TN.

Efroymson, R.A., M.E. Will, and G.W. Suter II 1997b. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision,* ES/ER/TM-126/R2, Lockheed Martin Energy Systems, Oak Ridge National Laboratory, Oak Ridge, TN.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten 1997c. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Plants: 1997 Revision,* ES/ER/TM-85/R3, Lockheed Martin Energy Systems, Oak Ridge National Laboratory, Oak Ridge, TN.

Funk, S.B., D.J. Roberts, D.L. Crawford, and R.L. Crawford 1993. "Initial-Phase Optimization for Bioremediation of Munition Compound-Contaminated Soil." Applied and Environmental Microbiology **50**(7): 2171–2177.

GSC 1998. SESOIL for Windows, Version 3.0, Laurel, MD.

Jones, D.S., G.W. Suter II, and R.N. Hull 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision*, ES/ER/TM-95/R4, Prepared for the U. S. Department of Energy Office of Environmental Management, Oak Ridge, TN, under contract DE-AC05-84OR21400, Prepared by Lockheed Martin Energy Systems, Inc., Oak Ridge, TN, November.

Kaplan, D.L. and A.M. Kaplan 1990. "Thermophilic biotransformation of 2,4,6-trinitrotoluene under simulated composting conditions," *Applied and Environmental Microbiology*, **44**(3): 757-760, 1982.

Lyman, W.J., W.F. Rheel, and D.H. Rosenblatt 1990. *Handbook of Chemical Property Estimation Methods*, American Chemical Society, Washington, D.C.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger 2000. "Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems," *Arch. Environ. Contamin. Toxico*l. **39**:20-31.

Morgan, Tim 1996. *Natural Resources and Environmental Overview of the Ravenna Army Ammunition Plant with Thoughts on the Future*, Unpublished paper, RVAAP Natural Resources Manager, April.

Morgan, Tim 2003. Personal communication by telephone with C.R. Wenzel, SAIC, 7 April 2003.

Morgan, Tim 2004. Personal communication by telephone with C.R. Wenzel, SAIC, 22 July 2004.

ODNR (Ohio Department of Natural Resources) 1993. Species and Plant Communities Inventory, Ravenna Army Ammunition Plant, Prepared by ODNR, Division of Natural Areas & Preserves in cooperation with The Nature Conservancy, Ohio Chapter.

ODNR (Ohio Department of Natural Resources) 1997. Species and Plant Communities Inventory, Ravenna Army Ammunition Plant, Prepared by ODNR, Division of Natural Areas & Preserves in cooperation with The Nature Conservancy, Ohio Chapter.

OHARNG (Ohio Army National Guard) 2001. *Integrated Natural Resources Management Plan and Environmental Assessment for the Ravenna Training and Logistics Site and the Ravenna Army Ammunition Plant, Portage and Trumbull Counties, Ohio*, Prepared by AMEC Earth & Environmental, Louisville, KY.

Ohio EPA (Ohio Environmental Protection Agency) 2002. *Ohio Administrative Code*, Chapters 3745-1 and 3745-2 for the Lake Erie Basin, December 30, online: http:/www.epa.state.oh.us/dsw/wqs/criteria/html.

Ohio EPA. (Ohio Environmental Protection Agency) 2003. *Ecological Risk Assessment Guidance Document,* Division of Emergency and Remedial Response, Draft Final.

SAIC (Science Applications International Corporation) 1999. *Plant Community Survey for the Ravenna Army Ammunition Plant*, prepared for the Ohio Army National Guard, Adjutant General's Department, AGOH-FM-EN, Columbus, OH.

Sample, B.E., D.M. Opresko, and G.W. Suter, II 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision,* ES/ER/TM-86/R3, Oak Ridge National Laboratory, Oak Ridge, TN.

Schroeder, P.R., T.S. Dozier, P.A. Zappi, B.M. McEnroe, J.W. Sjostrom, and R.L. Peyton 1994. "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3," EPA/600/R-94/168b, September 1994, U. S. Environmental Protection Agency Office of Research and Development, Washington, DC.

Singh, A.K., A. Singh, and M. Engelhardt. 1997. *The Lognormal Distribution in Environmental Applications.* U. S. Environmental Protection Agency, EPA/600/R-97-006, December 1997.

Suter, G.W. II and C.L. Tsao 1996. *Toxicological Benchmarks for Screening Potential Constituents of Concern for Effects on Aquatic Biota: 1996 Revision*, ES/ER/TM96/R2, Lockheed Martin Energy Systems, Oak Ridge National Laboratory, Oak Ridge, TN.

USACE (U. S. Army Corps of Engineers) 1996a. *Preliminary Assessment for the Ravenna Army Ammunition Plant, Ravenna, Ohio*.

USACE 1998a. *Phase I Remedial Investigation of High Priority Areas of Concern at the Ravenna Army Ammunition Plant*.

USACE 1998b. *RCRA Closure Field Investigation Report for the Deactivation furnace Area, Open Detonation Area, Building 1601, and Pesticides Building, Ravenna Army Ammunition Plant, Ravenna, Ohio*.

USACE 2001. *Final Phase II Remedial Investigation Report for the Winklepeck Burning Grounds at the Ravenna Army Ammunition Plant, Ravenna, Ohio,* DACA62-94-D-0029, D.O. 0060, April 2001.

USACE 2001a. *Facility-Wide Sampling and Analysis Plan for the Ravenna Army Ammunition Plant, Ravenna, Ohio*, DACA62-00-D-0001, D.O. CY02, Final, March.

USACE 2001b. Phase *II Remedial Investigation Report for the Winklepeck Burning Grounds at the Ravenna Army Ammunition Plant, Ravenna, Ohio*. DACA62-94-D-0029, D.O. 0060, Final, April 2001.

USACE 2002. *Work Plan and Sampling and Analysis Plan Addenda for the Phase II Remedial Investigation of Demolition Area 2 at the Ravenna Army Ammunition Plant, Ravenna, Ohio*.

USACE 2003. *RVAAP Facility-wide Ecological Risk Work Plan,* Louisville, KY.

USACE 2004. RVAAP's Facility-wide Human Health Risk Assessor Manual, January 2004.

USACE (United States Army Corps of Engineers). 2005. *Facility-wide Biological and Water Quality Study 2003, Ravenna Army Ammunition Plant, Part 1 – Streams and Part II – Ponds*. U.S. Army Corps of Engineers, Louisville District, with the State of Ohio Environmental Protection Agency, Division of Surface Water. Pp. 144 and several appendices.

USACE 2005. Phase III RI Report for Winkepeck Burning Grounds, Ravenna Army Ammunition Plant, Ravenna, Ohio. DACA62-00-D-0001, D.O. CY08, March 2005.

USAEHA 1984. *Hazardous Waste Management Study No. 37-26-0442-84*.

USAEHA 1992. *Geohydrologic Study No. 38-26-KF95-92*.

USATHAMA 1978. *Installation Assessment of Ravenna Army Ammunition Plant.* Report No. 132.

USDA (U.S. Department of Agriculture) 1978. Soil Survey of Portage County, Ohio.

USEPA (U. S. Environmental Protection Agency) 1989. *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A)*, EPA/540/1-89/002, Washington, D.C.

USEPA 1989a. *Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual,* EPA/540/1-89-001.

USEPA 1989b. *Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document,* EPA/600/3-89/013.

USEPA 1990. *National Oil and Hazardous Substance Pollution Contingency Plan*, Final Rule, RF Vol. 55, No. 46, March 8, 1990, available from U. S. Government Printing Office, Washington, D.C.

USEPA 1990a (USEPA SW-846)*, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Analytical Protocols*

USEPA 1991. *Ecological Assessment of Superfund Sites: An Overview,* EcoUpdate 1(2), Office of Solid Waste and Emergency Response, Publ. 9345.0-051.

USEPA 1991. *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals*), OSWER Directive 9285.7-01B, Office of Emergency and Remedial Response, Washington, D.C.

USEPA 1992. *Supplemental Guidance to RAGS: Calculating the Concentration Term*, OSWER Directive 9285.7-081, Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA 1992. *Framework for Ecological Risk Assessment*. Risk Assessment Forum, EPA/630/R-92/001, Washington, D.C.

USEPA 1993. *Wildlife Exposure Factors Handbook,* EPA/600/P-93/187a, Office of Health and Environmental Assessment, Office of Research and Development, U. S. Environmental Protection Agency, Washington, D.C.

USEPA 1996. *Soil Screening Guidance: User's Guide*, EPA/540/R-96/018, Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA 1996. *Soil Screening Guidance: Technical Background Document,* Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA 1997a. *Exposure Factors Handbook*, EPA/600/P-95/002Fa, Office of Research and Development, U. S. Environmental Protection Agency, Washington, D.C.

USEPA 1997b. *Health Effects Assessment Summary Tables (HEAST)*, Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final*. U. S. EPA Environmental Response Team, Edison, NJ, June.

USEPA 1998. *Guidelines for Ecological Risk Assessment*, EPA/630/R-95/002 Fa.

USEPA 1999. *Ecological Data Quality Levels (EDQLs). RCRA QAPP Instructions,* U. S. Environmental Protection Agency, Region 5, Chicago, IL, Revision, April.

USEPA 2000a. *Dermal Guidance*, Draft January 2000, from Mark Johnson, EPA Region 5.

USEPA 2000b. *Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins*. EPA Region 4, originally published November 1995, Website version last updated May 2000. Online: http://www.epa.gov/region4/waste/ots/healtbul.htm.

USEPA 2002a. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim,* OSWER 9285.7-02EP, September, 2001.

USEPA 2002b. *Region 9 Preliminary Remediation Goals (PRGs)*, October 2002 update, created by Stanford J. Smucker, online: http:/www.epa.gov/region09/waste/sfund/prg/index.html.

USEPA 2002c. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites, OSWER 9285.6-10, December, 2002.

USEPA 2004. *Integrated Risk Information System (IRIS) Database*, Office of Research and Development, Washington, D.C.

USGS (United States Geological Survey) 1966. *Geology and Ground-Water Resources of Portage County, Ohio.* USGS Professional Paper No. 511.

USIOC 2000. *Report of Analytical Results Demolition Area #2 CERCLA Sites*.

VISTA Technologies, 2000. *Report of Analytical Results Demolition Area #2 CERCLA Sites.* Prepared for U.S. Army Industrial Operations Command, Environental Contracting Division, Rock Island, IL, March 6, 2000.

Wentsel R.S., R.T. Checkai, T.W. LaPoint, M. Simini, D. Ludwig, and L. Brewer 1994. *Procedural Guidelines for Ecological Risk Assessments at U.S. Army Sites, Volume 1,* ERDEC-TR-221, Aberdeen Proving Ground, MD.

Wentzel, R.S., R.T. Checkai, T.W. LaPoint, M. Simini, D. Ludwig, and L. Brewer 1996. *Tri-Service Procedural Guidelines for Ecological Risk Assessments, Volumes 1 and 2,* ERDEC-TR-221, Aberdeen Proving Ground, MD.

White, G.W. 1987. *Glacial Geology of Northeastern Ohio.* State of Ohio Department of Natural Resources, Division of Geological Survey, Bulletin 68.

Winslow, J.D., and G.W. White 1966. *Geology and Ground-Water Resources of Portage County, Ohio*. United States Geological Survey Professional Paper 511.

Yeh, G.T. 1992. AT123D: An Analytical Solution for Transient One-, Two-, or Three-Dimensional Transport in a Homogenous, Anisotropic Aquifer with Uniform, Stationary Regional Flow, Oak Ridge National Laboratory, Oak Ridge, TN.