RAAP 050506 \ 05011

RADFORD ARMY AMMUNITION PLANT, VIRGINIA

SWMU 39
RCRA Facility Investigation/
Corrective Measures Study Report

Prepared for:

USACE Baltimore District
10 S. Howard St.
Baltimore, MD 21201

Prepared by:

Shaw Environmental, Inc.
2113 Emmorton Park Rd.
Edgewood, MD 21040
Contract No. DACA31-01-F-0085

Final Document

June 2005

3.

DEPARTMENT OF THE ARMY
RADFORD ARMY AMMUNITION PLANT
P.O. BOX 2
RADFORD VA 24143-0002

REPLY TO
ATTENTION OF

SJMRF-OP

17 August 2005

MEMORANDUM FOR Cmdr, US Army Environmental Center, Attn: SFIM-AEC-CDN (Tony Perry), 5179 Hoadley Road, Aberdeen Proving Ground, MD 21010-5401

SUBJECT: Notification of Radford Army Ammunition Plant Decision Document SWMU 39- Excavation of Soil for Clean Close Out, Off Site Disposal

1. Reference Memorandum from Assistant Chief of Staff For Installation Management, 9 Sep 03, Subj: Policies for Staffing and Approving Decision Documents.

2. A copy of the subject decision document (enclosed) is submitted IAW reference. As the cost of the action in the subject decision document is under $2 million, approval authority is with the Installation Commander.

3. Point of contact is Mr. James J. McKenna, 540 639 8641 COM, 931 8641 DSN.

Encl

ROBERT N. DAVIE
Chief Operations Team

5

RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Decision Document

SWMU 39 - Excavation of Soil for Clean Close Out and Off-Site Disposal

Final **August 2005**

TABLE OF CONTENTS

Section		*Page*
1.0	PURPOSE	1
2.0	SITE RISK	2
3.0	REMEDIAL ALTERNATIVES	2
4.0	PUBLIC/COMMUNITY INVOLVEMENT	3
5.0	DECLARATION	3
6.0	APPROVAL AND SIGNATURE	4
7.0	REFERENCES	4

1.0 PURPOSE

This Decision Document (DD) is prepared in accordance with the Assistant Chief of Staff for Installation Management (ACSIM) memorandum (ACSIM, 2003) detailing policies for staffing and approving DDs and Defense Environmental Restoration Program (DERP) management guidance (DERP, 2001). This document describes the selected action (Excavation of Soil for Clean Close Out and Off-site Disposal) for soil contaminated with metals and dioxins/furans at Solid Waste Management Unit (SWMU) 39 – the Wastewater Ponds from the Propellant Incinerators at Radford Army Ammunition Plant (RFAAP). This alternative was selected in accordance with the Resource Conservation and Recovery Act of 1976 (RCRA), the Hazardous and Solid Waste Amendments of 1984 (HSWA), the RFAAP Resource Conservation and Recovery Act (RCRA) Permit requirements (USEPA, 2000) (EPA ID No. VA1210020730), and the Final RCRA Corrective Action Plan (USEPA, 1994), as applicable as well as the SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report, Final Document, June 2005.

SWMU 39 consists of two unlined and bermed earthen ponds. The ponds received scrubber and pre-cooler quench water from incinerator exhaust. The ponds were excavated approximately 6 to 8 feet into the natural grade. The excavated material was used to create a berm that surrounds each pond. A fence surrounds the ponds, and the enclosed area is approximately 450-ft. by 300-ft. at the widest points.

The RFAAP RCRA Corrective Action Permit, signed in September 2000, identified SWMU 39 as having the potential to pose a threat, or potential threat, to human health and the environment. The Permit required that a sampling strategy be developed to complete the delineation and characterization of the site. RCRA Facility Investigation (RFI) field efforts were conducted in 1999 and 2002. Data indicated that metals and dioxin/furans had contaminated soil at SWMU 39. The contamination was mostly confined to the top two feet of soil. Human Health and Screening Level Ecological risk assessments (*Section 2.0*) indicated there was elevated risk at the site and remedial measures were necessary to ensure the protection of human health and the environment.

Based on the findings of the SWMU 39 RFI, a Corrective Measures Study (CMS) was conducted. The CMS evaluated remedial alternatives (*Section 8.0*) to address the cadmium contamination at the site. The selected remedy was Excavation of Soil for Clean Close Out and Off-site Disposal. This alternative was selected as the final alternative for SWMU 39 because it is implementable and provides protection to human health and the environment. In addition, this alternative facilitates clean close out and is cost effective. By achieving clean close out, these corrective measures accomplish the Army's Installation Restoration Program (IRP) goal by cleaning up the site, mitigating risks, and restoring it for beneficial use. Therefore, the alternative - Excavation of Soil for Clean Close Out and Off-site Disposal - has been selected by the U.S. Army with concurrence from the U.S. Environmental Protection Agency (USEPA) Region III, Virginia Department of Environmental Quality (VDEQ) and the US Army Center for Health Promotion and Preventive Medicine (USACHPPM). Documents supporting this decision are located in the RFAAP information repository.

2.0 SITE RISK

A human health risk assessment (HHRA) and screening level ecological risk assessment (SLERA) was conducted as part of the SWMU 39 RFI/CMS.

The risks associated with five exposure scenarios were calculated the HHRA: current maintenance workers, future maintenance workers, future excavation workers, future adult residents, and future child residents. The potential cumulative risk for the current maintenance worker, the future maintenance worker, and the excavation worker were less than the USEPA's target risk range. The potential cumulative risks for the adult and child residents were within the USEPA's target risk range. The potential cumulative hazard index (HI) for the current and future maintenance worker and adult resident scenarios were less than 1. The potential cumulative HI for the future excavation worker scenario was slightly above 1; no individual chemical was equal to or greater than 1. The potential cumulative HI for the future child resident scenario was above 1, primarily due to vanadium and iron. The margin-of-exposure evaluation indicated that the intake from iron was within the allowable range. Lead was also evaluated as a chemical of potential concern (COPC) in the HHRA using the Adult Lead Model for the worker scenarios and the Integrated Exposure Uptake Biokinetic (IEUBK) model for the resident scenarios. For each scenario, site concentrations of lead in surface soil and total soil were above the health protective criterion.

A Screening Level Ecological Risk Assessment (SLERA) was conducted to identify potential hazards to ecological receptors. The assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles, from food-chain exposure, as well as a potential reduction in food supply from elevated concentrations of lead, copper, and chromium. For food-chain exposure, the primary hazard drivers were lead and dioxins/furans in surface soil. Thallium, chromium, and copper were secondary hazard drivers in surface soil for this exposure pathway. Regardless, based on uncertainties of toxicity, no wildlife RTE species confirmation in the SWMU 39 study area, the engineered treatment unit nature of the site, and the small size of the SWMU (2.6 acres), remedial measures solely to address ecological concerns are not warranted at this time. It should be noted, however, that the proposed remedial action will provide a significant reduction in ecological risk to potential receptors.

3.0 REMEDIAL ALTERNATIVES

Four corrective measures alternatives were evaluated to address metals and dioxins/furans in soil at SWMU 39:

1. No Further Action;
2. Institutional Controls (Land Use Controls, Groundwater Monitoring);
3. Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Land Use Controls, Groundwater Monitoring); and,
4. Excavation of Soil for Clean Close Out and Off-site Disposal.

These four alternatives were evaluated using the selection criteria: effectiveness, implementability, and cost. The corrective measures objective (CMO) for the RFI/CMS was to reduce contaminant concentrations in soil to mitigate the human health risk and to allow clean

close out of the site. To fully address this objective, a remedy that addressed the potential for future groundwater impact received preferential consideration. RFAAP is underlain by karst geology. The preferential remedial alternative in this type of geological setting is source removal. Allowing waste to remain in place above actionable regulatory levels represents a risk to RFAAP personnel and the environment.

Alternative Four was selected as the final alternative because it is implementable and provides a greater level of protection to human health and the environment not provided by Alternatives Two and Three. Alternative Four facilitates clean close out, is cost effective, and is protective of groundwater. By achieving clean close out, these corrective measures accomplish the Army's IRP goal by cleaning up the site, mitigating risks, and restoring it for beneficial use. This corrective measure can be implemented in approximately one year, however, this should be considered an estimate. The actual time to complete the corrective measures could be impacted by site-specific conditions, funding delays, and/or regulatory review. The total estimated cost for this alternative is $1,130,000.

This alternative includes the following:

- Delineation of soil containing arsenic, lead, vanadium, and dioxins/furans above the Residential RG;
- Excavation of the delineated area such that the remaining soil is below the Residential RG;
- Transportation and off-site disposal of soil; and,
- Site restoration activities.

Implementation of this alternative will reduce the concentrations of metals and dioxin/furans to below the Residential RGs and facilitate clean close out. In addition, the proposed human health RG for residential land use is expected to result in reduction of ecological risks associated with analytes in soil to levels that are protective of the environment. Therefore, implementation of this alternative meets the corrective action objective and is protective of human health and the environment.

4.0 PUBLIC/COMMUNITY INVOLVEMENT

RFAAP has a Restoration Advisory Board (RAB) which has been actively involved throughout the environmental investigation activities conducted during the RFI/CMS. The RAB includes representatives from USEPA and VDEQ, as well as members of the local community.

Comments on the RFI/CMS were solicited from the USEPA and VDEQ. Comments were received and considered by the U.S. Army prior to selection of the Excavation of Soil for Clean Close Out and Off-site Disposal alternative.

5.0 DECLARATION

The selected remedy is protective of human health and the environment, attains Federal and State requirements that are applicable or relevant and appropriate to this corrective measures action,

and is cost effective. This remedy utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable for this site. However, because onsite treatment of the principal threats of the site was not found to be practicable, this remedy does not satisfy the statutory preference for onsite treatment as a principal element of the remedy. Onsite treatment of metals and dioxin/furan-contaminated soil was determined to not be implementable and cost effective for the volume of contaminated soil at SWMU 39. The selected remedy will result in no hazardous substances remaining on-site above levels that would restrict future use, therefore, the five-year review process will not apply to this action.

6.0 APPROVAL AND SIGNATURE

In summary, the Army will implement the Excavation of Soil for Clean Close Out and Off-site Disposal alternative for SWMU 39 at RFAAP. The total cost for this action is below $2 million; therefore, the appropriate approval authority is the Installation Commander for RFAAP.

Approved By:

22 Aug 05

Ronald F. Fizer
LTC, CM, Commanding
Radford AAP

Date

7.0 REFERENCES

Assistant Chief of Staff for Installation Management (ACSIM), 2003. *Memorandum from Major General Larry J. Lust: Policies for Staffing and Approving Decision Documents (DDs)*, dated 09 September 2003.

Defense Environmental Restoration Program (DERP), 2001. *Memorandum for Assistant Secretary of the Army: Management Guidance for the Defense Environmental Restoration Program*, dated 28 September 2001.

U.S. Environmental Protection Agency (USEPA), 1994. *Final RCRA Corrective Action Plan*, Office of Solid Waste and Emergency Response. EPA/520/R/94/004.

U.S. Environmental Protection Agency (USEPA), 2000. *Radford Army Ammunition Plant Permit for Corrective Action and Waste Minimization*. Permit No. VA1210020730. 31 October 2000.

U.S. Army Radford Army Ammunition Plant (RFAAP), 2005. *SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report*, Final Document June 2005.

McKenna, Jim

From: McKenna, Jim
Sent: Friday, August 05, 2005 9:41 AM
To: Tony Perry (E-mail)
Cc: Karen Colmie Heckelman (E-mail); Katie Watson (E-mail); Stephen. C. Wood (E-mail); Davie, Robert; Redder, Jerome
Subject: SWMU 39 Decision Document, Final Aug 2005

Importance: High

All:

In the attached file is the subject document that I will present to the LTC Fizer for his signature. Note a draft document has been reviewed and approved by USACHPPM, JMC and NERO. The draft and final document are based on the final SWMU 39 RFI/CMS that was approved by the EPA Region III on June 6, 2005. The terminology used in this document is consistent with the approved RFI/CMS. In future reports RFAAP will consider alternate language.

If you have any questions or concerns please contact me at 540 639 8641.

Final SWMU 39 DD Aug 2005.doc

Jim McKenna
IMPORTANT NOTE: When replying to this message please cut and paste jim.mckenna@atk.com into the address line. Please do not hit the reply button. THIS A NEW ADDRESS. Thanks.

McKenna, Jim

From: Jennings, David M Mr NERO [david.m.jennings@us.army.mil]
Sent: Tuesday, November 16, 2004 7:48 AM
To: McKenna, Jim
Subject: RE: SWMU 39 Decision Document, staffing for review and approval

Sorry Jim, been out of the office for too much. I concur, too.

Dave

David M. Jennings
Installation Management Agency, Northeast Region
Environmental & Natural Resources Branch
SFIM-NE-PW-ER
5 North Gate Road
Fort Monroe, VA 23651-1048
(757) 788-7638
DSN: 680-7638

From: McKenna, Jim [mailto:jim.mckenna@us.army.mil]
Sent: Monday, November 15, 2004 11:32 AM
To: 'David Jennings, NERO IR'
Subject: RE: SWMU 39 Decision Document, staffing for review and approval
Importance: High

David, everyone else has concurred. Need your response. Thanks. Jim

Jim McKenna
IMPORTANT NOTE: When replying to this message please cut and paste Jim_McKenna@ATK.com into the address line. Please do not hit the reply button. Thanks.

-----Original Message-----
From: McKenna, Jim
Sent: Tuesday, November 09, 2004 10:34 AM
To: 'Jackson, Thomas'; 'Wyatt, William'; 'Williams, Keith J Mr USACHPPM'; 'David Jennings, NERO IR'
Subject: RE: SWMU 39 Decision Document, staffing for review and approval

If you got this message then I have not received your reply. Please respond with your concurrence. If you have questions or concerns please call me at 540 639 8641so we can discuss them. Thanks.

Jim McKenna
IMPORTANT NOTE: When replying to this message please cut and paste Jim_McKenna@ATK.com into the address line. Please do not hit the reply button. Thanks.

-----Original Message-----
From: McKenna, Jim
Sent: Tuesday, October 26, 2004 12:49 PM
To: Case, Joy; 'Jackson, Thomas'; 'Wyatt, William'; 'Williams, Keith J Mr USACHPPM'; 'David Jennings, NERO IR'
Cc: 'john e tesner'; Redder, Jerome; Davie, Robert

Subject: SWMU 39 Decision Document, staffing for review and approval
Importance: High

Joy, Tom, Bill, Keith, Dave:

The subject decision document is provided to you for review and approval in accordance with 9 Sep 2003 ASCIM Memorandum: Policies for Staffing and Approving Decision Documents (DD). To assist in your review and approval please note the following:

1. SWMU 39 is a site that is listed in and governed by our RCRA Corrective Action Permit. It is also in our Installation Action Plan and is eligible for ER,A funds. RFAAP is simply following the processes of both of those programs to achieve a common goal to efficiently address site risk.

2. This DD is for an action less than $2million therefore it is within the Installation Commander's signature authority. It has not been signed yet.

3. Due to karst geology underneath RFAAP source removal (i.e. clean site close out) is the preferred method to eliminate or mitigate migration of contaminants into the groundwater. Once contamination reaches the groundwater it is generally impractical to treat.

4. In addition to the industrial scenario, the residential risk scenario and related cleanup criteria was considered due to a) request from EPA, Region III and b) RFAAP's interest in assessing and evaluating the cost of clean close out versus leaving waste in place. For this site it is cost effective to remove the entire source of contamination than to leave waste in place. Note clean close out will allow RFAAP to "restore" this site to beneficial reuse whereas waste in place does not.

5. Details of the risk assessment and cleanup alternatives are provided in the SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report (RFI/CMS), Final, October 2004 and forms the basis for this DD. The SWMU 39 RFI/CMS Report has been revised to address comments from EPA and the Virginia Dept of Environmental Quality (DEQ) on the draft. As their comments have not materially changed the conclusions and/or recommendations, the SWMU 39 RFI/CMS Report has been recently resubmitted as final. Further note that USACHPPM concurred with the conclusions and recommendations contained in the draft SWMU 39 RFI/CMS Report on 9 Sep 2004. USAEC was provided the draft SWMU 39 RFI/CMS Report but heretofore has not commented on it. The final SWMU 39 RFI/CMS Report has been distributed to both USACHPPM and the USAEC.

6. Once RFAAP receives concurrence from the above addressees on this DD and receives approval from EPA and DEQ on the final SWMU 39 RFI/CMS Report, RFAAP will send the DD to USAEC for coordination per the ASCIM policy.

Please review and respond by email no later than 22 Nov 2004. If you have questions or concerns please contact me at 540 639 8641 or at the email address below. Note from 2 -4 Nov 2004, I will be out of the office attending the USAEC sponsored DERP workshop at the Hunt Valley Maryland Marriot and will not be able to access email.

Thank you in advance for your support of Radford AAP.

<< File: Draft SWMU 39 DD 26 Oct 2004.doc >>

Jim McKenna
IMPORTANT NOTE: When replying to this message please cut and paste Jim_McKenna@ATK.com into the address line. Please do not hit the reply button. Thanks.

McKenna, Jim

From: Williams, Keith J Mr USACHPPM [keith.j.williams@us.army.mil]
Sent: Friday, November 12, 2004 1:00 PM
To: McKenna, Jim
Subject: RE: SWMU 39 Decision Document, staffing for review and approval

Radford SWMU 39 Decision Docum...

Hi Jim,

Here's our draft memo. You'll get a final signed hard copy in the mail.

Keith

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Sent: Tuesday, November 09, 2004 10:34 AM
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Thank you in advance for your support of Radford AAP.

<< File: Draft SWMU 39 DD 26 Oct 2004.doc >>
>
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> Jim McKenna
> IMPORTANT NOTE: When replying to this message please cut and paste

> Jim_McKenna@ATK.com into the address line. Please do not hit the reply
> button. Thanks.

MCHB-TS-REH (40)

MEMORANDUM FOR Office of Environmental Quality (SJMRF- OP-EQ/Jim McKenna), Radford Army Ammunition Plant, PO Box 2, Radford, VA 24143-0002

SUBJECT: Final Decision Document SWMU 39 – Excavation of Soil for Clean Close Out and Off-Site Disposal, October 2004

1. The US Army Center for Health Promotion and Preventive Medicine reviewed the subject document on behalf of the Office of The Surgeon General pursuant to AR 200-1 (Environmental Protection and Enhancement). Thank you for the opportunity to review this document. One comment follows. We concur with the conclusions and recommendations contained in this report.

2. The scientist reviewing this document and our point of contact is Mr. Keith Williams, Environmental Health Risk Assessment Program, at DSN 584-7722 or commercial (410) 436-7722.

FOR THE COMMANDER:

DAVID A. REED
Program Manager
Environmental Health Risk
Assessment

CF:
HQDA (DASG-HS-PE)
USAMEDCOM (MCHO-CL-W)
USACE (CENWO-HX-H)
USAEC (SFIM-AEC-ER)

McKenna, Jim

From: Wyatt, William Mr JMC [bill.wyatt@us.army.mil]
Sent: Tuesday, November 09, 2004 11:42 AM
To: McKenna, Jim
Cc: Jackson, Thomas Mr AFSC; Wyatt, William Mr JMC
Subject: FW: SWMU 39 Decision Document, staffing for review and approval
Importance: High

Jim,

Concur w/ clean close out alt. DD.

Bill Wyatt

HQ, Joint Munitions Command, G4
Environmental Facilities Division
SFSJM-LGE
Rock Island, IL 61299-6200
DSN 793-8269; (309)782-8269
wyattw@osc.army.mil

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Thank you in advance for your support of Radford AAP.

<<Draft SWMU 39 DD 26 Oct 2004.doc>>

Jim McKenna
IMPORTANT NOTE: When replying to this message please cut and paste Jim_McKenna@ATK.com into the address line. Please do not hit the reply button. Thanks.

Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100
USA

15.

July 15, 2005

Mr. Robert Thomson
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Subject: Certification Statement for SWMU39 RCRA Facility Investigation/Corrective Measures Study Report Final Document, June 2005

Enclosed is one copy of the certification statement for SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report Final Document, June 2005. The report for the above mentioned subject was previously mailed to you by Alliant Ammunition and Powder Company LLC letter dated June 24, 2005 (ENV letter number 05-815-124).

Sincerely,

Paige N. Holt

Paige Holt, Acting Environmental Manager
Alliant Ammunition and Powder Company LLC

Enclosure

c: Russell Fish, P.E., EPA Region III

Jim Cutler
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

Durwood Willis
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

E. A. Lohman
Virginia Department of Environmental Quality
West Central Regional Office
3019 Peters Creek Road
Roanoke, VA 24019

Tony Perry
U.S. Army Environmental Center
5179 Hoadley Road, Attn: SFIM-AEC-CDN
Aberdeen Proving Ground, MD 21010-5401

Karen Colmie Heckelman
U.S. Army Environmental Center, Office of Counsel
Beal Road, Bldg E4460
Aberdeen Proving Ground, MD 21010-5401

05-815-133
JMcKenna/JJRedder

Dennis Druck
U.S. Army Center for Health Promotion and Preventive Medicine
5158 Blackhawk Road, Attn: MCHB-TS-REH
Aberdeen Proving Ground, MD 21010-5403

Steve Wood
Corps of Engineers, Baltimore District
ATTN: CENAB-EN-HM
10 South Howard Street
Baltimore, MD 21201

bc: Administrative File
J. McKenna, ACO Staff
Rob Davie-ACO Staff
P. W. Holt
J. J. Redder
Env. File

Coordination:
J. McKenna
M. A. Miano

05-815-133
JMcKenna/JJRedder

Concerning the following:

SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report
Final Document, June 2005
Radford Army Ammunition Plant

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

SIGNATURE: Anthony R. Skinner 7/15/05
PRINTED NAME: Anthony R. Skinner
TITLE: LTC, CM, Commanding
Radford AAP

SIGNATURE: K Dolph 7-18-05
PRINTED NAME: Ken Dolph
TITLE: Vice President Operations
Alliant Ammunition and Powder Company LLC

05-815-133
JMcKenna/JJRedder

Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100
USA

June 24, 2005

Mr. Robert Thomson
U. S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Subject: SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report Final Document, June 2005
Radford Army Ammunition Plant
EPA ID# VA1 210020730

Dear Mr. Thomson:

Enclosed is one copy of SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report Final Document, June 2005 Radford Army Ammunition Plant. It has been revised per the conditions set forth in your letter of June 6, 2005 and therefore we consider it to be approved. The certification and your additional two copies will be sent under separate cover as well as additional copies to the Virginia Department of Environmental Quality (VDEQ), U.S. Army Environmental Center, U.S. Army Center for Health Promotion and Preventive Medicine. Please coordinate with and provide any questions or comments to myself at (540) 639-8658, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

Paige Holt, Acting Environmental Manager
Alliant Ammunition and Powder Company LLC

Enclosure

w/o enclosure

c: Russell Fish, P.E., EPA Region III

Jim Cutler
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

Durwood Willis
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

E. A. Lohman
Virginia Department of Environmental Quality
West Central Regional Office
3019 Peters Creek Road
Roanoke, VA 24019

05-815-124
JMcKenna/JJRedder

Tony Perry
U.S. Army Environmental Center
5179 Hoadley Road, Attn: SFIM-AEC-CDN
Aberdeen Proving Ground, MD 21010-5401

Karen Colmie Heckelman
U.S. Army Environmental Center, Office of Counsel
Beal Road, Bldg E4460
Aberdeen Proving Ground, MD 21010-5401

Dennis Druck
U.S. Army Center for Health Promotion and Preventive Medicine
5158 Blackhawk Road, Attn: MCHB-TS-REH
Aberdeen Proving Ground, MD 21010-5403

Steve Wood
Corps of Engineers, Baltimore District
ATTN: CENAB-EN-HM
10 South Howard Street
Baltimore, MD 21201

bc: Administrative File
J. McKenna, ACO Staff
Rob Davie-ACO Staff
P. W. Holt
J. J. Redder, w/encl
Env. File

Coordination:

J. McKenna

M. A. Miano

05-815-124
JMcKenna/JJRedder

Rec'd ENV 6-14-05 C. Poet Ledder McKenna ENV file

05-69

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

June 6, 2005

In reply
Refer to 3HS11

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Commander,
Radford Army Ammunition Plant
Attn: SIORF-SE-EQ (Jim McKenna)
P.O. Box 2
Radford, VA 24141-0099

C.A. Jake
Environmental Manager
Alliant Techsystems, Inc.
Radford Army Ammunition Plant
P.O. Box 1
Radford, VA 24141-0100

Re: Radford Army Ammunition Plant
SWMU 39
Unlined earthen settling ponds
Draft *RFI/CMS*
Review of Army's May 3, 2005 response to EPA's 4/25/05 letter

Dear Mr. McKenna and Ms. Jake:

The U.S. Environmental Protection Agency (EPA) has reviewed the U.S. Army's (Army's) May 3, 2005 response to EPA's April 25, 2005 letter regarding the review of the Army's April, 2004 draft *RCRA Facility Investigation/Corrective Measures Study* (RFI/CMS) for the investigation of SWMU 39, located at the Radford Army Ammunition Plant (RFAAP). Based upon that review, we find the Army's response to be acceptable. In accordance with Part II. (E)(5) of RFAAP's Corrective Action Permit, the *RFI/CMS* can be finalized.

Please make the appropriate revisions to the draft *RFI/CMS* based upon the Army's response, and proceed to finalize the *RFI/CMS*. Please forward two complete copies of the final *RFI/CMS* for the investigation of SWMU 39 to EPA for insertion into the project files.

If you have any questions, please call me at 215-814-3357.

Sincerely,

Robert Thomson, PE, REM
Office of Federal Facility Remediation and Site Assessment

cc: Russell Fish, EPA
Leslie Romanchik, VDEQ-RCRA
James Cutler, VDEQ-CERCLA

Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100
USA

May 3, 2005

Mr. Robert Thomson
U. S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Subject: SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report
Final Document, October 2004
Radford Army Ammunition Plant
EPA ID# VA1 210020730

Dear Mr. Thomson:

Providing this response to your April 25, 2005 letter on the subject report. Per your May 2, 2005 email to Mr. Jim McKenna, use of the PROUCL methodology is not required for this report as it was not included under approved Work Plan Addendum No. 12 that contained this site. We agree to use the PROUCL methodology in future work plan addenda and to revise the Master Work Plan to reflect this. At present it appears that Work Plan Addendum No. 19 represents the first opportunity to incorporate PROUCL.

Please coordinate with and provide any questions or comments to myself at (540) 639-8266, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

C. A. Jake, Environmental Manager
Alliant Ammunition and Powder Company LLC

c: Russell Fish, P.E., EPA Region III

Jim Cutler
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

Durwood Willis
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

E. A. Lohman
Virginia Department of Environmental Quality
West Central Regional Office
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Roanoke, VA 24019

05-815-97
JMcKenna/JJRedder

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U.S. Army Environmental Center
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Aberdeen Proving Ground, MD 21010-5401

Karen Colmie Heckelman
U.S. Army Environmental Center, Office of Counsel
Beal Road, Bldg E4460
Aberdeen Proving Ground, MD 21010-5401

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Aberdeen Proving Ground, MD 21010-5403

Steve Wood
Corps of Engineers, Baltimore District
ATTN: CENAB-EN-HM
10 South Howard Street
Baltimore, MD 21201

Coordination: J. McKenna

bc: Administrative File
J. McKenna, ACO Staff
Rob Davie-ACO Staff
C. A. Jake
J. J. Redder
Env. File

05-815-97
JMcKenna/JJRedder

Redder, Jerome

From:	Thomson.Bob@epamail.epa.gov
Sent:	Monday, May 02, 2005 12:41 PM
To:	McKenna, Jim
Cc:	Redder, Jerome; Cutler,Jim
Subject:	Fw: List of prior year reports with approved WPAs that don't incorporate PROUCL

Please see the attached below from the EPA tox on the use of PROUCL.

Rob

----- Forwarded by Bob Thomson/R3/USEPA/US on 05/02/2005 12:39 PM -----

Nancy Rios-Jafolla/R3/USEPA/US
05/02/2005 11:59 AM

To: Bob Thomson/R3/USEPA/US@EPA
cc: Paul Leonard/R3/USEPA/US@EPA
Subject: Re: Fw: List of prior year reports with approved WPAs that don't incorporate PROUCL(Document link: Bob Thomson)

Bob,

Yes! This is okay!!
-----Bob Thomson/R3/USEPA/US wrote: -----

To: Nancy Rios-Jafolla/R3/USEPA/US@EPA
From: Bob Thomson/R3/USEPA/US
Date: 05/02/2005 09:13AM
cc: Paul Leonard/R3/USEPA/US@EPA
Subject: Fw: List of prior year reports with approved WPAs that don't incorporate PROUCL

Nancy:

There are a number of approved Work Plans for the Radford Army Ammunition Plant that do not include the requirement to utilize PROUCL.

WBG, IAA & BLA, single reports for the BDDT and RY respectively. Note we have already submitted the RY RI Report.
(WPA 12 also included the Bldg 4343 RFI/CMS Report and the SWMU 58 RFI Report which EPA/DEQ has approved. The SWMU 39 RFI/CMS report was included in WPA 12 as well. It has been submitted/reviewed/commented/responded, etc.)
3. Work Plan Addendum #13, SMWU 54 RFI/CMS
4. Work Plan Addendum #14, SWMU 40/71 RFI/CMS
5.Work Plan Addendum #17, SWMU 51 RFI/CMS
6. Work Plan Addendum #18, SWMU 41 RFI/CMS

Jim McKenna
IMPORTANT NOTE: When replying to this message please cut and paste Jim_McKenna@ATK.com into the address line. Please do not hit the reply button. Thanks.

McKenna, Jim

`-om: Thomson.Bob@epamail.epa.gov
nt: Monday, May 02, 2005 11:41 AM
.o: McKenna, Jim
Cc: Redder, Jerome; Cutler,Jim
Subject: Fw: List of prior year reports with approved WPAs that don't incorporate PROUCL

Please see the attached below from the EPA tox on the use of PROUCL.

Rob

----- Forwarded by Bob Thomson/R3/USEPA/US on 05/02/2005 12:39 PM -----

Nancy Rios-Jafolla/R3/USEPA/US
05/02/2005 11:59 AM

To: Bob Thomson/R3/USEPA/US@EPA
cc: Paul Leonard/R3/USEPA/US@EPA
Subject: Re: Fw: List of prior year reports with approved WPAs that don't incorporate PROUCL(Document link: Bob Thomson)

Bob,

Yes! This is okay!!
-----Bob Thomson/R3/USEPA/US wrote: -----

To: Nancy Rios-Jafolla/R3/USEPA/US@EPA
From: Bob Thomson/R3/USEPA/US
Date: 05/02/2005 09:13AM
cc: Paul Leonard/R3/USEPA/US@EPA
Subject: Fw: List of prior year reports with approved WPAs that don't incorporate PROUCL

Nancy:

There are a number of approved Work Plans for the Radford Army Ammunition Plant that do not include the requirement to utilize PROUCL. Work is ongoing under these Work Plans. There has been a request by the Army to let the work under these approved Work Plans go forward without utilizing PROUCL, with the understanding that future Work Plans, along with the Master Work Plan, will be modified to include the requirement to utilize PROUCL.

`s this okay with you???

Thanks....Rob Thomson

----- Forwarded by Bob Thomson/R3/USEPA/US on 05/02/2005 09:09 AM -----

"McKenna, Jim" <Jim.McKenna@atk.com>
04/29/2005 04:18 PM

To: Bob Thomson/R3/USEPA/US@EPA

cc: "Redder, Jerome" <Jerome.Redder@atk.com>, "Jim Cutler (E-mail)" <jlcutler@deq.virginia.gov>

Subject: List of prior year reports with approved WPAs that don't incorporate PROUCL

Rob,
Per our conversation per the IAP workshop this week below is the subject list. Note the Work Plan Addenda did not propose using PROUCL and the fieldwork is complete, data validated, reports have been drafted but have not been submitted to EPA yet.
1. Work Plan Addenda #9, SWMU 31 RFI
2. Work Plan Addenda #12, SWMUs 48, 49, 50, 58, 59, AOC Former Lead Furnace Area, New River Unit.
Note the NRU is comprised of six areas: Northern Burning Ground, Western Burning Ground, Building Debris Disposal Trench, Igniter Assembly Area, Bag Loading Area, Rail Yard. We are anticipating four Remedial Investigation/Feasibility Study Reports grouping the NBG & WBG, IAA & BLA, single reports for the BDDT and RY respectively. Note we have already submitted the RY RI Reportl.
(WPA 12 also included the Bldg 4343 RFI/CMS Report and the SWMU 58 RFI Report which EPA/DEQ has approved. The SWMU 39 RFI/CMS report was included in WPA 12 as well. It has been submitted/reviewed/commented/responded, etc.)
3. Work Plan Addendum #13, SMWU 54 RFI/CMS
4. Work Plan Addendum #14, SWMU 40/71 RFI/CMS
5.Work Plan Addendum #17, SWMU 51 RFI/CMS
6. Work Plan Addendum #18, SWMU 41 RFI/CMS

Jim McKenna
IMPORTANT NOTE: When replying to this message please cut and paste Jim_McKenna@ATK.com into the address line. Please do not hit the reply button. Thanks.

Rec'd Env 4-29-05

05-52

cc: Jake
Kellen
Mellenan
Env file

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

April 25, 2005

In reply
Refer to 3HS13

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Commander,
Radford Army Ammunition Plant
Attn: SIORF-SE-EQ (Jim McKenna)
P.O. Box 2
Radford, VA 24141-0099

C.A. Jake
Environmental Manager
Alliant Techsystems, Inc.
Radford Army Ammunition Plant
P.O. Box 1
Radford, VA 24141-0100

Re: Radford Army Ammunition Plant
SWMU 39
Unlined earthen settling ponds
Draft *RFI/CMS*
Review of Army's March 15, 2005 response to EPA's 2/9/05 letter

Dear Mr. McKenna and Ms. Jake:

The U.S. Environmental Protection Agency (EPA) has reviewed the U.S. Army's (Army's) March 15, 2005 response to EPA's February 9, 2005 letter regarding the review of the Army's April, 2004 draft *RCRA Facility Investigation/Corrective Measures Study* (RFI/CMS) for the investigation of SWMU 39, located at the Radford Army Ammunition Plant (RFAAP). Outlined below, please find EPA's comments based upon that review:

1. **Comment 16** (EPA Comment 2) EPA does not agree with the Army's response. The spreadsheet should use the same methodology used in the PROUCL. Additionally, it is recommended that the risk assessment work plan for the RFAAP site be updated to reflect current EPA guidance and procedures for future risk assessments.

This concludes EPA's review of the Army's March 15, 2005 response to EPA's February 9, 2005 letter regarding the review of the Army's April, 2004 draft *RFI/CMS* for the investigation of SWMU 39, located at the RFAAP. All remaining Army responses not included in the above comments have been satisfactorily addressed.

The referenced draft *RFI/CMS* is disapproved by EPA in its current form, and must be revised to reflect the comments above. Per Part II, Section E.4.e. of the EPA RCRA Corrective Action Permit, the Army is required to revise the draft document and submit a revised draft copy to EPA for review within 60 days of the receipt of EPA comments on the draft document. Part II, Section E.4.f. of the Permit allows for an additional 20 days for issuing the revised draft document to EPA, provided that timely notice is given, i.e. within 10 days. Additional time extensions can be requested under Part II, Section F. of the permit.

If you have any questions, please call me at 215-814-3357.

Sincerely,

Robert Thomson, PE, REM
Federal Facilities Branch

cc: Russell Fish, EPA
Leslie Romanchik, VDEQ-RCRA
James Cutler, VDEQ-CERCLA

McKenna, Jim

From: Thomson.Bob@epamail.epa.gov
Sent: Monday, April 04, 2005 10:26 AM
To: McKenna, Jim
Subject: RFAAP Conference call

Jim:

For April, I will only be in the Philadelphia office four days, and they are already "booked up". Additionally, the EPA technical reviewers who need to look over the Army's responses will not have completed their reviews until May. I suggest we discuss the availability of a conference call during the IAP workshop.

Rob

McKenna, Jim

From: McKenna, Jim
Sent: Thursday, March 24, 2005 7:30 AM
To: rob thomson (E-mail)
Cc: Willis,Durwood; Eng,Sherri; Thomson.Bob@epamail.epa.gov; Stephen. C. Wood (E-mail); Redder, Jerome; Parks Jeffrey N (E-mail); jim spencer (E-mail); Jim Cutler (E-mail); Davie, Robert
Subject: RE: RAAP conf. call
Importance: High

Rob,

We have a number of substantive issues to cover from our March 15, 2005 SWMU 39 and NRU Rail Yard letters and I believe it best handled by a conference call. Therefore please send us your availability. We need to get a handle on these issues prior to the IAP workshop which is fast approaching. Considering Jim Cutler's availability I recommend April 11th or 12th. Please reply to every one addressed on this email so we can get the ball rolling on setting up this call. Thanks.

FYI for those of you who may not receive my out of office message: I will be on leave tomorrow, Friday March 25, 2005 and TDY Tuesday and Wednesday March 29 & 30, 2005. On the afternoon of Tue. March 29 I can be reached through Jeff Parks, Shaw at 410 612 6326 and on Wed. March 30 through Steve Wood 410 962 4874 at the Baltimore District.

Jim McKenna
IMPORTANT NOTE: When replying to this message please cut and paste Jim_McKenna@ATK.com into the address line. Please do not hit the reply button. Thanks.

> -----Original Message-----
> **From:** Cutler,Jim [mailto:jlcutler@deq.virginia.gov]
> **Sent:** Wednesday, March 23, 2005 3:11 PM
> **To:** McKenna, Jim
> **Cc:** Willis,Durwood; Eng,Sherri; Thomson.Bob@epamail.epa.gov; Stephen. C. Wood (E-mail); 'Jerome
> **Subject:** RAAP conf. call
>
> Jim,
>
> DEQ is currently available April 11,12,13,15 and possibly April 8 for a conference call to discuss issues related to the latest response to comments per your March 17 letter.
>
> James L. Cutler Jr.
> Federal Facilities Project Manager
> Office of Remediation Programs
> Virginia Dept. of Environmental Quality
> 804-698-4498

Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100
USA

March 15, 2005

Mr. Robert Thomson
U. S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Subject: SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report
Final Document, October 2004
Radford Army Ammunition Plant
EPA ID# VA1 210020730

Dear Mr. Thomson:

Enclosed are Radford Army Ammunition Plant (RFAAP) responses to the comments contained in your letter dated February 9, 2005 on the subject report. Several review comments continue to be made although RFAAP has provided what we believe is adequate rationale that supports our original conclusions and recommendations. In our attached response, we reiterate our position with additional information that discusses the impact that specific comments will have on this report as well as other reports yet to be submitted. After you have had the opportunity to review them we recommend we have a conference call to resolve them prior to report revision. During this call we can also discuss the timeframe for our response. We strongly recommend to hold this call prior to the RFAAP Installation ·tion Workshop scheduled for April 27-28, 2005.

. ease coordinate with and provide any questions or comments to myself at (540) 639-8266, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

C. A. Jake, Environmental Manager
Alliant Ammunition and Powder Company LLC

Enclosure

w/o enclosure

c: Russell Fish, P.E., EPA Region III

w/enclosure

Jim Cutler
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

05-815-63
JMcKenna/JJRedder

Durwood Willis
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

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U.S. Army Center for Health Promotion and Preventive Medicine
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Coordination: J. McKenna

bc: Administrative File
J. McKenna, ACO Staff
Rob Davie-ACO Staff
C. A. Jake
J. J. Redder
Env. File

05-815-63
JMcKenna/JJRedder

Response to USEPA Comments dated 09 February 2005
for
Final SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report
October 2004

EPA Comment 1
Comment 9: EPA's review stated that the pH of the surface soil in the northern settling basin was 4.0, and the potential ecological impacts from the low pH should be evaluated. The Army's response states that the Report would discuss potential impacts to plants and invertebrates from this low pH soil. However, neither Section 4.2 nor Section 7.7.1 of the Report have any discussion regarding potential impacts from low pH.

RFAAP Response
During the revision of the document, the requested discussion was inserted into Section 7.1.4, as the more appropriate section.

EPA Comment 2
Comment 16: It was agreed that a separate spreadsheet can be used to calculate the UCL. However, the spreadsheet should use the same methodology used in the PROUCL. Refer to the PROUCL Users Manual and the UCL guidance (EPA 2002). Note that the bootstrap method is just one of many non-parametric methods used in the PROUCL to calculate the UCL for data that are not normally distributed.

RFAAP Response
At the outset of the project (WPAs 9 and 12, September 2002), the new UCL guidance and ProUCL software were reviewed. Although an early version of the software was obtained, it did not function properly. At that time, calculation spreadsheets were developed specifically for RFAAP. These spreadsheets have been linked to other RAGS, Part D spreadsheets for efficiency.

Use of our existing spreadsheets would maintain consistency in UCL calculations throughout the project. It should be noted that our process does follow UCL guidance, except for the number of non-parametric methods employed in the calculations. To date, four sites have been reviewed by USEPA (Building 4343, SWMU 58, SWMU 39, and the New River Unit Rail Yard). The RFIs for two of these (Building 4343 and SWMU 58) have been approved by USEPA. In addition, we have completed internal draft HHRAs and SLERAs for 12 additional RFAAP sites (SWMUs 31, 51, 48, 49, 50, 59, Former Lead Furnace Area, NRU areas: Building Debris Disposal Trench, Igniter Assembly Area, Bag Loading Area, Northern Burning Ground, Western Burning Ground,) that have not yet been submitted to USEPA. The effort involved in re-running the statistics for each site would amount to approximately 10 hours per site. Moreover, potential changes in 95% UCL values (used as EPCs in the risk calculations) would result in a "ripple effect" throughout the RAGS, Part D tables and the SLERAs. The effort required to re-run the risk calculations, revise the tables, and revise the text for both the HHRA and SLERA would be approximately 60 hours per site at a cost of approximately $6,000.00. Therefore to implement this comment for the above 15 sites that are under

contract to Shaw Environmental would require an additional 900 hours of effort at a cost of $90,000. Considering the ongoing effort at the three sites under contract to URS Corporation (SWMUs 40/71, 41, 54) represents an additional 180 hours of effort at a cost of approximately $18,000. Note the contractors' current operating budgets do not include this effort so additional funds if available would need to be programmed during the next IAP workshop. Assuming the funds will be available, the reprogramming could be accomplished during the April 2005 IAP workshop, but procurement of this additional effort realistically could not happen before FY06 thus delaying these reports for over a year. RFAAP does not believe that there is enough value added in switching the process at this time to justify the additional effort, cost and impact to schedules.

We have reviewed the *User Guide* for ProUCL Version 3.0 (dated April 2004). One limitation of the ProUCL software is stated in the Executive Summary, page xiii and Section F, page 57 of the *User Guide*:

"ProUCL does not handle left-censored data sets with non-detects, which are inevitable in many environmental applications. All parametric as well as non-parametric recommendations (as summarized in Tables 1 through 3 of the *User Guide*) to compute the mean, standard deviation, and 95% UCLs and all other statistics computed by ProUCL are based upon full data sets without censoring. It should be noted that for a mild or moderate number of non-detects (e.g., 15%), one may use the commonly used ½ detection limit (DL) proxy method to compute various statistics. However, the proxy methods should be used cautiously, especially when one is dealing with lognormally distributed data sets. For lognormally distributed data sets of small sizes, even a single value – small (e.g., obtained after replacing the non-detects by ½ DL) or large (e.g., an outlier) can have a drastic influence (can yield an unrealistically large 95% UCL) on the value of Land's 95% UCL. The issue of estimating the mean, standard deviation, and appropriate 95% UCL of the mean based upon left-censored data sets with varying degrees of censoring (e.g., 15%-50%, 50% to 75%, greater than 75%, etc.) is currently under investigation."

Because our data sets at RFAAP frequently have percentages of non-detects greater than 15% for some COPCs, we use ½ the reporting limit (RL) to represent the non-detect results. If we were to use the ProUCL software, the above limitation would contribute to the uncertainty involved in estimating exposure point concentrations (EPCs) for our risk assessments.

To confirm that the two methods are similar, we compared the 95% UCLs for SWMU 39 generated by ProUCL and by our spreadsheets. With some exceptions, our spreadsheets generated 95% UCL values that were either similar or more conservative than those computed by ProUCL. (Note that ½ the RL was used as the proxy value for non-detect results). For the HHRA (**Attachment 1**), the EPCs selected from ProUCL were greater than those from our spreadsheets for two out of ten COPCs in surface soil and three out of ten COPCs for total soil. For the SLERA (**Attachment 2**), the EPCs selected from ProUCL were greater than those from our spreadsheets for six out of 24 COPECs for surface soil.

We will continue to use the calculation spreadsheets that were specifically developed for the RFAAP project. At this point in the project we do not believe that changing the software or developing additional calculations adds value to the HHRA or the SLERA. Based on the above comparison between 95% UCLs generated by ProUCL and our spreadsheets, the use of ProUCL would not change the conclusions of the original risk assessment.

EPA Comment 3

Comment 17: The uncertainty in using a PEF for an industrial facility to calculate risk for a residential facility should be discussed in the Report. For example, discuss the impact on the final risk when using a PEF based on 3 acres vs. 0.5 acres.

RFAAP Response

The sampling and analysis program for SWMU 39 was designed to characterize the 2.6-acre site. The Q/C values from the *Soil Screening Level* (SSL) guidance are presented by source area, city, and climatic zone. References to the Q/C in this document are to "source area" and "site size". Thus, the 2.6-acre area was considered to be the source area for purposes of the PEF calculation.

Because the source area is larger than 0.5 acres used to represent residential lot and there were no plans for residential development, the sampling program was not designed to address 0.5-acre subareas or to define exposures areas for residential lots (as described in Section 4.1.4 of the SSL guidance). To address this uncertainty, we will assume that the sampling performed in the 2.6-acre area at the SWMU 39 is representative of concentrations in any one subarea of the site and use the Q/C term associated with a 0.5 acre area to calculate the PEF. This comparison will be discussed in the uncertainty section (Section 5.5) of the HHRA. This approach will also be used in subsequent HHRAs at RFAAP.

EPA Comment 4

Comment 20: EPA stated that it was unclear why this pre-screen is being performed to identify contaminants of potential ecological concern (COPEC) for food chain modeling in the screening ecological risk assessment (ERA), particularly when several screening values used to evaluate food chain effects are based on effects to earthworms and plants. The EPA BTAG recommended that food chain modeling be performed on all detected chemicals that have the potential to bioaccumulate. The Army's response states that this approach is conservative since the earthworm and plant screening values were lower than food chain values, and the list of bioaccumulative chemicals recommended by the EPA BTAG is applicable to sediment only. It must be noted the identified chemicals are considered to be bioaccumulative regardless of the media in which they are found. The list of bioaccumulative chemicals is also applicable to soil, and therefore, the same list should be used to evaluate food chain risks to terrestrial receptors. The EPA BTAG recommends that future risk assessments not use this pre-screen, and food chain modeling be performed on all bioaccumulative chemicals.

RFAAP Response

The list of "bioaccumulative chemicals" recommended by BTAG (that is based on an EPA document for sediment) does not, in fact, include all chemicals that may bioaccumulate in the terrestrial food chain. As shown in the SLERA, some chemicals not on the "bioaccumulative chemical" list (e.g., cobalt and thallium) are shown to bioaccumulate in plants, invertebrates. and/or small mammals/birds.

However, given BTAG's repeated objections on the use of the "prescreen," and due to a desire to expedite Agency acceptance of future SLERAs, the use of the prescreen will be eliminated for the food chain model and only "bioaccumulative chemicals" (as defined in the USEPA sediment guidance) will be included. Note that this change in the SLERA approach will only be initiated for future risk assessments that have not been already drafted by the contractor (i.e., SLERAs drafted to date include all sites from WPAs 9 and 12).

EPA Comment 5

Comment 21: EPA stated that based on a high level of uncertainty, either a baseline ecological risk assessment needed to be performed or ecologically-based remediation goals needed to be developed. The Army's response states that because the former lagoons will be filled with over two feet of clean soil, this will eliminate or reduce several ecological pathways. While the EPA BTAG still believes that there is considerable uncertainty whether cleaning up to human health criteria will be protective of all ecological receptors, placement of at least two feet of clean soil in the lagoons should reduce ecological exposure and risks to acceptable levels. However, the EPA BTAG recommends that the soil in the lagoons be limed to raise pH as discussed in the response to Comment 9 to reduce mobility of metals in the soil and reduce bioavailability to plants and other ecological receptors that may use deeper subsurface soils.

RFAAP Response

Since the soil with the low pH is proposed for removal, the document will be revised to indicate that six (three in each lagoon) post excavation samples will be collected and analyzed for pH. If the samples indicate low pH, lime will be added to the excavation prior to back filling.

We must point out that many of the uncertainties raised by the reviewers are created by using inexact techniques that we are required to use. Further we recognize that a Human Health Risk Assessment and a Screening Level Ecological Risk Assessment are not exact. Throughout the reports RAAP discusses the uncertainties of using the data, the assumptions, and the models. Since in most instances the most conservative, in fact overly conservative, inputs are used in the modeling and calculations, there may be uncertainty whether they estimate the true risk, but it is certain that if they don't it's because they consistently and dramatically over-estimate the real risk from the site. For this reason we do not feel the additional effort and expense is value added to perform either a baseline ecological risk assessment or to develop ecologically-based remediation goals.

Attachment 1
Comparison of ProUCL and RISK2000 UCL-Based Exposure Point Concentrations Used in the SWMU 39 HHRA

Exposure Point	Chemical of Potential Concern	Maximum Concentration (Qualifier)	ProUCL Exposure Point Concentration [1]			Risk 2000 Exposure Point Concentration [2]		
			Value	Units	Statistic	Value	Units	Statistic
Surface Soil (0-2')	TCDD-RME	2.07E-05	2.89E-05[3]	mg/kg	Approx. Gamma	2.07E-05	mg/kg	Max
	Aluminum	37400	25216	mg/kg	Student-t	25800	mg/kg	95%UCL-T
	Arsenic	7.26	4.1	mg/kg	Student-t	5.4	mg/kg	95%UCL-T
	Chromium	95.1	45.9	mg/kg	Approx. Gamma	46.8	mg/kg	95%UCL-T
	Copper	375	**351.8**	mg/kg	99% Chebyshev	117.7	mg/kg	95%UCL-BST
	Iron	52800	34557.9	mg/kg	Student-t	35207.2	mg/kg	95%UCL-T
	Lead	16500	10667.5	mg/kg	99% Chebyshev	12841.9	mg/kg	95%UCL-T
	Manganese	1380	689.4	mg/kg	Approx. Gamma	811.7	mg/kg	95%UCL-T
	Thallium	22.7	**17.0**	mg/kg	99% Chebyshev	4.3	mg/kg	95%UCL-BST
	Vanadium	92.7	63.2	mg/kg	Student-t	63.2	mg/kg	95%UCL-N
Total Soil (0-10')	TCDD-RME	2.07E-05	1.36E-05	mg/kg	Approx. Gamma	2.07E-05	mg/kg	Max
	Aluminum	37400	24904.3	mg/kg	Student-t	25200	mg/kg	95%UCL-T
	Arsenic	7.26	3.8	mg/kg	Approx. Gamma	4.3	mg/kg	95%UCL-T
	Chromium	95.1	42.4	mg/kg	Approx. Gamma	42.6	mg/kg	95%UCL-T
	Copper	375	**146.4**	mg/kg	95% Chebyshev	89.3	mg/kg	95%UCL-BST
	Iron	52800	33794.8	mg/kg	Student-t	34156.2	mg/kg	95%UCL-T
	Lead	16500	**7350.8**	mg/kg	99% Chebyshev	1710	mg/kg	95%UCL-BST
	Manganese	1380	572.3	mg/kg	Approx. Gamma	618.6	mg/kg	95%UCL-T
	Thallium	22.7	**11.8**	mg/kg	99% Chebyshev	3.1	mg/kg	95%UCL-BST
	Vanadium	92.7	63.1	mg/kg	Student-t	63.1	mg/kg	95%UCL-N

[1] ProUCL EPC UCL Statistics: Student's-t 95% UCL (Student-t); Approximate Gamma 95% UCL (Approx. Gamma); Chebyshev 95% UCL (95% Chebyshev); Chebyshev 99% UCL (99% Chebyshev).

[2] Risk 2000 EPC UCL Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); 95% UCL based on bootstrap statistic (95% UCL-Bst)

[3] Calculated ProUCL EPC value exceeds maximum detected concentration (MDC). The MDC would be selected as the EPC for the risk assessment.

NOTES:

Bold values indicate the ProUCL estimated EPC exceeds the Risk 2000 estimated EPC.

Non-detects: 1/2 detection limit was used for all NDs.

All bootstrap calulations use 5000 iterations.

mg/kg = milligram per kilogram.

Attachment 2
Comparison of ProUCL and RISK2000 UCL-Based Exposure Point Concentrations Used in the SWMU 39 SLERA

Exposure Point	Chemical of Potential Concern	Maximum Concentration (Qualifier)	ProUCL Exposure Point Concentration [1]			Risk 2000 Exposure Point Concentration [2]		
			Value	Units	Statistic	Value	Units	Statistic
Surface Soil (0-2')	TCDD-RME	2.07E-05	2.89E-05[3]	mg/kg	Approx. Gamma	2.07E-05	mg/kg	Max
	2,4-Dinitrotoluene	0.233	0.184	mg/kg	Student-t	0.202	mg/kg	95%UCL-Bst
	Diethylphthalate	0.059	0.201[3]	mg/kg	Student-t	0.059	mg/kg	Max
	Di-n-butyl phthalate	0.5225	**0.506**	mg/kg	97.5% Chebyshev	0.281	mg/kg	95%UCL-N
	Endrin	0.00379	N/R[4]	mg/kg	—	0.00379	mg/kg	Max
	Endrin aldehyde	0.000681	N/R[4]	mg/kg	—	0.000681	mg/kg	Max
	Endrin ketone	0.00282	N/R[4]	mg/kg	—	0.00282	mg/kg	Max
	Nitroglycerin	19.8	43.2[3]	mg/kg	99% Chebyshev	19.8	mg/kg	Max
	Aluminum	37400	25216	mg/kg	Student-t	25800	mg/kg	95%UCL-T
	Antimony	1.4	3.3[3]	mg/kg	97.5% Chebyshev	1.4	mg/kg	Max
	Beryllium	1.4	1.05	mg/kg	Student-t	1.05	mg/kg	95%UCL-N
	Chromium	95.1	45.9	mg/kg	Approx. Gamma	46.8	mg/kg	95%UCL-T
	Cobalt	29	17.9	mg/kg	Approx. Gamma	18.2	mg/kg	95%UCL-T
	Copper	375	**351.8**	mg/kg	99% Chebyshev	117.7	mg/kg	95%UCL-BST
	Iron	52800	34557.9	mg/kg	Student-t	35207.2	mg/kg	95%UCL-T
	Lead	16500	10667.5	mg/kg	99% Chebyshev	12841.9	mg/kg	95%UCL-T
	Manganese	1380	689.4	mg/kg	Approx. Gamma	811.7	mg/kg	95%UCL-T
	Mercury	0.102	0.061	mg/kg	Approx. Gamma	0.062	mg/kg	95%UCL-T
	Nickel	38.1	24.0	mg/kg	Approx. Gamma	24.0	mg/kg	95%UCL-T
	Selenium	1.2	**0.734**	mg/kg	95% Chebyshev	0.620	mg/kg	95%UCL-Bst
	Silver	1.35	**0.970**	mg/kg	95% Chebyshev	0.597	mg/kg	95%UCL-Bst
	Thallium	22.7	**17.0**	mg/kg	99% Chebyshev	4.3	mg/kg	95%UCL-BST
	Vanadium	92.7	63.2	mg/kg	Student-t	63.2	mg/kg	95%UCL-N
	Zinc	301	**120.0**	mg/kg	Modified-t	110.9	mg/kg	95%UCL-Bst

[1] ProUCL EPC UCL Statistics: Student's-t 95% UCL (Student-t); Modified-t 95% UCL, adjusted for skewness (Modified-t); Approximate Gamma 95% UCL (Approx. Gamma); Chebyshev 95% UCL (95% Chebyshev); Chebyshev 97.5% UCL (97.5% Chebyshev); Chebyshev 99% UCL (99% Chebyshev).
[2] Risk 2000 EPC UCL Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); 95% UCL based on bootstrap statistic (95% UCL-Bst).

[3] Calculated ProUCL EPC value exceeds maximum detected concentration (MDC). The MDC would be selected as the EPC for the risk assessment.

[4] N/R: ProUCL does not recommend a UCL.

NOTES:

Bold values indicate the ProUCL estimated EPC exceeds the Risk 2000 estimated EPC.

Non-detects: 1/2 detection limit was used for all NDs.

All bootstrap calulations use 5000 iterations.

mg/kg = milligram per kilogram.

65.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

February 9, 2005

In reply
Refer to 3HS13

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Commander,
Radford Army Ammunition Plant
Attn: SIORF-SE-EQ (Jim McKenna)
P.O. Box 2
Radford, VA 24141-0099

C.A. Jake
Environmental Manager
Alliant Techsystems, Inc.
Radford Army Ammunition Plant
P.O. Box 1
Radford, VA 24141-0100

Re: Radford Army Ammunition Plant
SWMU 39
Unlined earthen settling ponds
Draft *RFI/CMS*
Review of Army's October 2004 response to EPA's 9/8/04 letter

Dear Mr. McKenna and Ms. Jake:

The U.S. Environmental Protection Agency (EPA) has reviewed the U.S. Army's (Army's) October 2004 response to EPA's September 8, 2004 letter regarding the review of the Army's April, 2004 draft *RCRA Facility Investigation/Corrective Measures Study* (RFI/CMS) for the investigation of SWMU 39, located at the Radford Army Ammunition Plant (RFAAP). Outlined below, please find EPA's comments based upon that review:

1. **Comment 9** EPA's review stated that the pH of the surface soil in the northern settling basin was 4.0, and the potential ecological impacts from the low pH should be evaluated. The Army's response states that the Report would discuss potential impacts to plants and invertebrates from this low pH soil. However, neither Section 4.2 nor

Section 7.7.1 of the Report have any discussion regarding potential impacts from low pH.

2. **Comment 16.** It was agreed that a separate spreadsheet can be used to calculate the UCL. However, the spreadsheet should use the same methodology used in the PROUCL. Refer to the PROUCL Users Manual and the UCL guidance (EPA 2002). Note that the bootstrap method is just one of many non-parametric methods used in the PROUCL to calculate the UCL for data that are not normally distributed.

3. **Comment 17.** The uncertainty in using a PEF for an industrial facility to calculate risk for a residential facility should be discussed in the Report. For example, discuss the impact on the final risk when using a PEF based on 3 acres vs. 0.5 acres.

4. **Comment 20** EPA stated that it was unclear why this pre-screen is being performed to identify contaminants of potential ecological concern (COPEC) for food chain modeling in the screening ecological risk assessment (ERA), particularly when several screening values used to evaluate food chain effects are based on effects to earthworms and plants. The EPA BTAG recommended that food chain modeling be performed on all detected chemicals that have the potential to bioaccumulate. The Army's response states that this approach is conservative since the earthworm and plant screening values were lower than food chain values, and the list of bioaccumulative chemicals recommended by the EPA BTAG is applicable to sediment only. It must be noted the identified chemicals are considered to be bioaccumulative regardless of the media in which they are found. The list of bioaccumulative chemicals is also applicable to soil, and therefore, the same list should be used to evaluate food chain risks to terrestrial receptors. The EPA BTAG recommends that future risk assessments not use this pre-screen, and food chain modeling be performed on all bioaccumulative chemicals.

5. **Comment 21** EPA stated that based on a high level of uncertainty, either a baseline ecological risk assessment needed to be performed or ecologically-based remediation goals needed to be developed. The Army's response states that because the former lagoons will be filled with over two feet of clean soil, this will eliminate or reduce several ecological pathways. While the EPA BTAG still believes that there is considerable uncertainty whether cleaning up to human health criteria will be protective of all ecological receptors, placement of at least two feet of clean soil in the lagoons should reduce ecological exposure and risks to acceptable levels. However, the EPA BTAG recommends that the soil in the lagoons be limed to raise pH as discussed in the response to Comment 9 to reduce mobility of metals in the soil and reduce bioavailability to plants and other ecological receptors that may use deeper subsurface soils.

This concludes EPA's review of the Army's October 2004 response to EPA's September 8, 2004 letter regarding the review of the Army's April, 2004 draft *RFI/CMS* for the investigation of SWMU 39, located at the RFAAP. All remaining Army responses not included in the above comments have been satisfactorily addressed. The referenced draft *RFI/CMS* is disapproved by EPA in its current form, and must be revised to reflect the comments above. Per Part II, Section E.4.e. of the EPA RCRA Corrective Action Permit, the Army is required to revise the draft document and submit

a revised draft copy to EPA for review within 60 days of the receipt of EPA comments on the draft document. Part II, Section E.4.f. of the Permit allows for an additional 20 days for issuing the revised draft document to EPA, provided that timely notice is given, i.e. within 10 days. Additional time extensions can be requested under Part II, Section F. of the permit.

If you have any questions, please call me at 215-814-3357.

Sincerely,

Robert Thomson, PE, REM
Federal Facilities Branch

cc: Russell Fish, EPA
Leslie Romanchik, VDEQ-RCRA
James Cutler, VDEQ-CERCLA

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY

W. Tayloe Murphy, Jr.
Secretary of Natural Resources

Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box 10009, Richmond, Virginia 23240
Fax (804) 698-4500 TDD (804) 698-4021
www.deq.state.va.us

Robert G. Burnley
Director

(804) 698-4000
1-800-592-5482

December 9, 2004

Mr. Jim McKenna
Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, Virginia 24143-0100

Re: Response to VDEQ Comments on SWMU 39 RCRA RFI/CMS

Dear Mr. McKenna:

The Virginia Department of Environmental Quality (VDEQ) has reviewed the Response to VDEQ Comments that were incorporated into the October 2004 Final Report. The responses have satisfactorily addressed our comments. Although no PCBs were detected in the settling pond sediments, we are still interested in the source of PCBs detected at Outfall 13A which drains the from the Waste Propellant Incinerator area. VDEQ anticipates continued discussion with respect to potential onsite sources of PCBs at RAAP.

Please contact me at (804) 698-4498 if you have any questions or comments regarding the above site.

Sincerely,

James L. Cutler, Jr., CPG
Federal Facilities Project Manager
Office of Remediation Programs

cc: Durwood Willis, VDEQ
Robert Thompson, US EPA Region 3
Norman Auldridge, VDEQ-WCRO
Jerry Redder
Steve Wood

DEPARTMENT OF THE ARMY
US ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND MD 21010-5403

REPLY TO
ATTENTION OF

MCHB-TS-REH

22 NOV 2004

MEMORANDUM FOR Office of Environmental Quality (SJMRF-OP-EQ/Mr. Jim McKenna), Radford Army Ammunition Plant, P.O. Box 2, Radford, VA 24143-0002

SUBJECT: Final Decision Document SWMU 39 – Excavation of Soil for Clean Close Out and Off-Site Disposal, October 2004

1. The US Army Center for Health Promotion and Preventive Medicine reviewed the subject document on behalf of the Office of The Surgeon General pursuant to AR 200-1 (Environmental Protection and Enhancement). Thank you for the opportunity to review this document. We concur with the conclusions and recommendations contained in this report.

2. The scientist reviewing this document and our point of contact is Mr. Keith Williams, Environmental Health Risk Assessment Program, at DSN 584-7722 or commercial (410) 436-7722.

FOR THE COMMANDER:

JACK M. HELLER
Director
Health Risk Management

CF:
HQDA(DASG-HS-PE)
USACE (CENWO-HX-H)
USAEC (SFIM-AEC- CD)

Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24141
USA

October 25, 2004

Mr. Robert Thomson
U. S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Subject: SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report
Final Document, October 2004
Radford Army Ammunition Plant
EPA ID# VA1 210020730

Dear Mr. Thomson:

Enclosed is one certified copy of SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report Final Document, October 2004 Radford Army Ammunition Plant for your review and comment or approval. Your additional three copies will be sent under separate cover as well as additional copies to the Virginia Department of Environmental Quality (VDEQ), U.S. Army Environmental Center, U.S. Army Center for Health Promotion and Preventive Medicine. Attached are our responses to the comments contained in your letter dated September 8, 2004 and in Mr. Durwood Willis' letter dated May 28, 2004 on the draft report.

Please coordinate with and provide any questions or comments to myself at (540) 639-8266, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

C. A. Jake, Environmental Manager
Alliant Ammunition and Powder Company LLC

Enclosure

w/o enclosure

c: Russell Fish, P.E., EPA Region III

w/enclosure

Durwood Willis (2 copies)
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

E. A. Lohman
Virginia Department of Environmental Quality
West Central Regional Office
3019 Peters Creek Road
Roanoke, VA 24019

Tony Perry
U.S. Army Environmental Center
5179 Hoadley Road, Attn: SFIM-AEC-CDN
Aberdeen Proving Ground, MD 21010-5401

04-815-158
JMcKenna/JJRedder

Keith Williams
U.S. Army Center for Health Promotion and Preventive Medicine
5158 Blackhawk Road, Attn: MCHB-TS-REH
Aberdeen Proving Ground, MD 21010-5403

John Tesner
Corps of Engineers, Baltimore District
ATTN: CENAB-EN-HM
10 South Howard Street
Baltimore, MD 21201

bc: Administrative File
J. McKenna, ACO Staff
Rob Davie-ACO Staff
C. A. Jake
J. J. Redder
Env. File

Coordination: J. McKenna

04-815-158
JMcKenna/JJRedder

Concerning the following:

SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report
Final Document, October 2004
Radford Army Ammunition Plant

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

SIGNATURE: _____
PRINTED NAME: Anthony R. Skinner
TITLE: LTC, CM, Commanding
Radford AAP

SIGNATURE: _____
PRINTED NAME: Anthony Miano
TITLE: Vice President Operations
Alliant Ammunition and Powder Company, LLC

04-815-158
JMcKenna/JJRedder

Response to USEPA Comments dated 08 September 2004
for
Draft SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report
April 2004

General Comments

EPA Comment 1
The Tables in the draft Report and Appendices are missing several target analyte list (TAL) metals. Table B-1 is missing antimony (Sb), cadmium (Cd), mercury (Hg), and selenium (Se). Table B-2 is missing Cd, Hg, and Se. Table B-3 is missing Cd, Hg, and silver (Ag). Table 4-1 is missing Se. Please clarify if the missing TAL metals in the tables were not detected during the specific sampling referenced in the individual tables or revise the individual tables to include all TAL metals which were detected. In addition, Tables B-1 and B-2 are missing the laboratory and data validation qualifiers. Please revise Tables B-1 and B-2 to include the laboratory and data validation qualifiers.

RFAAP Response
Tables B-1 and B-2 present data collected in 1992. Laboratory and validation qualifiers were not provided with the data and are not presented because they were not available. The tables presented in the main body of the report are positive detection tables. Analytes that were not detected in any of the samples on a table are not shown. The complete analyte list was presented in Table 2-6 of the QAP Addendum in WPA 012.

EPA Comment 2
The pagination/numbering used within the draft Report (in particular for the oversized tables and figures) is confusing and somewhat difficult to follow. This makes it appear to the reviewer that pages have been inadvertently omitted. Please consider revising the draft Report to place the oversized tables and figures at the end of the appropriate section.

RFAAP Response
Oversized tables and figures will be moved to the back of each section.

EPA Comment 3
The draft Report has estimated the area/volume of contamination based upon a limited number of sample results obtained within the site fence line and at the site fence line perimeter, but does acknowledge that this estimation "most likely defines the limits of contamination." Since the recommended corrective measure alternative is to excavate contaminated soils for clean closure and off-site disposal, and since this proposed alternative will require confirmation sampling at the excavation perimeter and floor, EPA has not recommended additional sampling to determine the actual extent of contamination. However, EPA may require higher than normal sample numbers per linear foot of excavation perimeter (in particular within the southern settling pond, and the northern settling pond eastern perimeter) to determine completeness of the remediation.

RFAAP Response
Comment acknowledged.

EPA Comment 4
The cost calculations provided in Section 9 do not provide reference(s) for the unit cost and number figures used within the calculations (e.g. Alternatives 3 and 4, transportation and disposal costs). Please revise the draft Report to provide reference(s) for the unit cost and number figures used within the cost calculations.

RFAAP Response
References for cost items and number figures will be included, as requested.

EPA Comment 5
The cost calculations for Alternative 4 do not follow a logical progression when compared to Alternative 3. As an example, the excavation required for Alternative 4 is approximately 3.25% larger than the excavation required for Alternative 3, but the total costs for individual unit (e.g. day, hour, CY) Excavation Capitol Costs for Alternative 4, are not at least 3.25% greater than those for Alternative 3 (e.g. Alternative 3, Excavation, QC Personnel, 780 hours, Alternative 4, Excavation, QC Personnel 790 hours, which is only a 1.28% increase). Please clarify why the excavation, confirmation sampling, waste characterization, and site restoration costs for Alternative 4 are not at least 3.25% or more higher than the costs proposed for Alternative 3 [Alternative 4 requires a sloped excavation to 6 feet below ground surface (bgs), compared to Alternative 3, which requires a simple 2 foot bgs excavation], or revise the Report to increase the Alternative 4 excavation, confirmation sampling, waste characterization, and site restoration costs by an appropriate multiplier of at least 3.25%.

RFAAP Response
While the duration to delineate and excavate the additional volume of soil is linear, the time to backfill the site is not. The report proposes that the lagoons be filled to ground surface following excavation. The quantity of backfill required to bring the excavation to natural grade far exceeds the quantity of soil to be removed. The assumptions used to estimate the time required for each element are provided as footnote 2 in the cost estimates.

EPA Comment 6
The weighted ranking system proposed within Section 11 does not follow EPA guidance, which does not assign any weighted rankings to the evaluation criteria of effectiveness, implementability or cost. Please revise the draft Report to remove the proposed weighted ranking system.

RFAAP Response
The weighted ranking system is considered to be an appropriate tool for evaluating alternatives, and has been used at other Federal Facility sites in USEPA Region III to select an appropriate alternative in the past. The categories (effectiveness, implementability, and cost) were given a weighting factor to reflect each category's relative importance in the decision process. Effectiveness was considered to be most important category in the selection of a corrective measures alternative and was therefore given highest weighting factor in the decision analysis. This is appropriate because the effectiveness criterion directly addresses the main goal of the CMS: to select an alternative that will best achieve the established corrective action objectives. Cost was similarly given the lowest weighting factor as the USEPA has determined that cost is only to play a limited role in the screening of process options **(USEPA, 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, OSWER Directive 9355.3-01)**.

Note: This process was used for the AOC 4343 RFI/CMS report which USEPA accepted as Final. Also, there appears to be a conflict with Comment #32 which requests that RFAAP revise the ranking system, not remove it.

Specific Comments

EPA Comment 7
Section 2.3.1, Previous Investigations, page 2-6: It is stated in the second paragraph of this section that, "analytical results for inorganics are indicated on the tables and figures as exceedances when they exceed both the background value and a screening value. Eliminating screening level exceedances in the contamination assessment of Solid Waste Management Unit (SWMU) 39 that are below background values allows site-specific constituents to be more clearly indicated on the tables and figures." This statement implies that constituents detected at concentrations less than background concentrations were not selected as constituents of potential concern (COPCs) for SWMU 39. Current U.S. EPA guidance (Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites, U.S. EPA September 2002) recommends "a baseline risk assessment approach that retains constituents that exceed risk-based screening concentrations." The guidance goes on to recommend that "COPCs with high background concentrations should be discussed in the risk characterization, and if data are available, the contribution of background to site concentrations should be distinguished. COPCs that have both release-related and background-related sources should be included in the risk assessment. When concentrations of naturally occurring elements at a site exceed risk-based screening levels, that information should be discussed qualitatively in the risk characterization." This approach is preferred in order to present a more thorough assessment of risks associated with hazardous substances, pollutants and contaminants at a site, and to prevent the inadvertent omission of potentially release-related constituents from the risk assessment. Please note this procedure when preparing future risk assessment reports.

Please note that the option exists to prepare a residual risk analysis after evaluating total risk, as described above. A residual risk analysis may be used to more completely characterize site-related and naturally-occurring chemical influences. This additional analysis may be prepared as part of the uncertainty analysis or as a secondary portion of the risk characterization.

RFAAP Response
Risk Assessment methodologies are presented in the risk assessment sections (Sections 6 [HHRA] and 7 [SLERA]). The statement quoted by the reviewer refers to tables and figures in the previous investigation and contamination assessment sections (Sections 2 and 4, respectively), where figures and tables comparing the site data to established comparison criteria are presented. The discussion of previous investigations and results provides a basis to discuss extent and nature of contamination. Comparisons to Region III RBCs provide a framework of discussion for this analysis. The risk assessments in Sections 6 and 7 do not screen out COPCs based on background, therefore a residual risk analysis is not conducted.

EPA Comment 8
Section 4.2.1.1, Soil Screening Level Comparison, pages 4-13 to 4-14: This section discusses the soil screening level (SSL) comparisons for analytes detected at SWMU 39. This section references groundwater sampling at nearby wells and indicates that maximum contaminant levels (MCLs) and tap water screening level exceedances were not noted. The draft Report does not provide a table summarizing the groundwater data. Please revise the draft Report to provide a table summarizing the groundwater data at/near SWMU 39.

RFAAP Response
A table presenting groundwater data for the site will be provided.

EPA Comment 9
Section 4.2 on page 4-7 states the pH of the surface soil measured in the northern settling basin was 4.0. The potential ecological impacts from the low pH in the soil should be evaluated, since pH this low can directly effect invertebrate and plant populations. The low pH soil may also explain why the vegetation in the pond basins is scarce (see Section 7.7.1 on page 7-29 and pictures in Appendix F-1).

RFAAP Response
As only one soil sample (39SB05A) was analyzed for pH, it is unknown if all surface soils at the site have pH concentrations as low as 4.0. As soil pH decreases below 5.5, the availability of aluminum and manganese increases, and may reach a point of toxicity to plants. In addition, soil microorganisms associated with nitrification require a certain soil pH range to function efficiently (e.g., 5.5 to 6.5). Soil with a pH of 4.0 would be considered to have "extreme acidity" related to plant nutrients and aluminum (*Soil Acidity and Aglime*, Pennsylvania State University Cooperative Extension, Agronomy Facts 3, 1995). As stated in Section 7.7.1 of the report, the average lead concentration in surface soil of 1,520 mg/kg is considerably above the phytotoxicity benchmark of 50 mg/kg. Text will be added to this section that states low soil pH would also be expected to increase the availability of aluminum and manganese, potentially resulting in plant toxicity. Additional discussion will be added to the report regarding potential toxicity to soil invertebrates from low pH.

It should be noted that the addition of lime would increase soil pH and reduce the availability of aluminum and manganese. This type of action will be considered in the CMS.

EPA Comment 10

Section 4.2.1.2, Nature and Extent of Contamination, page 4-14: This section states that there is a single screening level exceedance for tetrachlorodibenzodioxin (TCDD) toxicity equivalent (TE) in the northern pond. This contradicts the information provided in Table 4-2, which shows two exceedances of residential risk-based concentrations (RBCs) (samples 39SB05A and 39SB06A). Please clarify which is correct and revise the draft Report accordingly. In addition, since there are exceedances of residential RBC screening levels for TCDD TE in both the northern and southern settling ponds, and since only one sample was collected and analyzed for dioxins/dibenzofurans in each of the settling ponds, the conclusion that dioxins and dibenzofurans are not a major contaminant at the site can not be supported at this time. Please revise the draft Report to note that dioxins/dibenzofurans are a major contaminant at the site or to propose additional sampling for dioxins/dibenzofurans in the northern and southern settling ponds.

RFAAP Response

A total of seven soil samples were collected and analyzed for dioxin/furans. The paragraph in Section 4.2.1.2 will be revised as shown below (bold text indicates inserted text, strike-out indicates deleted text).

> "The sole organic compounds to have a screening level exceedance were dioxin/furans. Although no single dioxin/furan exhibited an exceedance, there was a single **industrial** exceedance of the TCDD TE for combined dioxin/furans in one surface soil sample in the northern pond **and one residential exceedance of the TCDD TE in the southern settling pond. Samples collected below the surface soil interval (39SB5B,C & 39SB6B,C) did not show elevated levels of dioxin/furans, indicating that these constituents are not migrating vertically through the soil column.** ~~The single exceedance indicates that dioxins/furans are not a major contaminant at the site.~~"

Since dioxins/furans are also evaluated in the Human Health and Screening Level Ecological Risk Assessments, the issue of whether they are a major contaminant will be addressed in those sections and in the final conclusions to the report.

EPA Comment 11

Section 5.1 Inorganic Compounds, on page 5-1 states that "the majority of the metals are non-toxic while some metals are toxic to human health and the environment." This statement is misleading since most metals are toxic if at high enough concentrations. This issue should be clarified.

RFAAP Response

The text will be revised to read: "the majority of the metals are non-toxic at the concentrations found in site soil, while other metals may be toxic at the concentrations found on site."

EPA Comment 12

Section 6.0, Human Health Risk Assessment, page 6-1: Several of the references provided in the introductory paragraphs of this section are out of date, and have been superceded by more recent guidance. Specifically, U.S. EPA's Dermal Exposure Assessment: Principles and Applications

(1992c) and Assessing Dermal Exposure from Soil (1995b) have been superceded by Risk Assessment Guidance for Superfund, Part E: Supplemental Guidance for Dermal Risk Assessment (March 2003). In addition, with respect to child exposures, the Army should make use of U.S. EPA's Child-Specific Exposure Factors Handbook (2002) in selection of exposure parameter values for this receptor population, to the greatest extent practicable and where not superceded by subsequent guidance. Please revise the draft Report to reference the most current and applicable guidance.

RFAAP Response

The citation for the *Risk Assessment Guidance for Superfund, Part E* (Dermal Guidance) will be added to the report. The final version of the document is dated July 2004, and will be the version cited. The same exposure parameters and dermal absorption factors that are presented in the final guidance document, however, have been used in the HHRA for SWMU 39.

The *Child-Specific Exposure Factors Handbook*, is designated as an "Interim Draft" and the authors acknowledge that this document is still under some development. The handbook provides child-specific exposure factors for various age groups. USEPA has proposed eleven distinct age groupings to be considered in risk assessments. (Note that none of these categories matches up with our current age group of 0 to 6 years of age). According to the document, "...The age groups and the guidance on how to use them are currently under development and will be subjected to peer review. It is important to note that EPA will be directing efforts to revise this handbook to conform with the age grouping guidance as soon as the guidance is finalized. A revised handbook is expected in Fall 2003." Since the most current document available (via internet search) was dated September 2002, RFAAP does not believe it appropriate to use this guidance at this time.

EPA Comment 13

Section 6.1.1, Methodology for Data Summary, page 6-5: It is stated in the second bullet point on this page that the frequency of detection was used to summarize the analytical data for use in the human health risk assessment (HHRA). Although frequency of detection is recommended in RAGS Part A as one method of reducing a data set for the purposes of conducting a risk assessment, it is no longer recommended by U.S. EPA. It is further stated that "frequency of detection... was not **generally** [emphasis added] used as a selection criterion for COPCs in this HHRA." It is not clear what is meant by this statement, and how frequency of detection was used in evaluating data for this HHRA. Please revise the draft Report to clarify this statement.

RFAAP Response

Frequency of detection was not used as a criterion to select COPCs for this HHRA. Text will be revised to clarify this point.

EPA Comment 14

Section 6.1.2.2, page 6-8: All onsite and background data sets should undergo normality distribution testing regardless of the frequency of non-detects prior to statistical comparison of the means.

RFAAP Response
Onsite and background data sets are tested for the normal distribution regardless of the frequency of nondetects. The text will be revised accordingly.

EPA Comment 15
Section 6.1.3, Comparison of Inorganic Compounds to Background Levels, pages 6-8 through 6-10: The last paragraph of this section states that for surface soil, "arsenic and manganese exceeded screening criterion but were shown to be within background concentrations and were eliminated from the quantitative HHRA. For total soil, manganese exceeded screening criteria but was excluded on the basis of background comparisons." As stated above in Specific Comment 7, U.S. EPA does not support the screening of detected constituents against background concentrations for the purpose of eliminating COPCs from consideration in the risk assessment. Consideration of background should be an important concern during formulation of risk management options after total estimates of risk and hazard have been summarized for the receptor populations at issue. Please revise the quantitative risk evaluation to include arsenic and manganese as COPCs in surface and subsurface soil, in order to obtain a complete assessment of total risk.

RFAAP Response
RFAAP has agreed that chemicals would not be eliminated based on background in the HHRAs. This report was already under review when that agreement was reached. The report will be revised as requested.

EPA Comment 16
Section 6.2.2, page 6-19: Please consider using the PROUCL to calculate UCLs in future reports.

RFAAP Response

At the outset of the project, the new UCL guidance and PROUCL software were reviewed. Although an early version of the software was obtained, it did not function properly. As described in Section 6.2.2 of the RFI/CMS, however, the approach that is used for generating statistics for HHRAs at RFAAP parallels the approach described in the UCL guidance. In particular, the "bootstrap method" was used to calculate UCLs for data sets with non-parametric distributions.

Although an improved version of the PROUCL software is now available on USEPA's website, RFAAP prefers to continue using the calculation spreadsheets that were specifically developed for the RFAAP project. The following rationale is offered:

- Use of our existing spreadsheets would maintain consistency in UCL calculations throughout the project.
- Spreadsheets for the UCL calculations are linked with other RAGS, Part D spreadsheets. The use of a separate software package would be less efficient.

This position was stated previously in the final Response to EPA Comments on Building 4343 which EPA accepted as complete.

EPA Comment 17
Section 6.2.3, page 6-21: Note for future reports that the PEF calculation for residential areas should be based upon 0.5 acres (the size of the average lot for a residential home), and not the entire size of the site.

RFAAP Response
This site's most probable future use is to continue as an industrial area. As such, sampling has been designed to evaluate this most probable future use. However, at the request of USEPA during earlier comment cycles on previous RFI/CMS, residential scenarios are included in RFAAP HHRA's. The site-specific PEF is, therefore, based on the approximate area of soil samples collected at the site. Because the samples collected at SWMU 39 represent the entire area of the site, the PEF was calculated on the basis of the approximate size of the site (3 acres) rather than using the default value (0.5 acre) for a residential property. RFAAP proposes to leave the PEF value unchanged.

EPA Comment 18
Section 6.4, Human Health Risk Characterization, pages 6-32 through 6-38: The summary of human health risk characterization for each potentially exposed population does not include the results of the quantitative evaluation if the results fall below the target risk range or target hazard index. For each applicable population, the statement is made that risks were "less than the target risk range of 1 x 10-6 to 1 x 10-4," but specific results are not provided. The specific results of the quantitative risk evaluation should be provided in Section 6.4 for each receptor population, in order to provide a transparent presentation of the risk evaluation. Please revise the draft Report to include the results of the quantitative risk evaluation conducted for each potentially exposed population. U.S. EPA will review the acceptability of the individual estimates of risk and hazard predicated on the degree of conservatism and uncertainty inherent in the quantitative point estimates.

RFAAP Response
The specific values for the risk estimates and hazard indices for all receptors - including those that are below the target risk range and target hazard index- will be added to the text.

EPA Comment 19
Section 7.1, Site Characterization, on page 7-2 states that the ponds are dry, but may temporarily hold standing water after rain events. In photo F-5, there appears to be standing water in the settling pond. Section 7.3 on page 7-17 states that since surface water and sediment are not associated with the site, aquatic receptors were not evaluated in the risk assessment. Additional information should be presented on the duration of time that the site holds water to support this statement, particularly for amphibians, that can use these temporary areas for breeding.

RFAAP Response
The standing water shown in photo F-5 is very small (approximately 0.1 acre or less) and isolated. Additional information will be added to the report that discusses the expected duration of time that the site holds water. No surface water or sediment samples were collected from the site, and the collection of these types of samples are not recommended, as the site is not expected to exhibit conditions that would support temporary breeding areas for amphibians. These lagoons were engineered treatment units, not otherwise naturally

occurring features at SWMU 39. This alone is thought to be justification for no further action from an ecological risk perspective (please see response to comment 21).

EPA Comment 20

Section 7.2.5 on page 7-14 provides the source of screening values used to evaluate food chain exposure. It is unclear why this pre-screen is being performed to identify contaminants of potential ecological concern (COPEC) for food chain modeling in the screening ecological risk assessment (ERA). In addition, Table 7-7 shows that several of the screening values used to evaluate food chain effects are based on effects to earthworms and plants, and not upper trophic level receptors. The EPA BTAG recommends that food chain modeling be performed on all detected chemicals that have the potential to bioaccumulate. The list of bioaccumulative compounds that the EPA Region III BTAG considers is on Table 4-2 in Bioaccumulative Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs (EPA-823-R-00-001). If a compound found at the site is on the list, it must be considered in the food chain evaluation. The use of a pre-screen prior to food chain modeling is not acceptable at the RFI level of evaluation. This approach likely changes the list of chemicals showing risk from food chain modeling.

RFAAP Response

A pre-screen was performed to identify the COPECs for inclusion in the food chain model. This approach has been used for previous SLERAs performed for sites at RFAAP and is considered to be a conservative approach. Although Table 7-7 shows some screening values are based on earthworms or plants, this is because the screening values for these receptors were lower than those based on upper trophic level receptors. Ecological soil screening levels (SSLs) from USEPA and preliminary remediation goals (PRGs) from ORNL both consider bioaccumulation for avian and mammalian wildlife receptors. The conservative pre-screen approach used for the SLERA is to select the lowest screening value from these two references, even if they are based on direct-contact exposure for earthworms or plants. It should be noted that SSLs consider bioaccumulation for the meadow vole, short-tailed shrew, long-tailed weasel, mourning dove, American woodcock, and red-tailed hawk; and PRGs consider bioaccumulation for short-tailed shrew, white-footed mouse, red fox, white-tailed deer, American woodcock, and red-tailed hawk. Ecological data quality levels (EDQLs) from USEPA Region 5 were also used, and these levels consider bioaccumulation for the meadow vole and masked shrew.

The list of bioaccumulative compounds presented in Table 4-2 in *Bioaccumulative Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs* (EPA-823-R-00-001) are for sediment only (not soil) and do not take into account potential toxicity. For these reasons, the SSL and PRG screening values, as well as the EDQLs, are deemed more appropriate for use in the prescreen.

EPA Comment 21

Section 7.9 on page 7-37 states that based on the uncertainties of toxicity, on the fact that no rare, threatened or endangered species are present, and the small size of the site, remedial measures solely to address ecological concerns may not be warranted at this time for soil. The section further states that the information collected indicates that a more thorough assessment is warranted, in this case in the form of a corrective measure study (CMS). Section 8.2.1 on page 8-2 states that the estimates from the screening ERA are associated with a considerable degree of uncertainty and are, by themselves, not appropriately definitive to recommend ecologically-based remedial goals. The EPA

BTAG does agree that there is considerable uncertainty in the ERA, however, this is not sufficient justification for no remedial action to address ecological risk. The EPA BTAG does support reducing uncertainty in the ERA by continuing with the ERA process and completing a baseline ERA. The draft report states that this additional assessment will include a CMS, which by itself does not reduce uncertainty with the ERA, since no additional assessment is performed. Therefore, if a baseline ERA is not going to be performed, the remedial measures discussed in the CMS will need to include the development of ecologically-based remediation goals.

RFAAP Response
Setting ecological PRGs based on the results of the SLERA would be highly conservative and would most likely result in clean up levels lower than those developed for human health receptors. This response appeals for a more pragmatic approach with full knowledge of the expense that would be incurred in the implementation of a full ERA. RFAAP requests stakeholder buy-in to go forward with remediating to human health remediation goals (RGs). It is RFAAP's opinion that a full ERA would yield very little additional significant information that would facilitate site remediation and closeout.

These lagoons were engineered treatment units, not otherwise naturally occurring features at SWMU 39. Technically this alone is thought to be justification for no further action from an ecological risk perspective. However, it is equally noteworthy that the proposed action will both remove the source areas to human health RG's, and bring the former lagoon areas to grade, i.e., over two feet of soil will be placed over residual concentrations of COPC's that may remain post-excavation. Said cover provides an additional barrier and eliminates or reduces several ecological risk pathways.

EPA Comment 22
Section 8.1 on page 8-1 states that the screening ERA concluded that remedial measures to address ecological concerns are not warranted for soils. The EPA BTAG does not agree with this conclusion. Section 7.9 on page 7-37 actually states that a more thorough assessment is needed. Therefore, it is unclear how a conclusion of no need for remedial measures can be reached when admitting that a more thorough assessment is needed to reduce uncertainty. (See previous comment for additional discussion of this issue.)

RFAAP Response
A more thorough assessment was conducted in the CMS, where residual COPEC concentrations, after remediation to human health PRGs, were compared with baseline COPEC concentrations. The ERA concluded that "Based on uncertainties of toxicity, on the fact that no wildlife RTE species have been confirmed at the SWMU 39 study area, and the small size of the SWMU (2.6 acres), remedial measures solely to address ecological concerns may not be warranted at this time for soil." It should also be noted that remedial measures include backfilling the excavated areas and what remains of the original treatment lagoons with clean fill to bring them level with surrounding soil. This would provide over two feet of soil cover between the ground surface and residual COPECs that may remain post excavation.

EPA Comment 23
Section 8.1 on page 8-1 states that based on the results of the human health and ecological risk evaluations, the contaminants of interest (COI) selected are arsenic, lead, vanadium, and

dioxins/furans. Based on the screening ERA (Section 7.9), copper and chromium also need to be included as COIs.

RFAAP Response
Copper and chromium are presented in Table 8-2 as ecological risk drivers in soil, and are evaluated. Copper and chromium will be added as COIs.

EPA Comment 24
Table 8-2 on page 8-3 provides a summary of the ecological implications of human health soil remedial goals on ecological receptors. The table presents a column which presents the percent reduction in the ecological effects quotient (EEQ). The percent reduction in the EEQ is not relevant from an ecological risk perspective since the EEQs are still greater than one for several receptors based on the lowest observed adverse effect level (LOAEL) for copper and dioxins to the shrew, and chromium to the robin and earthworm, indicating potential risk to these receptors. The EPA BTAG is also concerned with the limited data that were used to calculate residual concentrations, defined as the concentration estimated by removing the soil samples from the ecological data base that are within the proposed excavation footprint. Additional sampling is recommended to better define residual concentrations that would remain.

RFAAP Response
The percent reduction in the EEQs is considered relevant, as this type of information provides important data to aid risk management decisions. The finding that several COPECs have EEQs greater than 1 is discussed in Section 8.2.1 (see response to Comment No. 26). The data set used to calculate the residual COPEC concentrations included nine samples, and did not include consideration of clean backfill that will be added to the lagoons should the proposed remedial alternative be selected . Confirmation sampling following remediation will better define concentrations that remain, and will include the sampling of clean backfill, in order to estimate COPEC concentrations throughout the area of exposure post-remediation.

EPA Comment 25
In the first bullet on page 8-4, Section 8.2.1 states that for the shrew, the estimated residual concentrations of copper, lead and dioxins in surface soil are expected to reduce this receptors EEQ from 850 to 269, or by almost 70%. The section further states that this reduction is considered significant. The source of these EEQs and how they were calculated should be included. While there is a reduction, the EEQ is still greater than one, indicating the potential for risk.

RFAAP Response
The source of the EEQs and how they were calculated is presented in the footnotes to Table 8-2. Mitigating circumstances associated with those COPECs with EEQs above 1 are presented in Section 8.2.1 (see response to Comment No. 26).

EPA Comment 26
Section 8.2.1 on page 8-4 states that while some of the food chain hazard driver COPECs are still estimated to have potential EEQs greater than one, this finding is not considered significant. The reasons provided mainly deal with the high level of uncertainty with derivation of toxicity reference values, and whether there is ecological risk when a EEQ is greater than one. As stated previously, high uncertainty in the ERA is not sufficient justification for a conclusion of insignificant risk. The

high uncertainty points to the need for a baseline ERA to reduce uncertainty and more definitely define the nature of the ecological risk. If a baseline ERA is not going to be performed, the remedial measures discussed in the CMS will need to include the development of ecologically-based remediation goals. Therefore, the EPA BTAG does not support the conclusion on page 8-4 that the proposed human health remedial goals for residential land use are expected to result in residual COPEC concentrations in surface that soil that are protective of the environment.

RFAAP Response
The potentially elevated EEQs associated with residual COPEC concentrations are addressed by presenting and applying alternative toxicity factors and bioaccumulation factors, discussed in detail in Section 7.8 of the report. Overly conservative toxicity factors and bioaccumulation factors were generally used in the SLERA and in the initial estimation of residual COPEC EEQs. The application of alternative factors, from USEPA and others, resulted in the EEQs falling below 1 for most of the residual COPEC concentrations. The assertion is not being made that a high level of uncertainty is justification for a conclusion of insignificant risk; the application of alternative toxicity and bioaccumulation factors results in an estimation of acceptable risk. RFAAP does not believe that the cost of deriving site-specific toxicity and bioaccumulation factors is justified when alternative factors are available from USEPA and other published studies. Confirmation sampling following remediation will better define concentrations that remain, and will include the sampling of clean backfill, in order to estimate COPEC concentrations throughout the area of exposure post-remediation.

Also see response to Comment No. 21.

EPA Comment 27
Section 8.2.1 on page 8-4 states that "EEQs of 1 or lower are not necessarily a requirement to demonstrate acceptable ecological impacts." This statement should be changed to "EEQs less than one are not necessarily a requirement to demonstrate acceptable ecological impacts," since EEQs equal to one indicate the potential for ecological risk.

RFAAP Response
The statement will be revised as requested.

EPA Comment 28
Section 8.2.1 on page 8-4 also states that no additional ecological remedial goals are needed because there is limited ecological habitat at the site, and the habitat that is present is generally of low quality and is not expected to attract ecological receptors. This statement will likely not be true once the remedial action is completed, the pH problem with the soil is corrected, and vegetation becomes established. The low quality habitat currently present at the site is because of the low pH and/or contamination present at the site, which will be addressed during remedial activities.

RFAAP Response
This statement will be deleted from the report. See response to Comment No. 21.

EPA Comment 29
Section 8.4 on page 8-5 provides an estimate of the area and volume of contamination that would need to be removed to meet residential remedial goals. The volume estimates are based on removal

of soil in a 10 foot by 10 foot area around one sample in the northern settling pond where lead was 4,530 mg/kg and a 20 foot by 20 foot area in the southern settling pond where lead was 16,500 mg/kg. It is unclear why the lead contamination at 39SB1A at 7070 mg/kg in the northern settling pond is also not proposed for removal since it exceeds the remedial goal of 400 mg/kg. In addition, the composite sample 39SL2 in the northern settling pond had a concentration of 21,000 mg/kg lead. All of these data, and because of the nature of the release, suggest that contamination above remedial goals is much more widespread in these settling ponds than is depicted in Figure 8-1, and additional sampling is needed to further delineate the area needing remediation.

RFAAP Response

The area of contamination used for scoping and cost estimating purposes in the CMS is as follows:

- Industrial Area: 10 ft x 10 ft area in the southern pond and the entire footprint of the northern pond to a depth of 2 ft bgs.
- Residential Area: 20 ft x 20 ft area in the southern pond and the entire footprint of the northern pond to a depth of 2 ft bgs. Additional soil from the northern pond is also assumed to be excavated to a depth of 6 ft bgs.

To clarify the area of contamination used in the CMS, the area of contamination on Figure 8-1 has been hatched. In addition, the text has been revised as follows:

"Based on the CMOs described in *Section 8.3*, the area and volume of contamination have been calculated. The results of the SWMU 39 soil investigations indicate that lead and dioxins/furans (as TCDD TE) are present in surface soil at concentrations exceeding the Industrial RG (see Figure 4-2). No COIs were detected above the Industrial RG at depths greater than 1 ft bgs. Although not defined during the field activities, the calculated area of contamination (24,912 ft^2), presented as Figure 8-1, most likely defines the limit of contamination. This area consists of a 10 ft by 10 area in the southern pond and the entire footprint of the northern pond. The depth of soil to be removed to reduce the contaminant concentrations to less than their respective Industrial RGs was assumed to be 2 ft bgs. Based on the assumed area and depth of contamination, the total estimated volume of contaminated soil is 1,845 yd^3.

The area and volume of contamination for clean close out (i.e., exceeding the Residential RG) was similarly calculated. However, there is one location in the northern pond (39SB05C at a depth of 3-5 ft bgs) where lead was detected at depth above the Residential RG, but below the Industrial RBC. Therefore, it was assumed that additional excavation at depth was required in the northern pond to reduce contaminant concentrations to residential RGs. For this area, it was assumed that the volume of contamination in this area could be defined as a trapezoid with 1:1 side slope to a depth of 6 ft bgs with a base area 10 ft by 10 ft. Therefore, the total area of soil contamination, also presented on Figure 8-1, is estimated as 25,212 ft^2. The estimated volume of soil exceeding the Residential RGs is 1,905 yd^3."

EPA Comment 30

Section 9.3 on page 9-5 and 9-6 states that the area to be excavated will be delineated via surface and subsurface soil sampling prior to mobilization of the excavation personnel. The section further

states that it is assumed that samples would be collected from a total of 80 locations for analysis. Delineation should not be limited to areas identified in Figure 8-1 where contamination is above residential remedial goals. The entire area within both settling ponds needs to be delineated to determine the area that needs remediation. Because the areas to be remediated are likely to be much larger than the area depicted in Figure 8-1, the cost estimate for this alternative will likely be much greater than what is shown in Table 9-2. This comment also applies to Alternative 4 discussed in Section 9.4.

RFAAP Response
The delineation of the area to be excavated is not anticipated to be limited to the areas identified in Figure 8-1. This information will be added to the text for clarification as requested. As available data does not indicate a larger area to be excavated, the costs are considered to be accurate within the acceptable EPA range (i.e., -30% to +50%), so have not been revised. (USEPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, OSWER Directive 9355.3-01).

EPA Comment 31
Section 11 on page 11-1 discusses the ranking of the corrective measures alternatives. The section states that based on the ranking, Alternative 4, Excavation of Soil for Clean Close ut and Off-site Disposal, is the selected alternative for the site. The EPA BTAG supports the selection of this alternative. However, remedial goals protective of ecological receptors will need to be developed and used to ensure clean closure of the site. If human health remedial goals areO used, the residual contamination may still result in potential ecological risk, and monitoring will be needed to confirm that the cleanup is protective of ecological receptors.

RFAAP Response
Remedial goals protective of ecological receptors are not required, as the application of alternative (as opposed to worst-case) toxicity and bioaccumulation factors generally result in the residual COPEC concentrations achieving EEQs less than or equal to one, following planned remediation to meet human health based PRGs. Please note that the area will be covered with clean fill to grade (greater than 2 feet of fill over the former lagoon areas). Confirmation sampling following remediation will better define concentrations that remain, and will include the sampling of clean backfill, in order to estimate COPEC concentrations throughout the area of exposure, post-remediation.

EPA Comment 32
Section 11.0, Ranking of Corrective Measures Alternatives, page 11-1: This section indicates that the selection criteria for each alternative will be ranked 1 through 5, with a 5 indicating the most favorable alternative and a 1 indicating the least favorable alternative. The rankings for cost do not follow this recommendation, since the least favorable alternative for cost (Alternative 3) is only ranked a 2, not a 1 as previously indicated. Please clarify why the most expensive alternative is not ranked a 1, as proposed in Section 11.0, or revise the Report to rank the least favorable alternative for cost as a "1."

RFAAP Response
The rankings for cost for Alternative 3 will be revised to a "1" as requested.

Response to VDEQ Comments dated 28 May 2004
for
Draft SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report
Dated April 2004

VDEQ Comment 1
Field Investigation Program: Please note in this section that the groundwater investigation will be conducted as part of a base-wide groundwater study. It should also be noted that the existing groundwater monitoring wells may not be sufficient for a field investigation program addressing groundwater.

RFAAP Response
Comment noted. A statement will be added to this section indicating that a groundwater investigation is currently being conducted to address groundwater on a regional basis within the Horseshoe Area of Radford Army Ammunition Plant (RFAAP). One of the goals of the groundwater study is to assess the suitability of the existing groundwater wells for monitoring specific SWMUs. Recommendations for the possible installation of additional wells and the abandonment of wells which are not suitable for monitoring groundwater will be included in the groundwater study report. RFAAP believes that the second statement in Comment 1 would be more appropriately addressed in the groundwater study report, rather than the SWMU 39 RFI/CMS Report.

VDEQ Comment 2
Field Investigations Program: Based on comments to Addendum 12, it was anticipated that all TAL and TCL analytes would be addressed during the field investigation. Please address the lack of SVOC sampling as part of the field investigation.

RFAAP Response
As described in Work Plan Addendum (WPA) 12, several samples collected from within and outside the settling ponds at SWMU 39 were analyzed for TCL SVOCs during previous investigations, including the 1992 Verification Investigation and the 1998 RFI. Two surface soil and 22 subsurface soil samples collected during the 1998 RFI were analyzed for low level PAHs in addition to TCL SVOCs. Results from both previous investigations indicated that low levels of SVOCs were detected at concentrations below residential and SSL transfer screening levels. Based on these findings, and as stated in WPA 12, site media (with the exception of surface water) were considered characterized for SVOCs. During the 2002 field investigation, surface water was not present in the settling ponds; therefore, surface water samples were not collected.

VDEQ Comment 3
Nature and Extent of Contamination: Previous comments by the staff indicated that all data should be reported, not just data for compounds detected. For instance, Table 4-3 provides data for PAHs, but only three compounds are reported.

RFAAP Response
Table 4-3 is intended to provide a summary of constituents that have been detected at the site. As stated in *Section 3.4*, the complete analytical (raw) data and validation reports are

contained on the CD provided at the back of the report. This is consistent with recent RFI/CMS submittals.

VDEQ Comment 4

Contaminant Fate and Transport: Should vanadium be included in Figure 4-1, as it is addressed in this section? Dioxins and furans were detected in several samples, but there is no discussion of the precursors of this class of compounds, other than being derived from the burning of organic matter in the presence chlorine. What were the potential sources of chlorine? Sediment samples collected by the DEQ West Central Regional Office from a drainage way from this SWMU contained PCBs. Why would PCBs be identified in the vicinity of this SWMU?

RFAAP Response

Analytes detected above residential screening levels and the 95% UTL (for inorganics) are presented on Figure 4-1. Vanadium was not detected above the 95% UTL background concentration; therefore, it was not included on the figure. This is consistent with the presentation of data on figures in RFAAP RFI reports. As discussed in the second paragraph in *Section 5.0*, vanadium was found to be statistically above background levels; therefore, it was selected as a COC and discussed in the fate and transport discussion.

The source of the chlorine for dioxins/furans detected at SWMU 39 was likely the chlorinated slurry water in the propellant mix that was burned in the incinerators. This information has been added to *Section 5.0* for clarity.

Three surface and four subsurface soil samples were analyzed for PCBs during the 2002 RFI field effort. PCBs were not detected in the samples. After reviewing the DEQ West Central Regional Office's New River Stream Survey Report, it appears that the DEQ PCB sample location was not collected at storm water Outfall 13A, but in the field upstream of the outfall. Therefore, PCB sample results from this location would not be reflective of conditions at the outfall.

VDEQ Comment 5

Development of Corrective Measures Objectives: It appears that the preferred remedial path is to clean close this site. Section 8.4 notes that calculations were performed to determine the volume excavated to meet residential screening values (1,905 cubic yards). This appears to be based on the same depth (2 feet) as used in the calculation for removal to meet the industrial screening value. Please clarify the determination of the removal volume to meet the residential and industrial levels. It appears that profiling of the depth of contamination would allow more accurate estimation of the volume to be removed. Will the depth of contamination be determined for both settling ponds?

RFAAP Response

Contaminants above residential remedial goals were limited to surface soil at SWMU 39 with the exception of one location, 39SB05C at a depth of 3-5 ft bgs. As discussed in *Section 8.4, Area and Volume of Contamination*, it was assumed that a trapezoidal area with a 1:1 side slope to a depth of 6 ft bgs would be excavated from the vicinity of this sample to remove the contamination detected at depth in addition to that removed from the surface. It is proposed that delineation of the area and depth of contamination will be performed as part of the corrective measures at SWMU 39, prior to commencement of the excavation activities (see details on *Pages 9-5 through 9-8, Contamination Delineation*).

VDEQ Comment 6

Corrective Measures Development, Alternative Four: Excavation of Soil for Clean Close Out and Off-site Disposal: This alternative should recognize the fact that the base-wide groundwater investigation may necessitate the installation of more wells at SWMU 39 and institutional controls with 5 Year Report requirements. Recognizing that a detailed work plan for implementation of corrective measures will be submitted, it should be noted that as part of the excavation, soils should be evaluated as hazardous using the standard TCLP method. If the material to be excavated is hazardous, then stockpiling of the material is not acceptable. Hazardous wastes should be contained in drums or roll off containers and not stockpiled.

RFAAP Response

As discussed in the response to Comment 1, a groundwater investigation is currently being conducted to address groundwater on a regional basis within the Horseshoe Area of RFAAP. An evaluation of whether corrective measures are required for groundwater will be performed based on the conclusions of that study. As groundwater will be assessed as a separate study, monitoring requirements and institutional controls potentially associated with it are not discussed in this report. This information has been added to *Section 9.0* for clarity.

As discussed in *Section 9.3*, eight samples (39SB1C, 39SBIE, 39SB2C, 39SB2E, 39SB3C, 39SB3E, 39SB4C, and 39SB4E) were analyzed for TCLP metals during the 1998 RFI (ICF KE, 1999). TCLP results (presented in *Appendix B-2, Table B-4*) indicated that lead was detected at concentrations below the TCLPRL. Therefore, it was assumed that the soil will be non-hazardous and will be disposed in a RCRA Subtitle D Landfill. However, the Army will analyze samples collected from the wastes as described on *Page 9-6, Waste Characterization*. As discussed in this paragraph, analysis for waste characteristics will be performed on composite samples collected from soil identified for excavation. If these samples indicate that the soil is a hazardous waste, it will be handled as such. The first sentence on *page 9-6 Waste Characterization* has been modified to more clearly indicate that soil to be excavated will have TCLP analysis performed insitu.

Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24141
USA

October 4, 2004

Mr. Robert Thomson
U. S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Subject: SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report
Radford Army Ammunition Plant
EPA ID# VA1 210020730

Dear Mr. Thomson:

Per Part II, Section F of the permit, we are requesting an extension of the submittal date for the subject report from November 8, 2004 to December 8, 2004. The reason for this extension is the time necessary to revise the subject report and prepare responses to comments from your September 8, 2004 letter on the same. We will make every to attempt to expedite delivery of this report ahead of the requested extension date.

Note an extension under Part II, Section E.4.f. was not possible as an accurate estimate of the effort and additional time needed could not be made within 10 days of receipt of your letter to assess whether an additional 20 days would be sufficient.

'ase coordinate with and provide any questions or comments to myself at (540) 639-8266, Jerry Redder of my staff (540) 639-7536 or McKenna, ACO Staff (540) 639-8641.

Sincerely,

C. A. Jake, Environmental Manager
Alliant Ammunition and Powder Company LLC

Enclosure

c: Russell Fish, P.E., EPA Region III

Durwood Willis
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

E. A. Lohman
Virginia Department of Environmental Quality
West Central Regional Office
3019 Peters Creek Road
Roanoke, VA 24019

Tony Perry
U.S. Army Environmental Center
5179 Hoadley Road, Attn: SFIM-AEC-CDN
Aberdeen Proving Ground, MD 21010-5401

04-815-146
JMcKenna/JJRedder

Keith Williams
U.S. Army Center for Health Promotion and Preventive Medicine
5158 Blackhawk Road, Attn: MCHB-TS-REH
Aberdeen Proving Ground, MD 21010-5403

John Tesner
Corps of Engineers, Baltimore District
ATTN: CENAB-EN-HM
10 South Howard Street
Baltimore, MD 21201

bc: Administrative File
J. McKenna, ACO Staff
Rob Davie-ACO Staff
C. A. Jake
J. J. Redder
Env. File

Coordination: J. McKenna

04-815-146
JMcKenna/JJRedder

154

McKenna, Jim

From: Williams, Keith J Mr USACHPPM [keith.j.williams@us.army.mil]
Sent: Thursday, September 09, 2004 8:19 AM
To: McKenna, Jim
Subject: Review

Hi Jim,
Review is attached.

Keith J. Williams
Environmental Scientist
Environmental Health Risk Assessment Program
US Army Center for Health Promotion and Preventive Medicine
Aberdeen Proving Ground, Maryland

phone: 410-436-7722
fax: 410-436-8170
email: keith.williams@apg.amedd.army.mil

MCHB-TS-REH (40)

MEMORANDUM FOR Radford Army Ammunition Plant ATTN: SOSRF-OP-EQ (Jim McKenna), PO Box 2, Radford, VA 24143-0002

SUBJECT: Draft SWMU 39 RCRA Facility Investigation Report, May, 2004

1. The US Army Center for Health Promotion and Preventive Medicine reviewed the subject document on behalf of the Office of The Surgeon General pursuant to AR 200-1 (Environmental Protection and Enhancement). Thank you for the opportunity to review this document. One comment follows. We concur with the conclusions and recommendations contained in this report.

2. The scientist reviewing this document and our point of contact is Mr. Keith Williams, Environmental Health Risk Assessment Program, at DSN 584-7722 or commercial (410) 436-7722.

FOR THE COMMANDER:

DAVID A. REED
Program Manager
Environmental Health Risk
Assessment

CF:
HQDA(DASG-HS-PE)
USAMEDCOM (MCHO-CL-W)
USACE (CENWO-HX-H)
USAEC (SFIM-AEC-ER)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

September 8, 2004

In reply
Refer to 3HS13

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Commander,
Radford Army Ammunition Plant
Attn: SIORF-SE-EQ (Jim McKenna)
P.O. Box 2
Radford, VA 24141-0099

C.A. Jake
Environmental Manager
Alliant Techsystems, Inc.
Radford Army Ammunition Plant
P.O. Box 1
Radford, VA 24141-0100

Re: Radford Army Ammunition Plant
SWMU 39
Review of Army draft *RFI/CMS Report*

Dear Mr. McKenna and Ms. Jake:

The U.S. Environmental Protection Agency (EPA) has reviewed the Army's April, 2004 draft *RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) Report* for the investigation of SWMU 39, located at the Radford Army Ammunition Plant (RFAAP). Outlined below, please find EPA's comments based upon that review:

GENERAL COMMENTS

1. The Tables in the draft Report and Appendices are missing several target analyte list (TAL) metals. Table B-1 is missing antimony (Sb), cadmium (Cd), mercury (Hg), and selenium (Se). Table B-2 is missing Cd, Hg, and Se. Table B-

3 is missing Cd, Hg, and silver (Ag). Table 4-1 is missing Se. Please clarify if the missing TAL metals in the tables were not detected during the specific sampling referenced in the individual tables or revise the individual tables to include all TAL metals which were detected. In addition, Tables B-1 and B-2 are missing the laboratory and data validation qualifiers. Please revise Tables B-1 and B-2 to include the laboratory and data validation qualifiers.

2. The pagination/numbering used within the draft Report (in particular for the oversized tables and figures) is confusing and somewhat difficult to follow. This makes it appear to the reviewer that pages have been inadvertently omitted. Please consider revising the draft Report to place the oversized tables and figures at the end of the appropriate section.

3. The draft Report has estimated the area/volume of contamination based upon a limited number of sample results obtained within the site fence line and at the site fence line perimeter, but does acknowledge that this estimation "most likely defines the limits of contamination." Since the recommended corrective measure alternative is to excavate contaminated soils for clean closure and off-site disposal, and since this proposed alternative will require confirmation sampling at the excavation perimeter and floor, EPA has not recommended additional sampling to determine the actual extent of contamination. However, EPA may require higher than normal sample numbers per linear foot of excavation perimeter (in particular within the southern settling pond, and the northern settling pond eastern perimeter) to determine completeness of the remediation.

4. The cost calculations provided in Section 9 do not provide reference(s) for the unit cost and number figures used within the calculations (e.g. Alternatives 3 and 4, transportation and disposal costs). Please revise the draft Report to provide reference(s) for the unit cost and number figures used within the cost calculations.

5. The cost calculations for Alternative 4 do not follow a logical progression when compared to Alternative 3. As an example, the excavation required for Alternative 4 is approximately 3.25% larger than the excavation required for Alternative 3, but the total costs for individual unit (e.g. day, hour, CY) Excavation Capitol Costs for Alternative 4, are not at least 3.25% greater than those for Alternative 3 (e.g. Alternative 3, Excavation, QC Personnel, 780 hours, Alternative 4, Excavation, QC Personnel 790 hours, which is only a 1.28% increase). Please clarify why the excavation, confirmation sampling, waste characterization, and site restoration costs for Alternative 4 are not at least 3.25% or more higher than the costs proposed for Alternative 3 [Alternative 4 requires a sloped excavation to 6 feet below ground surface (bgs), compared to Alternative 3, which requires a simple 2 foot bgs excavation], or revise the Report to increase the Alternative 4 excavation, confirmation sampling, waste characterization, and site restoration costs by an appropriate multiplier of at least 3.25%.

6. The weighted ranking system proposed within Section 11 does not follow EPA guidance, which does not assign any weighted rankings to the evaluation criteria

of effectiveness, implementability or cost. Please revise the draft Report to remove the proposed weighted ranking system.

SPECIFIC COMMENTS

7. **Section 2.3.1, Previous Investigations, page 2-6:** It is stated in the second paragraph of this section that, "analytical results for inorganics are indicated on the tables and figures as exceedances when they exceed both the background value and a screening value. Eliminating screening level exceedances in the contamination assessment of Solid Waste Management Unit (SWMU) 39 that are below background values allows site-specific constituents to be more clearly indicated on the tables and figures." This statement implies that constituents detected at concentrations less than background concentrations were not selected as constituents of potential concern (COPCs) for SWMU 39. Current U.S. EPA guidance (*Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*, U.S. EPA September 2002) recommends "a baseline risk assessment approach that retains constituents that exceed risk-based screening concentrations." The guidance goes on to recommend that "COPCs with high background concentrations should be discussed in the risk characterization, and if data are available, the contribution of background to site concentrations should be distinguished. COPCs that have both release-related and background-related sources should be included in the risk assessment. When concentrations of naturally occurring elements at a site exceed risk-based screening levels, that information should be discussed qualitatively in the risk characterization." This approach is preferred in order to present a more thorough assessment of risks associated with hazardous substances, pollutants and contaminants at a site, and to prevent the inadvertent omission of potentially release-related constituents from the risk assessment. Please note this procedure when preparing future risk assessment reports.

   Please note that the option exists to prepare a residual risk analysis after evaluating total risk, as described above. A residual risk analysis may be used to more completely characterize site-related and naturally-occurring chemical influences. This additional analysis may be prepared as part of the uncertainty analysis or as a secondary portion of the risk characterization.

8. **Section 4.2.1.1, Soil Screening Level Comparison, pages 4-13 to 4-14:** This section discusses the soil screening level (SSL) comparisons for analytes detected at SWMU 39. This section references groundwater sampling at nearby wells and indicates that maximum contaminant levels (MCLs) and tap water screening level exceedances were not noted. The draft Report does not provide a table summarizing the groundwater data. Please revise the draft Report to provide a table summarizing the groundwater data at/near SWMU 39.

9. **Section 4.2 on page 4-7** states the pH of the surface soil measured in the northern settling basin was 4.0. The potential ecological impacts from the low pH in the soil should be evaluated, since pH this low can directly effect invertebrate and plant populations. The low pH soil may also explain why the vegetation in

the pond basins is scarce (see Section 7.7.1 on page 7-29 and pictures in Appendix F-1).

10. **Section 4.2.1.2, Nature and Extent of Contamination, page 4-14:** This section states that there is a single screening level exceedance for tetrachlorodibenzodioxin (TCDD) toxicity equivalent (TE) in the northern pond. This contradicts the information provided in Table 4-2, which shows two exceedances of residential risk-based concentrations (RBCs) (samples 39SB05A and 39SB06A). Please clarify which is correct and revise the draft Report accordingly. In addition, since there are exceedances of residential RBC screening levels for TCDD TE in both the northern and southern settling ponds, and since only one sample was collected and analyzed for dioxins/dibenzofurans in each of the settling ponds, the conclusion that dioxins and dibenzofurans are not a major contaminant at the site can not be supported at this time. Please revise the draft Report to note that dioxins/dibenzofurans are a major contaminant at the site or to propose additional sampling for dioxins/dibenzofurans in the northern and southern settling ponds.

11. **Section 5.1 Inorganic Compounds, on page 5-1** states that "the majority of the metals are non-toxic while some metals are toxic to human health and the environment." This statement is misleading since most metals are toxic if at high enough concentrations. This issue should be clarified.

12. **Section 6.0, Human Health Risk Assessment, page 6-1:** Several of the references provided in the introductory paragraphs of this section are out of date, and have been superceded by more recent guidance. Specifically, U.S. EPA's *Dermal Exposure Assessment: Principles and Applications* (1992c) and *Assessing Dermal Exposure from Soil* (1995b) have been superceded by *Risk Assessment Guidance for Superfund, Part E: Supplemental Guidance for Dermal Risk Assessment* (March 2003). In addition, with respect to child exposures, the Army should make use of U.S. EPA's *Child-Specific Exposure Factors Handbook* (2002) in selection of exposure parameter values for this receptor population, to the greatest extent practicable and where not superceded by subsequent guidance. Please revise the draft Report to reference the most current and applicable guidance.

13. **Section 6.1.1, Methodology for Data Summary, page 6-5:** It is stated in the second bullet point on this page that the frequency of detection was used to summarize the analytical data for use in the human health risk assessment (HHRA). Although frequency of detection is recommended in RAGS Part A as one method of reducing a data set for the purposes of conducting a risk assessment, it is no longer recommended by U.S. EPA. It is further stated that "frequency of detection... was not **generally** [emphasis added] used as a selection criterion for COPCs in this HHRA." It is not clear what is meant by this statement, and how frequency of detection was used in evaluating data for this HHRA. Please revise the draft Report to clarify this statement.

14. **Section 6.1.2.2, page 6-8:** All onsite and background data sets should undergo normality distribution testing regardless of the frequency of non-detects prior to statistical comparison of the means.

15. **Section 6.1.3, Comparison of Inorganic Compounds to Background Levels, pages 6-8 through 6-10:** The last paragraph of this section states that for surface soil, "arsenic and manganese exceeded screening criterion but were shown to be within background concentrations and were eliminated from the quantitative HHRA. For total soil, manganese exceeded screening criteria but was excluded on the basis of background comparisons." As stated above in Specific Comment 7, U.S. EPA does not support the screening of detected constituents against background concentrations for the purpose of eliminating COPCs from consideration in the risk assessment. Consideration of background should be an important concern during formulation of risk management options after total estimates of risk and hazard have been summarized for the receptor populations at issue. Please revise the quantitative risk evaluation to include arsenic and manganese as COPCs in surface and subsurface soil, in order to obtain a complete assessment of total risk.

16. **Section 6.2.2, page 6-19:** Please consider using the PROUCL to calculate UCLs in future reports.

17. **Section 6.2.3, page 6-21:** Note for future reports that the PEF calculation for residential areas should be based upon 0.5 acres (the size of the average lot for a residential home), and not the entire size of the site.

18. **Section 6.4, Human Health Risk Characterization, pages 6-32 through 6-38:** The summary of human health risk characterization for each potentially exposed population does not include the results of the quantitative evaluation if the results fall below the target risk range or target hazard index. For each applicable population, the statement is made that risks were "less than the target risk range of 1×10^{-6} to 1×10^{-4}," but specific results are not provided. The specific results of the quantitative risk evaluation should be provided in Section 6.4 for each receptor population, in order to provide a transparent presentation of the risk evaluation. Please revise the draft Report to include the results of the quantitative risk evaluation conducted for each potentially exposed population. U.S. EPA will review the acceptability of the individual estimates of risk and hazard predicated on the degree of conservatism and uncertainty inherent in the quantitative point estimates.

19. **Section 7.1, Site Characterization, on page 7-2** states that the ponds are dry, but may temporarily hold standing water after rain events. In photo F-5, there appears to be standing water in the settling pond. Section 7.3 on page 7-17 states that since surface water and sediment are not associated with the site, aquatic receptors were not evaluated in the risk assessment. Additional information should be presented on the duration of time that the site holds water to support this statement, particularly for amphibians, that can use these temporary areas for breeding.

20. **Section 7.2.5 on page 7-14** provides the source of screening values used to evaluate food chain exposure. It is unclear why this pre-screen is being performed to identify contaminants of potential ecological concern (COPEC) for food chain modeling in the screening ecological risk assessment (ERA). In addition, Table 7-7 shows that several of the screening values used to evaluate food chain effects are based on effects to earthworms and plants, and not upper trophic level receptors. The EPA BTAG recommends that food chain modeling be performed on all detected chemicals that have the potential to bioaccumulate. The list of bioaccumulative compounds that the EPA Region III BTAG considers is on Table 4-2 in *Bioaccumulative Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs* (EPA-823-R-00-001). If a compound found at the site is on the list, it must be considered in the food chain evaluation. The use of a pre-screen prior to food chain modeling is not acceptable at the RFI level of evaluation. This approach likely changes the list of chemicals showing risk from food chain modeling.

21. **Section 7.9 on page 7-37** states that based on the uncertainties of toxicity, on the fact that no rare, threatened or endangered species are present, and the small size of the site, remedial measures solely to address ecological concerns may not be warranted at this time for soil. The section further states that the information collected indicates that a more thorough assessment is warranted, in this case in the form of a corrective measure study (CMS). Section 8.2.1 on page 8-2 states that the estimates from the screening ERA are associated with a considerable degree of uncertainty and are, by themselves, not appropriately definitive to recommend ecologically-based remedial goals. The EPA BTAG does agree that there is considerable uncertainty in the ERA, however, this is not sufficient justification for no remedial action to address ecological risk. The EPA BTAG does support reducing uncertainty in the ERA by continuing with the ERA process and completing a baseline ERA. The draft report states that this additional assessment will include a CMS, which by itself does not reduce uncertainty with the ERA, since no additional assessment is performed. Therefore, if a baseline ERA is not going to be performed, the remedial measures discussed in the CMS will need to include the development of ecologically-based remediation goals.

22. **Section 8.1 on page 8-1** states that the screening ERA concluded that remedial measures to address ecological concerns are not warranted for soils. The EPA BTAG does not agree with this conclusion. Section 7.9 on page 7-37 actually states that a more thorough assessment is needed. Therefore, it is unclear how a conclusion of no need for remedial measures can be reached when admitting that a more thorough assessment is needed to reduce uncertainty. (See previous comment for additional discussion of this issue.)

23. **Section 8.1 on page 8-1** states that based on the results of the human health and ecological risk evaluations, the contaminants of interest (COI) selected are arsenic, lead, vanadium, and dioxins/furans. Based on the screening ERA (Section 7.9), copper and chromium also need to be included as COIs.

24. **Table 8-2 on page 8-3** provides a summary of the ecological implications of human health soil remedial goals on ecological receptors. The table presents a column which presents the percent reduction in the ecological effects quotient (EEQ). The percent reduction in the EEQ is not relevant from an ecological risk perspective since the EEQs are still greater than one for several receptors based on the lowest observed adverse effect level (LOAEL) for copper and dioxins to the shrew, and chromium to the robin and earthworm, indicating potential risk to these receptors. The EPA BTAG is also concerned with the limited data that were used to calculate residual concentrations, defined as the concentration estimated by removing the soil samples from the ecological data base that are within the proposed excavation footprint. Additional sampling is recommended to better define residual concentrations that would remain.

25. **In the first bullet on page 8-4, Section 8.2.1** states that for the shrew, the estimated residual concentrations of copper, lead and dioxins in surface soil are expected to reduce this receptors EEQ from 850 to 269, or by almost 70%. The section further states that this reduction is considered significant. The source of these EEQs and how they were calculated should be included. While there is a reduction, the EEQ is still greater than one, indicating the potential for risk.

26. **Section 8.2.1 on page 8-4** states that while some of the food chain hazard driver COPECs are still estimated to have potential EEQs greater than one, this finding is not considered significant. The reasons provided mainly deal with the high level of uncertainty with derivation of toxicity reference values, and whether there is ecological risk when a EEQ is greater than one. As stated previously, high uncertainty in the ERA is not sufficient justification for a conclusion of insignificant risk. The high uncertainty points to the need for a baseline ERA to reduce uncertainty and more definitely define the nature of the ecological risk. If a baseline ERA is not going to be performed, the remedial measures discussed in the CMS will need to include the development of ecologically-based remediation goals. Therefore, the EPA BTAG does not support the conclusion on page 8-4 that the proposed human health remedial goals for residential land use are expected to result in residual COPEC concentrations in surface that soil that are protective of the environment.

27. **Section 8.2.1 on page 8-4** states that "EEQs of 1 or lower are not necessarily a requirement to demonstrate acceptable ecological impacts." This statement should be changed to "EEQs less than one are not necessarily a requirement to demonstrate acceptable ecological impacts," since EEQs equal to one indicate the potential for ecological risk.

28. **Section 8.2.1 on page 8-4** also states that no additional ecological remedial goals are needed because there is limited ecological habitat at the site, and the habitat that is present is generally of low quality and is not expected to attract ecological receptors. This statement will likely not be true once the remedial action is completed, the pH problem with the soil is corrected, and vegetation becomes established. The low quality habitat currently present at the site is because of the low pH and/or contamination present at the site, which will be addressed during remedial activities.

29. **Section 8.4 on page 8-5** provides an estimate of the area and volume of contamination that would need to be removed to meet residential remedial goals. The volume estimates are based on removal of soil in a 10 foot by 10 foot area around one sample in the northern settling pond where lead was 4,530 mg/kg and a 20 foot by 20 foot area in the southern settling pond where lead was 16,500 mg/kg. It is unclear why the lead contamination at 39SB1A at 7070 mg/kg in the northern settling pond is also not proposed for removal since it exceeds the remedial goal of 400 mg/kg. In addition, the composite sample 39SL2 in the northern settling pond had a concentration of 21,000 mg/kg lead. All of these data, and because of the nature of the release, suggest that contamination above remedial goals is much more widespread in these settling ponds than is depicted in Figure 8-1, and additional sampling is needed to further delineate the area needing remediation.

30. **Section 9.3 on page 9-5 and 9-6** states that the area to be excavated will be delineated via surface and subsurface soil sampling prior to mobilization of the excavation personnel. The section further states that it is assumed that samples would be collected from a total of 80 locations for analysis. Delineation should not be limited to areas identified in Figure 8-1 where contamination is above residential remedial goals. The entire area within both settling ponds needs to be delineated to determine the area that needs remediation. Because the areas to be remediated are likely to be much larger than the area depicted in Figure 8-1, the cost estimate for this alternative will likely be much greater than what is shown in Table 9-2. This comment also applies to Alternative 4 discussed in Section 9.4.

31. **Section 11 on page 11-1** discusses the ranking of the corrective measures alternatives. The section states that based on the ranking, Alternative 4, Excavation of Soil for Clean Close Out and Off-site Disposal, is the selected alternative for the site. The EPA BTAG supports the selection of this alternative. However, remedial goals protective of ecological receptors will need to be developed and used to ensure clean closure of the site. If human health remedial goals are used, the residual contamination may still result in potential ecological risk, and monitoring will be needed to confirm that the cleanup is protective of ecological receptors.

32. **Section 11.0, Ranking of Corrective Measures Alternatives, page 11-1:** This section indicates that the selection criteria for each alternative will be ranked 1 through 5, with a 5 indicating the most favorable alternative and a 1 indicating the least favorable alternative. The rankings for cost do not follow this recommendation, since the least favorable alternative for cost (Alternative 3) is only ranked a 2, not a 1 as previously indicated. Please clarify why the most expensive alternative is not ranked a 1, as proposed in Section 11.0, or revise the Report to rank the least favorable alternative for cost as a "1."

This concludes EPA's review of the Army's draft *RFI/CMS Report* for the investigation of SWMU 39, located at the RFAAP. The referenced draft *RFI/CMS Report* is disapproved by EPA in its current form, and must be revised to reflect the comments above. Per Part II, Section E.4.e. of the EPA RCRA Corrective Action Permit, the Army is required to revise the draft document and submit a revised draft copy to EPA for review within 60 days of the receipt of EPA comments on the draft document. Part II, Section E.4.f. of the Permit allows for an additional 20 days for issuing the revised draft document to EPA, provided that timely notice is given, i.e. within 10 days. Additional time extensions can be requested under Part II, Section F. of the permit.

If you have any questions, please call me at 215-814-3357.

Sincerely,

Robert Thomson

Robert Thomson, P.E., R.E.M.
Federal Facilities Branch

cc: Russell Fish, EPA
Leslie Romanchik, VaDEQ-RCRA
Durwood Willis, VaDEQ-CERCLA

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY

W. Tayloe Murphy, Jr.
Secretary of Natural Resources

Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box 10009, Richmond, Virginia 23240
Fax (804) 698-4500 TDD (804) 698-4021
www.deq.state.va.us

Robert G. Burnley
Director

(804) 698-4000
1-800-592-5482

May 28, 2004

Mr. Jim McKenna
Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100

Re: SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report

Dear Mr. McKenna:

Thank you for providing the Department of Environmental Quality, Office of Remediation Programs, the opportunity to review the SWMU 39 RCRA Facility Investigation/Corrective Measures Study Report. The following are the staff's comments:

Field Investigation Program - Please note in this section that the groundwater investigation will be conducted as part of a base-wide groundwater study. It should also be noted that the existing groundwater monitoring wells may not be sufficient for a field investigation program addressing groundwater.

Field Investigations Program - Based on comments to Addendum 12, it was anticipated that all TAL and TCL analytes would be addressed during the field investigation. Please address the lack of SVOC sampling as part of the field investigation.

Nature and Extent of Contamination - Previous comments by the staff indicated that all data should be reported, not just data for compounds detected. For instance, Table 4-3 provides data for PAHs, but only three compounds are reported.

Contaminant Fate and Transport - Should vanadium be included in Figure 4-1, as it is addressed in this section? Dioxins and furans were detected in several samples, but there is no discussion of the precursors of this class of compounds, other than being derived from the burning of organic matter in the presence chlorine. What were the potential sources of chlorine? Sediment samples collected by the DEQ West Central Regional Office from a drainage way from this SWMU contained PCBs. Why would PCBs be identified in the vicinity of this SWMU?

Development of Corrective Measures Objectives - It appears that the preferred remedial path is to clean close this site. Section 8.4 notes that calculations were performed to determine the volume excavated to meet residential screening values (1,905 cubic yards). This appears to be based on the same depth (2 feet)

as used in the calculation for removal to meet the industrial screening value. Please clarify the determination of the removal volume to meet the residential and industrial levels. It appears that profiling of the depth of contamination would allow more accurate estimation of the volume to be removed. Will the depth of contamination be determined for both settling ponds?

Corrective Measures Development, Alternative Four: Excavation of Soil for Clean Close Out and Off-site Disposal - This alternative should recognize the fact that the base-wide groundwater investigation may necessitate the installation of more wells at SWMU 39 and institutional controls with 5 Year Report requirements. Recognizing that a detailed work plan for implementation of corrective measures will be submitted, it should be noted that as part of the excavation, soils should be evaluated as hazardous using the standard TCLP method. If the material to be excavated is hazardous, then stockpiling of the material is not acceptable. Hazardous wastes should be contained in drums or roll off containers and not stockpiled.

If there are questions concerning these comments, please contact me at 804-698-4192.

Sincerely,

Durwood H. Willis
Federal Facilities Program Manager

cc: Norman L. Auldridge, VDEQ - WCRO
Robert Thompson, US EPA Region III

Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100
USA

May 7, 2004

Mr. Robert Thomson
U. S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Subject: SWMU 39, RCRA Facility Investigation/Corrective Measures Study Report, Draft Document, April 2004
Radford Army Ammunition Plant
EPA ID# VA1 210020730

Dear Mr. Thomson:

Enclosed is one certified copy of SWMU 39, RCRA Facility Investigation/Corrective Measures Study Report, Draft Document, April 2004 Radford Army Ammunition Plant for your review and comment or approval. Your additional three copies will be sent under separate cover as well as additional copies to the Virginia Department of Environmental Quality (VDEQ), U.S. Army Environmental Center, U.S. Army Center for Health Promotion and Preventive Medicine.

Please coordinate with and provide any questions or comments to myself at (540) 639-8266, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

C. A. Jake, Environmental Manager
Alliant Ammunition and Powder Company, LLC

Enclosure

w/o enclosure

c: Russell Fish, P.E., EPA Region III

Durwood Willis
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

Mark Leeper
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

E. A. Lohman
Virginia Department of Environmental Quality
West Central Regional Office
3019 Peters Creek Road
Roanoke, VA 24019

04-815-64
JMcKenna/JJRedder

Tony Perry
U.S. Army Environmental Center
5179 Hoadley Road, Attn: SFIM-AEC-ERP
Aberdeen Proving Ground, MD 21010-5401

Katie Watson
Engineering & Environment, Inc.
7927 Camberley Drive
Powell, TN 37849

Dennis Druck
U.S. Army Center for Health Promotion and Preventive Medicine
5158 Blackhawk Road, Attn: MCHB-TS-HER
Aberdeen Proving Ground, MD 21010-5403

John Tesner
Corps of Engineers, Baltimore District
ATTN: CENAB-EN-HM
10 South Howard Street
Baltimore, MD 21201

Coordination: J. McKenna
J. McKenna

bc: Administrative File
J. McKenna, ACO Staff
Rob Davie-ACO Staff
C. A. Jake
J. J. Redder
Env. File

04-815-64
JMcKenna/JJRedder

Concerning the following:

SWMU 39
RCRA Facility Investigation/Corrective Measures Study Report
Draft Document, April 2004
Radford Army Ammunition Plant

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

SIGNATURE: FOR (CEA)
PRINTED NAME: Anthony R. Skinner
TITLE: LTC, CM, Commanding
Radford AAP

SIGNATURE:
PRINTED NAME: Anthony Miano
TITLE: Vice President Operations
Alliant Ammunition and Powder Company LLC

04-815-64
JMcKenna/JJRedder

RADFORD ARMY AMMUNITION PLANT, VIRGINIA

SWMU 39
RCRA Facility Investigation/ Corrective Measures Study Report

Prepared for:

USACE Baltimore District
10 S. Howard St.
Baltimore, MD 21201

Shaw™

Prepared by:

Shaw Environmental, Inc.
2113 Emmorton Park Rd.
Edgewood, MD 21040
Contract No. DACA31-01-F-0085

Final Document **June 2005**

TABLE OF CONTENTS

Section		*Page*
EXECUTIVE SUMMARY		**ES-1**
1.0	**INTRODUCTION**	**1-1**
2.0	**SITE BACKGROUND**	**2-1**
2.1	Site Description	2-1
2.2	Site Geology	2-4
2.3	Site History and Operations	2-4
2.3.1	Previous Investigations	2-6
3.0	**FIELD INVESTIGATION PROGRAM**	**3-1**
3.1	Soil Sampling Procedures	3-1
3.1.1	Surface Soil	3-2
3.1.2	Subsurface Soil	3-2
3.2	Global Positioning System Activities	3-2
3.3	Management of Investigative-derived Material	3-2
3.4	Quality Assurance	3-3
3.5	Modifications to the Sampling Plan	3-4
4.0	**NATURE AND EXTENT OF CONTAMINATION**	**4-1**
4.1	RCRA Facility Investigation, Shaw, 2002	4-1
4.2	Analytical Results – RCRA Facility Investigation, Shaw, 2002	4-1
4.2.1	Nature and Extent Analysis	4-2
4.3	Conceptual Site Model	4-5
5.0	**CONTAMINANT FATE AND TRANSPORT**	**5-1**
5.1	Inorganic Compounds	5-1
5.1.1	Chromium	5-2
5.1.2	Copper	5-2
5.1.3	Iron	5-3
5.1.4	Lead	5-3
5.1.5	Vanadium	5-4
5.2	Organic Compounds	5-5
5.2.1	Dioxins/Furans	5-5
6.0	**HUMAN HEALTH RISK ASSESSMENT**	**6-1**
6.1	Data Summary and Selection of COPCs	6-1
6.1.1	Methodology for Data Summary	6-4
6.1.2	Methodology for Selection of COPCs for Human Health	6-5
6.1.3	Data Summary and Selection of COPCs for Sampled Media	6-11
6.1.4	Summary of Chemicals Selected as COPCs	6-14
6.2	Human Health Exposure Assessment	6-14
6.2.1	Potential Human Exposure Pathways	6-14
6.2.2	Determination of Exposure Point Concentrations	6-18
6.2.3	Quantification of Dose Due to Chemical Exposures	6-20
6.3	Human Health Toxicity Assessment	6-26

6.3.1 Health Effects Classification and Criteria Development 6-27
6.3.2 Health Effects Criteria for COPCs 6-29
6.3.3 Adjustment for Dermal Absorption 6-32
6.4 Human Health Risk Characterization 6-32
6.4.1 Risk Estimates for Maintenance Workers under Current Land-Use Conditions at SWMU 39 6-33
6.4.2 Risk Estimates for Maintenance Workers under Future Land-Use Conditions at SWMU 39 6-34
6.4.3 Risk Estimates for Excavation Worker under Future Land-Use Conditions at SWMU 39 6-35
6.4.4 Risk Estimates for Adult Residents under Future Land-Use Conditions at SWMU 39 6-36
6.4.5 Risk Estimates for Child Resident under Future Land-Use Conditions at SWMU 39 6-37
6.4.6 Summary of Predominant COPCs at SWMU 39 6-38
6.5 Uncertainties in the HHRA 6-38
6.6 HHRA Summary 6-46

7.0 ECOLOGICAL RISK ASSESSMENT 7-1
7.1 Site Characterization 7-2
7.1.1 General Installation Background 7-2
7.1.2 Surface Water 7-4
7.1.3 Wetlands 7-4
7.1.4 Vegetative Communities 7-4
7.1.5 Species Inventory 7-6
7.1.6 Threatened, Rare and Endangered Species Information 7-6
7.2 Identification of COPECs and Concentration Statistics 7-7
7.2.1 Data Organization 7-7
7.2.2 Descriptive Statistical Calculations 7-14
7.2.3 Frequency of Detection 7-14
7.2.4 Natural Site Constituents (Background and Essential Nutrients) 7-14
7.2.5 Comparison to Risk-Based Screening Ecotoxicity Values 7-14
7.2.6 Summary of COPEC Selection 7-17
7.3 Identification of Exposure Pathways and Potential Receptors for Analysis 7-17
7.3.1 Terrestrial Receptors 7-19
7.4 Identification of Assessment and Measurement Endpoints 7-22
7.4.1 Assessment Endpoints 7-23
7.4.2 Measurement Endpoints 7-24
7.5 Exposure Estimation 7-24
7.5.1 Intake 7-26
7.5.2 Bioaccumulation and Bioconcentration Factors 7-26
7.6 Ecological Effects Characterization 7-27
7.6.1 Selection of Literature Benchmark Values 7-27
7.6.2 Development of Toxicity Reference Values 7-28
7.7 Risk Characterization 7-29
7.7.1 Terrestrial Plant Impact Assessment 7-29
7.7.2 Predictive Risk Estimation for Terrestrial Wildlife 7-30

7.7.3 Background Metals Considerations 7-32
7.8 Uncertainty Analysis 7-34
7.9 SLERA Results and Conclusions 7-36

8.0 DEVELOPMENT OF CORRECTIVE MEASURES OBJECTIVES 8-1
8.1 Summary of Chemicals of Interest 8-1
8.2 Remedial Goals 8-1
8.2.1 Residual Ecological Hazards 8-2
8.3 Site-Specific Corrective Measures Objectives 8-5
8.4 Area and Volume of Contamination 8-5

9.0 CORRECTIVE MEASURES DEVELOPMENT 9-1
9.1 Alternative One – No Further Action 9-1
9.2 Alternative Two – Institutional Controls (Land Use Controls, Groundwater Monitoring) 9-1
9.3 Alternative Three – Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Land Use Controls, Groundwater Monitoring) 9-3
9.4 Alternative Four – Excavation of Soil for Clean Close Out and Off-site Disposal 9-8

10.0 DETAILED ANALYSIS OF CORRECTIVE ACTION ALTERNATIVES 10-1
10.1 Evaluation Criteria 10-1
10.1.1 Effectiveness of the Alternative 10-1
10.1.2 Implementability of the Alternative 10-1
10.1.3 Cost of the Alternative 10-1
10.2 Effectiveness 10-1
10.2.1 Overall Protection of Human Health and the Environment 10-1
10.2.2 Compliance with Federal, State, and Local Regulations 10-2
10.2.3 Long-term Effectiveness and Permanence 10-2
10.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment 10-2
10.2.5 Short-Term Effectiveness 10-2
10.3 Implementability 10-3
10.3.1 Technical Feasibility 10-3
10.3.2 Administrative Feasibility 10-3
10.3.3 Availability of Services and Materials 10-3
10.4 Cost 10-3

11.0 RANKING OF CORRECTIVE MEASURES ALTERNATIVES 11-1

12.0 SUBSTANTIATION/JUSTIFICATION OF FINAL REMEDY 12-1

13.0 REFERENCES 13-1

LIST OF TABLES

Table 2-1	Facility-Wide Point Estimates for Background Soil	2-10
Table 3-1	2002 RFI Environmental Samples and Analyses	3-1
Table 4-1	Analytes Detected in SWMU 39 Soil – 2002 RFI	EOS
Table 4-2	Dioxins/Furans Detected in SWMU 39 Soil – 2002 RFI	EOS
Table 4-3	SWMU 39 Soil Sampling Summary	EOS
Table 4-4	Potential Exposure Pathways and Receptors – SWMU 39	4-7
Table 6-1	Selection of Exposure Pathways	6-2
Table 6-2	Toxicity Equivalency Factors (TEFs)	6-6
Table 6-3	USEPA Region III RBCs for Chemicals Detected at SWMU 39	6-7
Table 6-4	SWMU 39 Sample Groupings	6-12
Table 6-5	Summary of Chemicals of Potential Concern at SWMU 39	6-15
Table 6-6	Samples Collected from Inside Versus Outside the Ponds	6-42
Table 6-7	Comparison of Results from Adult Lead Model Samples Collected Inside versus Outside Ponds	6-43
Table 6-8	Comparison of Results from IEUBK Model Samples Collected Inside versus Outside Ponds	6-44
Table 6-9	Dermal Absorption Factors	6-45
Table 7-1	Ecoregions of RFAAP	7-4
Table 7-2	Species Inventory within RFAAP's Grassland Community Type	7-6
Table 7-3	Threatened, Rare, and Endangered Species in RFAAP's Grassland Community	7-6
Table 7-4	Surface Soil Samples Used in the SWMU 39 SLERA	7-7
Table 7-5	Occurrence, Distribution and Selection of Chemicals of Potential Ecological Concern for Surface Soil at SWMU 39 for Direct Contact Exposure	7-8
Table 7-6	Occurrence, Distribution and Selection of Chemicals of Potential Ecological Concern for Surface Soil at SWMU 39 for Food Chain Exposure	7-10
Table 7-7	Selection of Ecological Screening Toxicity Values for Food Chain Exposure at SWMU 39	7-12
Table 7-8	Exposure Point Concentration Summary for Ecological Receptors for Surface Soil at SWMU 39	7-15
Table 7-9	Wildlife EEQ Hazard Summary for Food Chain Exposure	7-31
Table 7-10	Direct Contact Toxicity Evaluation for Surface Soil at SWMU 39	7-33
Table 7-11	Uncertainty Analysis	7-37
Table 8-1	Identification of Remedial Goals for Arsenic and Vanadium in SMWU 39 Soil	8-2
Table 8-2	Ecological Implications of Human Health Soil RGs on Ecological Receptors	8-3
Table 9-1	Cost for Alternative Two: Institutional Controls (Land Use Controls, Groundwater Monitoring)	9-2
Table 9-2	Cost for Alternative Three: Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls	9-5
Table 9-3	Cost for Alternative Four: Excavation of Soil for Clean Close Out and Off-site Disposal	9-9
Table 10-1	Summary of Costs SWMU 39 Corrective Measures Alternatives	10-3
Table 11-1	Ranking Assessment of Corrective Measures Alternatives	11-2

Note: EOS indicates an oversized table is located at the end of the section.

LIST OF FIGURES

Figure 2-1 Site Location Map, Horseshoe Area, SWMU 39 2-2
Figure 2-2 SWMU 39 Site Map 2-3
Figure 2-3 SWMU 39 Geologic Cross Section Lines A-A' and B-B' 2-5
Figure 2-4 SWMU 39 Geologic Cross Section A-A' ..... EOS
Figure 2-5 SWMU 39 Geologic Cross Section B-B' ..... EOS
Figure 2-6 SWMU 39 Previous Investigations, Sampling Locations and Results ..... EOS
Figure 4-1 SWMU 39, 2002 RFI Soil Sampling Locations and Results ..... EOS
Figure 4-2 SWMU 39 VI and RFI Sampling Locations and Results ..... EOS
Figure 7-1 Simplified Terrestrial Food Web Conceptual Site Exposure Model (CSEM) 7-20
Figure 8-1 SMWU 39 Area of Contamination 8-6

Note: EOS indicates an oversized figure is located at the end of the section.

LIST OF APPENDICES

Appendix A Quality Assurance/Quality Control

- Appendix A-1 Analytical Services and Procedures
- Appendix A-2 Quality Assurance/Quality Control Evaluation
- Appendix A-3 2002 RFI Field Audit Report

Appendix B Previous Investigation Analytical Data Tables and Lithologic Boring Logs

- Appendix B-1 Lithologic Boring Logs
- Appendix B-2 Previous Investigation Analytical Data Tables

Appendix C Sample Location Coordinates and Elevations

Appendix D Contaminant Fate and Transport

Appendix E HHRA Tables and Statistical Comparison Results

- Appendix E-1 HHRA Tables
- Appendix E-2 Statistical Comparison Results

Appendix F SLERA Site Reconnaissance Photographs and Risk Characterization Tables

- Appendix F-1 SLERA Site Reconnaissance Photographs
- Appendix F-2 SLERA Risk Characterization Tables

Appendix G USEPA Guidance Documents and Remedial Goal Calculations

- Appendix G-1 USEPA Guidance Documents
- Appendix G-2 Remedial Goal Calculations

Appendix H National Environmental Policy Act Compliance Evaluation

LIST OF ACRONYMS AND ABBREVIATIONS

°C ..... degrees Celsius
ADD ..... Average Daily Dose
ADI ..... Allowable Daily Intake
ARAR ..... Applicable or Relevant and Appropriate Requirement
ATK ..... Alliant TechSystems, Inc.
ATSDR ..... Agency for Toxic Substances Disease Registry
AUF ..... Area Use Factor
BAF ..... Bioaccumulation Factor
BCF ..... Bioconcentration Factor
BTAG ..... Biological Technical Assistance Group
CD ..... Compact Disc
CFR ..... Code of Federal Regulations
CMO ..... Corrective Measures Objective
CMS ..... Corrective Measures Study
COI ..... Contaminant of Interest
COPC ..... Chemical of Potential Concern
COPEC ..... Chemical of Potential Ecological Concern
CSEM ..... Conceptual Site Exposure Model
CSF ..... Cancer Slope Factor
CSM ..... Conceptual Site Model
DAF ..... Dilution Attenuation Factor
DOT ..... Department of Transportation
DQO ..... Data Quality Objective
EEQ ..... Environmental Effects Quotient
EPC ..... Exposure Point Concentration
ERAGS ..... Ecological Risk Assessment Guidance for Superfund
ERIS ..... Environmental Restoration Information System
FAR ..... Federal Acquisition Regulation
ft bgs ..... feet below ground surface
ft msl ..... feet above mean sea level
FWBSR ..... Facility-Wide Background Study Report
GPS ..... Global Positioning System
GSD ..... Geometric Standard Deviation
HEAST ..... Health Effects Assessment Summary Tables
HHRA ..... Human Health Risk Assessment
HI ..... Hazard Index
H_o ..... Null Hypothesis
HQ ..... Hazard Quotient
HSWA ..... Hazardous and Solid Waste Amendments
HWMU ..... Hazardous Waste Management Unit
ICF KE ..... ICF Kaiser Engineers
IDM ..... Investigative-derived Materials
IEUBK ..... Integrated Exposure Uptake Biokinetic
IRIS ..... Integrated Risk Information System
ISP ..... Incinerator Spray Pond
LADD ..... Lifetime Average Daily Dose
LANL ..... Los Alamos National Laboratory
LOAEL ..... Lowest Observable Adverse Effect Level
m/s ..... meters per second
MCL ..... Maximum Contaminant Level
MDC ..... Maximum Detected Concentration
mg/kg ..... milligrams per kilogram
mg/kg-day ..... mg chemical/kg body weight per day
mg/L ..... milligrams per liter
MHSP ..... Master Health and Safety Plan
mm Hg ..... millimeters Mercury
MMA ..... Main Manufacturing Area

MQAP ..... Master Quality Assurance Plan
MWP ..... Master Work Plan
NCEA ..... National Center for Environmental Assessment
NCP ..... National Contingency Plan
ND ..... Non-Detect
NG ..... Nitroglycerin
ng/kg ..... nanograms per kilogram
NHANES III.. National Health and Nutrition Evaluation Survey
NIBC ..... Not Important Bioaccumulative Constituent
NOAEL ..... No Observable Adverse Effect Level
NRU ..... New River Unit
ORNL ..... Oak Ridge National Laboratory
OSWER ..... Office of Solid Waste and Emergency Response
PAH ..... Polynuclear Aromatic Hydrocarbon
PCB ..... Polychlorinated Biphenyl
PEF ..... Particulate Emission Factor
PETN ..... Pentaerythritol tetranitrate
PID ..... Photoionization Detector
PPE ..... Personal Protective Equipment and Clothing
ppm ..... parts per million
PRG ..... Preliminary Remediation Goal
QA ..... Quality Assurance
QA/QC ..... Quality Assurance/Quality Control
QC ..... Quality Control
RAGS ..... Risk Assessment Guidance for Superfund
RBC ..... Risk-Based Concentration
RCRA ..... Resource Conservation and Recovery Act
RDA ..... Recommended Daily Allowance
RFAAP ..... Radford Army Ammunition Plant
RfC ..... Risk Reference Concentration
RfD ..... Risk Reference Dose
RFI ..... RCRA Facility Investigation
RG ..... Remedial Goal
RME ..... Reasonable Maximum Exposure
RTE ..... Rare, Threatened, or Endangered
RTEC ..... Registry of Toxic Effects Concentrations
Shaw ..... Shaw Environmental, Inc.
SLERA ..... Screening Level Ecological Risk Assessment
SMDP ..... Scientific/Management Decision Point
SQL ..... Sample Quantitation Limit
SSL ..... Soil Screening Level
SVOC ..... Semivolatile Organic Compound
SWMU ..... Solid Waste Management Unit
TAL ..... Target Analyte List
TCL ..... Target Compound List
TCLP ..... Toxicity Characteristic Leachate Procedure
TCLPRL ..... Toxicity Characteristic Leachate Procedure Regulatory Limit
TE ..... Toxicity Equivalent
TEF ..... Toxicity Equivalence Factor
TMV ..... Toxicity, Mobility, or Volume
TOC ..... Total Organic Carbon
TRV ..... Toxicity Reference Value
TSDF ..... Treatment, Storage, and Disposal Facility
UCL ..... Upper Confidence Limit
USACE ..... U.S. Army Corps of Engineers
USEPA ..... U.S. Environmental Protection Agency
UTL ..... Upper Tolerance Limits
VDEQ ..... Virginia Department of Environmental Quality
VI ..... Verification Investigation
VOC ..... Volatile Organic Compound
WHO ..... World Health Organization

EXECUTIVE SUMMARY

Shaw Environmental, Inc. conducted a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Solid Waste Management Unit (SWMU) 39, the Wastewater Ponds from the Propellant Incinerators, during the month of July 2002. The investigation is required by the 2000 RCRA Corrective Action permit (USEPA, 2000a) for the Radford Army Ammunition Plant (RFAAP) and was performed in accordance with Master Work Plan (MWP) Addendum 012 (IT, 2002a). MWP Addendum 012 was prepared to facilitate the investigation effort to comply with the requirements set forth in the 2000 RCRA Corrective Action permit and was approved by the U.S. Environmental Protection Agency (USEPA) Region III and the Virginia Department of Environmental Quality (VDEQ).

Three previous investigations were conducted at SWMU 39, including the 1987 RCRA Facility Assessment, the 1992 Verification Investigation (VI), and the 1998 RFI. The 1992 VI identified lead and thallium concentrations in composite pond samples and thallium in surface soil adjacent to a former (now RCRA clean closed) concrete-lined incinerator spray pond [Hazardous Waste Management Unit (HWMU) 39] at levels exceeding industrial screening levels. The 1998 RFI also detected lead concentrations above industrial screening levels in the ponds, but did not confirm thallium exceedances inside the ponds or in monitoring well borings outside the ponds.

Previous investigation sampling strategies were targeted towards chemicals that may have been present at SWMU 39, based on site history. Per the 2000 RCRA permit, a broader sampling strategy was required to complete the delineation of known site contaminants and characterize the site for chemical parameters not previously investigated. A sampling strategy was developed in MWP Addendum 012 (IT, 2002a) to complete the delineation and characterization of the site. 2002 RFI activities included the collection and chemical and physical analysis of eight surface and four subsurface soil samples from the settling ponds and from the perimeter areas surrounding the ponds. These samples and chemical results from the previous investigations were combined for the nature and extent assessment.

This assessment indicated that organic constituents [volatile organic compounds (VOCs), semivolatile organic compounds/polynuclear aromatic hydrocarbons (SVOCs/PAHs), pesticides/polychlorinated biphenyls (PCBs), herbicides, and explosives] are not a concern at the site. Cumulative toxicity equivalents for dioxins/furans were greater than the residential screening level in a surface soil sample collected in the southern settling pond and greater than the industrial soil screening level in a surface soil sample collected in the northern settling pond. Iron (one sample) and lead were detected in soil at concentrations greater than industrial screening levels in the ponds. Samples collected during the 2002 RFI to verify elevated thallium concentrations detected during the 1992 VI contained thallium concentrations less than the residential screening level. In addition, there is no history of the use of thallium in or near SWMU 39 and it is further believed that the detections may be the result of false positives. Therefore, the analytical data indicates that lead in the surface soil of the settling ponds is the constituent of greatest concern.

Fate and transport analysis indicates that elevated levels of lead are immobile under site conditions and confined to surface soil in the settling ponds. The migration of lead in the subsurface environment is controlled by the solubility of lead complexes and adsorption to aquifer materials (USEPA, 1997d). Adsorption to soil greatly limits the mobility of lead in the

environment. Lead may be immobilized by ion exchange with hydrous oxides or clays or by chelation with humic or fulvic acids in the soil (USEPA, 1997d). This appears to be occurring within the settling ponds.

A Human Health Risk Assessment (HHRA) was conducted at SWMU 39 to identify potential risks at the site. The risks associated with five exposure scenarios were calculated at the site: current maintenance workers, future maintenance workers, future excavation workers, future adult residents, and future child residents. The potential cumulative risk for the current maintenance worker, the future maintenance worker, and the excavation worker were less than the USEPA's target risk range. The potential cumulative risks for the adult and child residents were within the USEPA's target risk range. The potential cumulative hazard index (HI) for the current and future maintenance worker and adult resident scenarios were less than 1. The potential cumulative HI for the future excavation worker scenario was slightly above 1; no individual chemical was equal to or greater than 1. The potential cumulative HI for the future child resident scenario was above 1, primarily due to vanadium and iron. The margin-of-exposure evaluation indicated that the intake from iron was within the allowable range. Lead was also evaluated as a chemical of potential concern (COPC) in the HHRA at SWMU 39 using the Adult Lead Model for the worker scenarios and the Integrated Exposure Uptake Biokinetic (IEUBK) model for the resident scenarios. For each scenario, site concentrations of lead in surface soil and total soil were above the health protective criterion for lead.

A Screening Level Ecological Risk Assessment (SLERA) was also conducted at SWMU 39 to identify potential hazards to ecological receptors. The assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles, from food-chain exposure, as well as a potential reduction in food supply from elevated concentrations of lead, copper, and chromium. For food-chain exposure, the primary hazard drivers were lead and dioxins/furans in surface soil. Thallium, chromium, and copper were secondary hazard drivers in surface soil for this exposure pathway.

Because the RFI demonstrated that lead and dioxin/furan contamination is present at concentrations associated with unacceptable human health concerns and potential impacts to ecological receptors, an evaluation of corrective measures to address lead and dioxins/furans in soil was performed.

Four corrective measures alternatives were evaluated as part of this RFI/Corrective Measures Study (CMS) Report. These alternatives consist of the following:

- Alternative One: No Further Action;
- Alternative Two: Institutional Controls (Land Use Controls, Groundwater Monitoring);
- Alternative Three: Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Land Use Controls, Groundwater Monitoring); and,
- Alternative Four: Excavation of Soil for Clean Close Out and Off-site Disposal.

These four alternatives were evaluated using the selection criteria: effectiveness, implementability, and cost. The corrective measures objective (CMO) for this RFI/CMS is to reduce contaminant concentrations in soil to levels that are protective of industrial workers at the site. However, the Army has also elected to evaluate residential exposure pathways to assess what the increase in remedial effort would be to remediate the site for unrestricted future reuse and facilitate clean close out. Therefore, residential Remedial Goals (RGs) were developed and credit was given to those alternatives that met this more stringent criterion.

Alternative Four was selected as the final alternative for SWMU 39 because it is implementable and provides a greater level of protection to human health and the environment not provided by the other Alternatives. Alternative Four is the sole alternative that facilitates clean close out. By achieving clean close out, Alternative Four accomplishes the Army Installation Restoration Program goal by cleaning up the SWMU 39 study area and restoring it for beneficial reuse. The other two clean up alternatives do not achieve such a goal. In addition, Alternative Four has a lower cost than Alternative Three and meets CMOs, which Alternative Two does not. Alternative Four can be implemented in approximately one year. This time frame is considered an estimate and the actual time to complete the corrective measures will be impacted by site-specific conditions. The total estimated cost for this alternative is $1,130,000.

This alternative includes the following:

- Delineation of soil containing contaminants of interest (COIs) above the Residential RG;
- Excavation of the delineated area such that the remaining soil is below the Residential RG;
- Transporation and off-site disposal of soil; and,
- Site restoration activities.

Implementation of this alternative will reduce the concentrations of COIs to levels below the Residential RGs and facilitate clean close out. In addition, the proposed human health RGs for residential land use is expected to result in residual chemical of potential ecological concern (COPEC) concentrations in surface soil that significantly reduce environment hazards. Therefore, implementation of this alternative meets the corrective action objective and is protective of human health and the environment.

165

1.0 INTRODUCTION

Shaw Environmental, Inc. (Shaw) was tasked by the U.S. Army Corps of Engineers (USACE), Baltimore District, to perform additional characterization activities at eight sites in the Main Manufacturing Area (MMA) and six sites at the New River Unit (NRU) of Radford Army Ammunition Plant (RFAAP), in accordance with Contract No. DACA31-01-F-0085.

Samples were collected for most analyte classes during previous investigations at these sites; however, data gaps existed in certain chemical parameters and in delineating the extent of identified contamination. A data review, including the development of a conceptual site model (CSM) and conducting a data gap analysis, was performed for each site in Master Work Plan (MWP) Addendum 012 (IT, 2002a). Once the data needs were identified, sampling strategies were developed to complete characterization and delineation for each site.

The field investigation at Solid Waste Management Unit (SWMU) 39, the Wastewater Ponds from the Propellant Incinerators, was specifically conducted to:

1. further assess the potential horizontal and vertical migration of lead and thallium within the settling ponds;
2. confirm and delineate the horizontal extent of thallium concentrations previously detected in surface soil east of the Resource Conservation and Recovery Act (RCRA) closed spray pond;
3. verify that elevated concentrations of metals are confined to the settling ponds; and,
4. characterize site media within and outside the ponds for previously untested analyte classes which included, target compound list (TCL) volatile organic compounds (VOCs), pesticides, polychlorinated biphenyls (PCBs), herbicides, explosives (including nitroglycerin [NG] and pentaerythritol tetranitrate [PETN]), and dioxins/furans. In addition, soil samples were analyzed for total organic carbon (TOC), grain size, and pH to assess the bioavailability and mobility of constituents in the soil.

This data, in conjunction with the existing data, provided a sufficient data set for completion of a Nature and Extent of Contamination Assessment (*Section 4.0*), Fate and Transport Evaluation (*Section 5.0*), a Human Health Risk Assessment (HHRA) (*Section 6.0*), and a Screening Level Ecological Risk Assessment (SLERA) (*Section 7.0*) for the SWMU 39 study area.

Based on the results of the human health and ecological risk assessments, it was decided that evaluation of potential remedial actions to address arsenic, lead, vanadium, and dioxins/furans [as TCDD toxicity equivalent (TE)] in soil was necessary. The purpose of the Corrective Measures Study (CMS) portion of this document was to develop and evaluate corrective measure alternatives and to recommend corrective measures to be implemented at SWMU 39. The CMS portion of this report presents corrective action objectives (*Section 8.0*), development of alternatives (*Section 9.0*), a detailed analysis of alternatives (*Section 10.0*), and a ranking (*Section 11.0*) and substantiation (*Section 12.0*) for the selection of the final remedy for SWMU 39.

Field activities were conducted in accordance with the MWP, Master Quality Assurance Plan (MQAP), the Master Health and Safety Plan (MHSP) (URS, 2003), and MWP Addendum 012 (IT, 2002a), as approved by U.S. Environmental Protection Agency (USEPA) Region III and the

Virginia Department of Environmental Quality (VDEQ). Modifications to MWP Addendum 012 proposed sampling activities are presented in *Section 3.5*.

The CMS was performed in compliance with the RFAAP RCRA Permit requirements (EPA ID No. VA1210020730) and the Final RCRA Corrective Action Plan (USEPA, 1994d). These documents provided guidance on the scope and the approach for the CMS portion of this report.

2.0 SITE BACKGROUND

2.1 Site Description

SWMU 39 consists of two unlined and bermed earthen ponds **(Photos 1 and 2)** and is located in the north-central section of the Horseshoe Area **(Figure 2-1)**, adjacent to and associated with the

Photo 1. Southeast view of northern settling pond

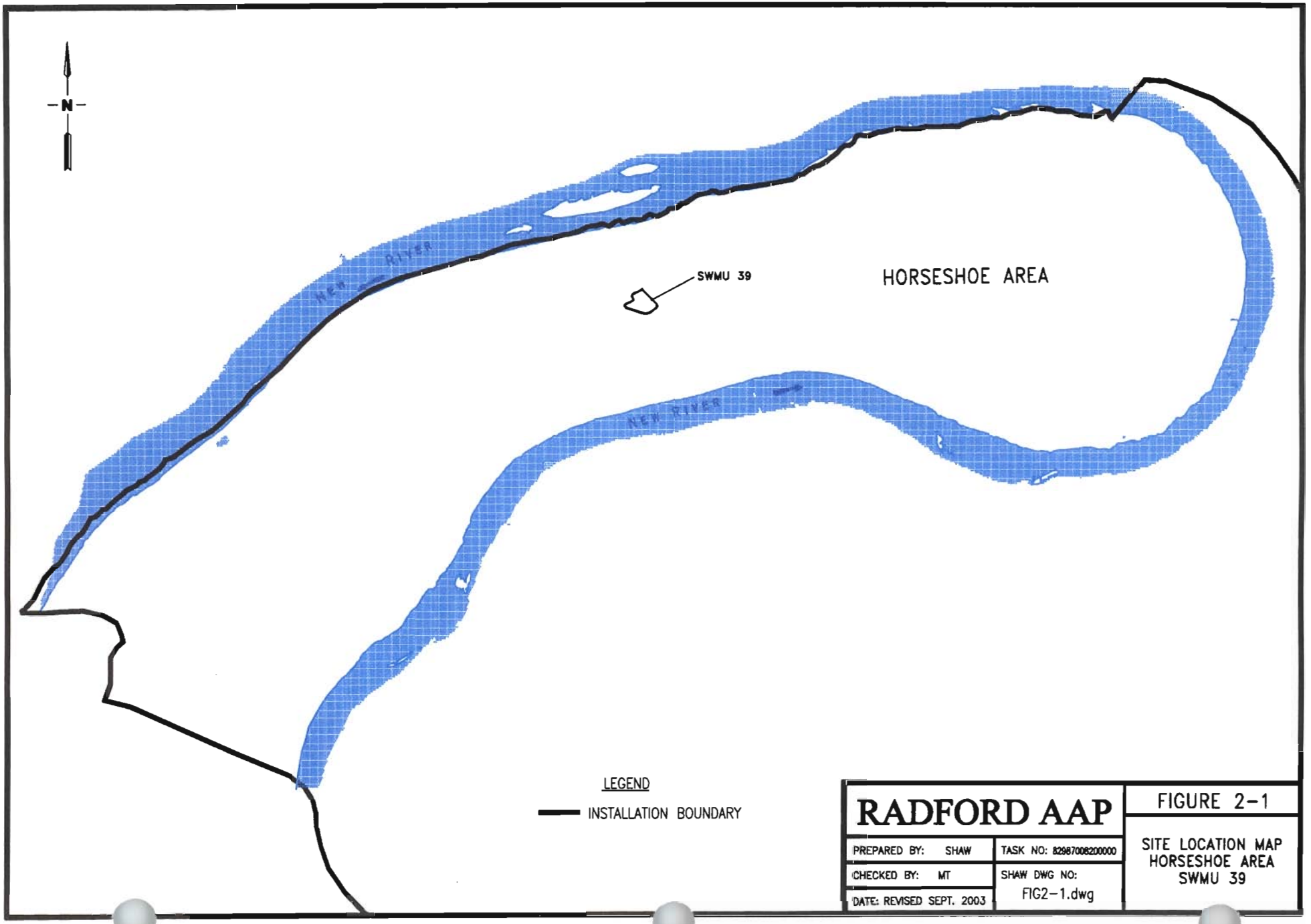
Photo 2. Southeast view of southern settling pond

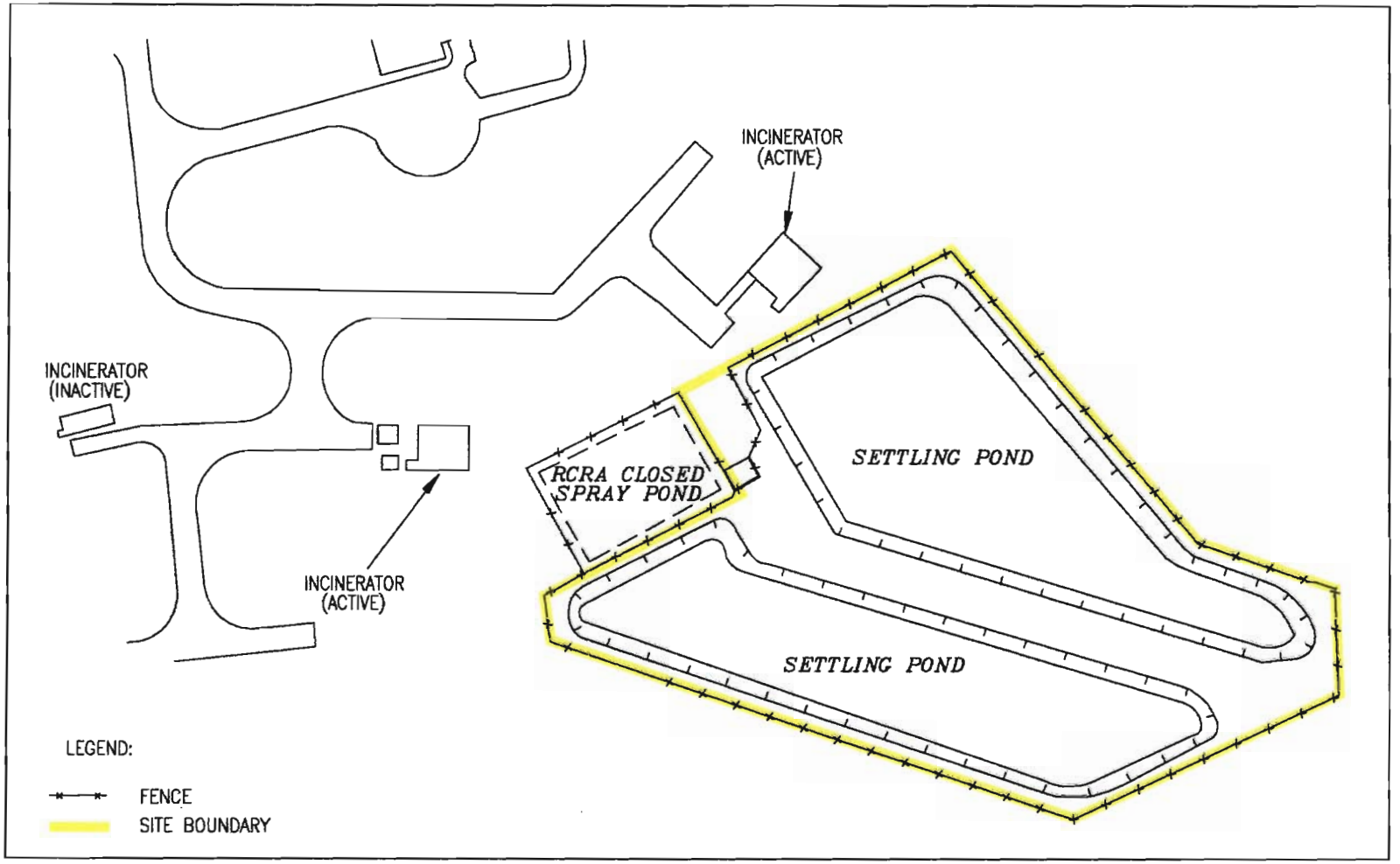
Hazardous Waste Incinerators. The SWMU is adjacent to a RCRA closed concrete-lined spray pond [Hazardous Waste Management Unit (HWMU) 39]. A site map depicting the locations of the settling ponds, the hazardous waste incinerators, and the former location of the incinerator spray pond (ISP) is presented on **Figure 2-2**.

The ISP was a concrete-lined pond used for the collection of incinerator scrubber wastewaters. The wastewater was reused as scrubber water for the incinerator. The Army and Hercules (the operating contractor for RFAAP at the time the spray pond was built) discovered that scrubber water collected in the ISP contained lead from the incinerated propellants and the sludges which formed in the basin met the standards for a characteristic hazardous waste. The ISP was demolished and the associated concrete basin and pipes were removed. After completion of a risk assessment for risk-based closure, the ISP was accepted as clean closed by the VDEQ and backfilled with clean soil (ATK, 1998).

The earthen settling ponds received scrubber and precooler quench water from incinerator exhaust. The settling ponds were excavated approximately 6 to 8 feet into the natural grade and contain no drainage outlet. The excavated material was used to create a berm that surrounds each pond. A fence surrounds the ponds, and the enclosed area is approximately 450-ft. by 300-ft. at the widest points. Caustic was reportedly added to neutralize the water received in the two settling ponds. Settled material has not been removed from the ponds (ATK, 1998).

SWMU 39 is a generally flat level area, at an elevation of approximately 1,700 feet above mean sea level (ft msl). A small section of the southern boundary rises to a maximum elevation of approximately 1,720 ft msl. Because the settling ponds are no longer in use, surface water is not present in the ponds except during heavy rain, snow melt or other precipitation events.


N
NEW RIVER
SWMU 39
HORSESHOE AREA
NEW RIVER
LEGEND
INSTALLATION BOUNDARY
RADFORD AAP
PREPARED BY: SHAW
TASK NO: 82987008200000
CHECKED BY: MT
SHAW DWG NO:
FIG2-1.dwg
DATE: REVISED SEPT. 2003
FIGURE 2-1
SITE LOCATION MAP
HORSESHOE AREA
SWMU 39



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RADFORD AAP

FIGURE 2-2

PREPARED BY: SHAW	TASK NO: 82967008200000
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DATE: REVISED NOV. 2003	

SWMU 39
SITE MAP

2.2 Site Geology

Stratigraphic characterization of the subsurface was performed during the advancement of soil and monitoring well borings at the site. Geologic cross-sections were developed based on the logging descriptions recorded during the advancement of these borings **(Appendix B-1)**. A plan view of the cross-sectional lines A-A' and B-B' is presented on **Figure 2-3**. The geologic cross sections are presented on **Figures 2-4 and 2-5** (oversized; located at the end of this section).

Borings advanced at the site ranged from 11.5 ft (39SB3) to 50 ft (39MW1) in depth. A layer of unconsolidated sediments ranging from 11.5 to 28 ft thick overlies bedrock at the site. The overburden deposits range from clay to gravel and can be divided into two general units, a finer grained deposit, consisting primarily of clay, silt and fine sand, and a coarser grained unit, consisting of sand and silt with gravel present.

As depicted on **Figures 2-4 and 2-5**, the upper layer [6-10 ft below ground surface (bgs)] consists of fine-grained, yellowish-red to reddish-brown sandy silt, sandy clay, or silty sand. The depositional environment for this unit was likely a flood plain, where flood waters with a high sediment load would deposit silt and clay away from the main river channel. The two settling ponds were excavated into this layer.

Below this layer, the soil is yellowish-red to brown sand and silty gravel. The amount of fines (clay and silt) in this layer is lower than in the upper layer and coarser sand and gravel begins to appear. This layer consists of fluvial deposits, where larger sand particles and gravel are deposited, but smaller silt and clay grains are carried away by the current. This layer becomes more gravelly with depth. The coarser grained fluvial deposits are incised into the overbank deposits and, in places, (39SB2 and 39MW4) the finer grained deposits are still seen in contact with bedrock.

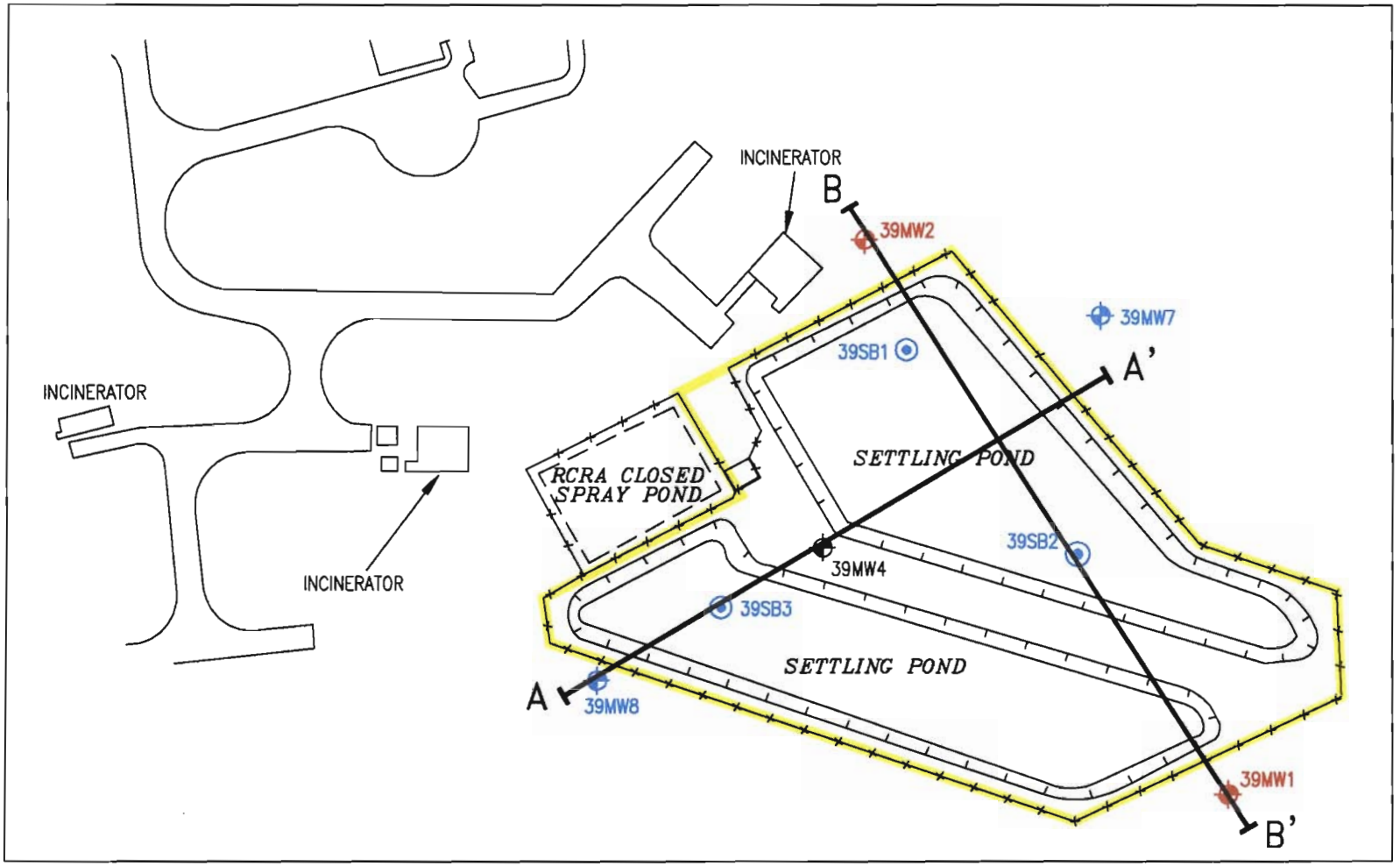
The Elbrook Formation underlying the site consists of argillaceous limestone and dolostone and is generally light gray to bluish-gray. The bedrock exhibits typical karst characteristics with evidence of subsurface solution features. The consistency of bedrock ranges from soft to hard with numerous weathered and fractured zones. Clay and silt-filled voids and solution cavities were encountered in four of the eight well borings, at depths of 20 to 37 ft bgs (39MW1: 20-30 ft; 39MW3: 20-35 ft; 39MW7: 21-25 ft; and 39MW8: 33-37 ft).

Groundwater conditions in the SWMU 39 vicinity are controlled by the karstic nature of the Elbrook Formation. Groundwater was encountered during 1998 RFI well installation within fracture and solution zones of the bedrock at depths ranging from 23 to 33 ft. Groundwater flow in the vicinity of SWMU 39 is to the west, northwest at a shallow hydraulic gradient. Observed subsurface conditions indicate that groundwater movement below SWMU 39 would likely be rapid through fractures, voids, and solution cavities with eventual discharge into the New River.

2.3 Site History and Operations

SWMU 39 consists of two unlined, earthen ponds that were associated with the Hazardous Waste Incinerators. According to the aerial photographic interpretation contained in the Installation Assessment (USEPA, 1992d), construction activity of the ponds was first noted at the site in 1975. Excavation of the ponds appeared to be completed by 1981.

Three incinerators were constructed at the site in 1979 to incinerate slurried waste and off-specification explosives and propellants. The westernmost incinerator was the prototype for the other two incinerators and is inactive. As described in USEPA (1987), the incinerators are



LEGEND:

- 1994 VI MONITORING WELL (DAMES & MOORE)
- 1997 RFI MONITORING WELL (ALLIANT TECHSYSTEMS)
- 1998 RFI MONITORING WELL (ICF KAISER)
- FENCE
- SITE BOUNDARY

0 100 FEET

SCALE

FILE: FIG 2-3.dwg PLOT: 11-20-03

RADFORD AAP		FIGURE 2-3
PREPARED BY: SHAW	TASK NO: 82987008200000	SWMU 39 GEOLOGIC CROSS SECTION LINES A-A' AND B-B'
CHECKED BY: MT	SHAW DWG NO: FIG 2-3	
DATE: REVISED NOV. 2003		

equipped with a refractory lined rotary kiln into which the propellant slurry is injected and incinerated. Combustion gasses are passed through an afterburner to effect total combustion. The exhaust gasses then pass through a water quench precooler to reduce the temperature prior to passing through a wet scrubber to remove noxious gasses and particulates. The gasses are exhausted and the wastewaters from both the quench towers and scrubbers were conveyed to the settling ponds (SWMU 39).

2.3.1 Previous Investigations

Three previous investigations have been conducted at this site. In 1987, under authority of the 1984 Hazardous and Solid Waste Amendments (HSWA), USEPA conducted a RCRA Facility Assessment at the site to evaluate releases of hazardous waste or hazardous waste constituents and to implement corrective actions, as necessary. In1992, in accordance with the 1989 RCRA permit requirements, Dames & Moore performed Verification Investigation (VI) sampling to evaluate potential contamination resulting from site activities. In 1998, ICF Kaiser Engineers (ICF KE) conducted an RFI to further characterize the nature and extent of contamination at the settling ponds through the investigation of surface and subsurface soil. These investigations and results of the chemical data are summarized below.

For the contamination assessment of SWMU 39, chemical results from the VI and RFI are compared to adjusted USEPA Region III industrial and residential risk-based concentrations (RBCs) (USEPA, 2004a), where non-carcinogenic analytes are adjusted downward to a hazard index (HI) of 0.1, as well as facility-wide background inorganic concentrations (IT, 2001), and other regulatory criteria. Industrial and residential RBCs were adjusted downward to an HI of 0.1 for non-carcinogenic compounds to ensure that chemicals with additive effects are not prematurely eliminated during screening. Current (April, 2004) RBC screening values and background 95% upper tolerance limits (UTLs) are presented for comparison in **Appendix B-2, Tables B-1 through B-3**. Analytical results for inorganics are indicated on the tables and figures as exceedances when they exceed both the background value and a screening value. Eliminating screening level exceedances in the contamination assessment of SWMU 39 that are below background values allows site-specific constituents to be more clearly indicated on the tables and figures.

2.3.1.1 RCRA Facility Assessment, USEPA, 1987

An assessment was conducted at the unit to evaluate potential hazardous waste or hazardous constituent releases and implement corrective actions, as necessary. The assessment consisted of a preliminary review and evaluation of available site information, personnel interviews, and a visual inspection of the site. During the 1987 Visual Site Inspection, environmental samples were not collected as part of the inspection and no visible signs of release were observed.

As reported in USEPA (1987), a sample was collected on 02 September 1983 from one of the settling ponds for characterization. Analysis from the sample did not exhibit hazardous waste characteristics as outlined in 40 Code of Federal Regulations (CFR) 261.34. Analytical results were reported as follows:

EP Toxicity (mg/L)	
Arsenic	0.010
Barium	1.1
Cadmium	< 0.1
Chromium	0.3
Lead	0.2
Mercury	0.0010
Selenium	0.012
Silver	< 0.1
Ignitability	Not ignitable at 60 °C
Corrosivity	Not corrosive
Reactivity	Not reactive

2.3.1.2 Verification Investigation, Dames & Moore, 1992

The VI field sampling program (Dames & Moore, 1992) consisted of the collection of three surface soil and two composite samples at the site to evaluate the following two environmental concerns at SWMU 39:

- Potential contamination of surface soil adjacent to the former ISP, and
- Leaching of constituents accumulating in the two unlined settling ponds.

Surface soil and composite samples were analyzed for Target Analyte List (TAL) metals, semivolatile organic compounds (SVOCs), and explosives. Sample locations and chemical results detected above residential and industrial screening levels and background (IT, 2001) criteria are shown on **Figure 2-6** (oversized; located at the end of this section). Detected analytical results are presented in **Appendix B-2, Tables B-1 and B-2**.

Surface Soil. To evaluate the potentially affected surface soil, three surface soil samples (39SS1, 39SS2, and 39SS3) were collected east of the former ISP. Samples were collected from a depth of 0–6 inches below the surface gravel and root zone. Detected analytical results for the soil samples are presented in **Appendix B-2, Table B-1**.

SVOCs and explosives were not detected in the soil samples. Eighteen of the 19 TAL metals detected were reported at concentrations below their respective residential screening levels. Thallium concentrations exceeded the industrial screening level of 14 milligrams per kilogram (mg/kg) in two of the three samples. Thallium was not detected in the third sample (39SS3). The highest concentration of thallium (22.7 mg/kg) was reported in sample 39SS1, located at the northeast corner of the spray pond.

It is believed that the thallium detections may be the result of false laboratory positives. For ICP SW-846 6010B analysis, which was the method most likely used for this analysis, the high concentrations of aluminum (14,400–22,800 mg/kg) and iron (25,100–33,600 mg/kg) in the samples may cause false positives. Aluminum concentrations greater than 1,000 mg/kg may

cause interference with thallium determination if not properly corrected for during analysis. Additionally, it should be noted that there is a high reporting limit for thallium in these samples. Method 6010B usually has a reporting limit of approximately 1-2 mg/kg. The reporting limit for 1992 VI samples was 10 times higher, indicating a possible 10x dilution, which would enhance the magnitude of error for the data reported. Given the high aluminum and iron, it is likely that the sample had interferences for the thallium and thus was possibly diluted and reported. This is further verified by the 10x higher reporting limit than normal for Method 6010B. The thallium values detected were less than the reporting limit, and therefore, in accordance with USACE (2001), should be considered estimated in terms of usability.

Composite samples. Two composite samples were collected from the settling ponds. Composite samples were collected from three locations in each settling pond to form a single sample that was representative of each pond (**Figure 2-6**). At each location, a sample was collected from 0–1 ft below the pond surface. Detected constituents in the samples are presented in **Appendix B-2, Table B-2.**

Analytical results indicated that chromium and copper concentrations (206 and 403 mg/kg, respectively) were detected between residential and industrial screening levels in the northern settling pond. Lead (21,000 mg/kg) and thallium (28 mg/kg) concentrations exceeded their respective industrial screening levels (800 mg/kg and 14 mg/kg, respectively) in the northern settling pond. Thallium (32.3 mg/kg) was also detected above its industrial screening level in the southern pond sample (39SL3). TCL SVOCs were detected in the northern settling pond at concentrations below residential screening levels. Explosives were not detected in either pond.

2.3.1.3 RCRA Facility Investigation, ICF KE, 1998

An RFI was conducted in 1998 by ICF KE (ICF KE, 1999) to further characterize the nature and extent of contamination identified during the 1992 VI at the settling ponds through the investigation of surface and subsurface soil. Soil borings were advanced within the ponds to confirm the 1992 VI composite sample results and assess the vertical extent of the detected concentrations. In addition, a monitoring well boring was advanced north and south of the settling ponds to assess the nature and extent of constituent migration in soil and groundwater outside of the ponds. Sample locations and chemical results detected above residential and industrial screening levels and background (IT, 2001) criteria are shown on **Figure 2-6.** Detected constituents are presented in **Appendix B-2, Tables B-3 and B-4.**

Northern Pond. One surface soil (39SB1A) and six subsurface soil samples were collected from the northern pond and analyzed for TAL metals, TCL SVOCs, and polynuclear aromatic hydrocarbons (PAHs). Subsurface soil samples were collected to a depth of 12-14 ft below the pond surface. Four additional samples were collected and analyzed for Toxicity Characteristic Leachate Procedure (TCLP) metals and physical parameters (grain size, percent moisture, and bulk density). SVOC/PAH concentrations were below the residential screening levels in the surface and subsurface soil samples and TCLP results (**Appendix B-2, Table B-4**) were below the TCLP regulatory limit (TCLPRL).

Analytical results for TAL metals indicated that lead exceeded its industrial screening level and chromium and copper exceeded residential screening levels in surface soil sample 39SB1A (0-0.5 ft), located in the northeast corner of the pond. Lead exceeded the residential screening level in the same boring (39SB1) in sample 39SB1B, collected at a depth of 1-2 ft. Chromium and copper concentrations were less than the residential screening level at this interval. Results from

the deeper sample from this boring (39SB1D: 6-8 ft) indicate that lead concentrations are below background at this depth. Results from boring 39SB2, collected from the southern end of the northern pond, were below background or residential screening levels.

Southern Pond. One surface soil (39SB3A) and five subsurface soil samples were collected from the southern pond and analyzed for TAL metals, TCL SVOCs, and PAHs. Subsurface soil samples were collected to a depth of 6-8 ft in the southern pond. Four additional samples were collected and analyzed for TCLP metals and physical parameters (grain size, percent moisture, and bulk density). SVOC/PAH concentrations were below the residential screening levels in the surface and subsurface soil samples and TCLP results (**Appendix B-2, Table B-4**) were below the TCLPRL.

TAL metals results from the southern pond indicated that barium, beryllium, iron and lead were greater than background in samples collected from less than two feet. Iron exceeded the industrial screening level in sample 39SB3B (1-2 ft). The remaining constituents exceeding background, including lead, were less than residential screening levels. Samples collected from a depth of greater than two feet from the southern pond had metals concentrations less than background or residential screening levels.

Well Borings. Four subsurface soil samples were collected during the advancement of two monitoring well borings (39MW7 and 39MW8). Well borings were advanced north of the northern settling pond (39MW7) and south of the southern settling pond (39MW8). One sample was collected from each boring at a depth approximately equal to the bottom of the settling ponds (6-8 ft bgs) and a second sample was collected 8 ft below the pond bottom (14-16 ft bgs). Samples were analyzed for TAL metals, TCL SVOCs, and PAHs. There were no residential exceedances in the samples collected from the well borings.

Results from the 1998 RFI indicate that screening level exceedances are limited to metals within the top two feet of the ponds. Lead, copper and chromium were detected in the northern pond above residential (industrial for lead) screening levels. Iron exceeded the industrial screening level in one sample from the southern pond. Samples collected at depths greater than two feet in the settling ponds did not have residential or background exceedances. Results from samples collected outside the settling ponds (i.e., monitoring well borings) were also below the residential screening levels.

2.3.1.4 Facility-Wide Background Study, IT Corporation, 2001

A Facility-Wide Background Study was conducted at the MMA and NRU at RFAAP in 2001. Task objectives were to characterize naturally occurring background soil inorganic concentrations to establish a baseline for inorganic compounds of concern at RFAAP. Data was statistically evaluated across soil types, soil horizons, and study areas to assess the potential for expanding the effective data into one set. Statistical tests demonstrated that the data was statistically similar across soil types and study areas, resulting in one set of background values for both surface and subsurface soil. Facility-wide point estimates for background soil data were calculated as 95% UTLs and are presented in **Table 2-1.** In general, UTLs were calculated as follows:

$$UTL = \overline{X} + k(a)$$

where:

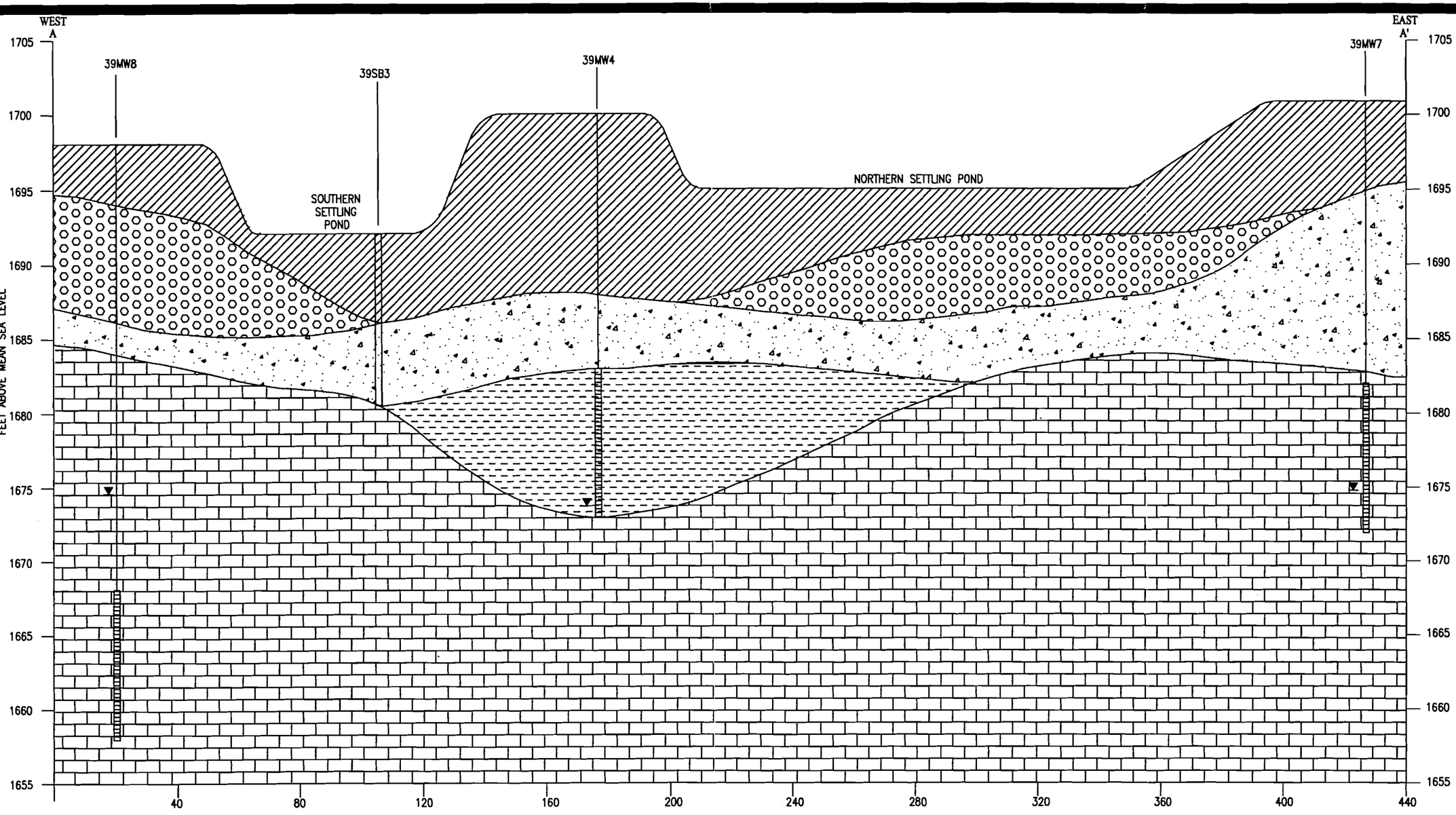
UTL = upper tolerance limit (confidence factor of 0.95 and coverage of 95%)
$\bar{x}$ = arithmetic mean
a = standard deviation
k = tolerance factor

Table 2-1
Facility-Wide Point Estimates for Background Soil

Chemical Name	Range of Data (mg/kg)	Background Concentration 95 % UTL (mg/kg)
Aluminum	3,620 - 47,900	40,041
Arsenic	1.2 - 35.9	15.8
Barium	23.4 - 174	209
Beryllium	0.61 - 5.4	1.02
Cadmium	0.62 - 2.5	0.69
Chromium	6.3 - 75.8	65.3
Cobalt	5.9 - 130	72.3
Copper	1.6 - 38.7	53.5
Iron	7,250 - 67,700	50,962
Lead	2.1 - 256	26.8
Manganese	16.7 - 2,040	2,543
Mercury	0.038 - 1.2	0.13
Nickel	4.6 - 94.2	62.8
Thallium	1.3 - 5.0	2.11
Vanadium	12.2 - 114	108
Zinc	4.7 - 598	202

It should be noted that for seven (aluminum, arsenic, chromium, iron, manganese, thallium, and vanadium) of the constituents, the 95% UTLs are greater than their respective residential screening levels. In addition, the 95% UTLs for arsenic, iron, manganese, and vanadium are greater than their industrial screening levels.

Inorganic constituents detected at concentrations exceeding screening levels are compared to the background concentrations to assess whether these metals are present at concentrations greater than naturally occurring levels. Inorganics detected at concentrations less than background levels are not considered site-related constituents in the Nature and Extent of Contamination Assessment.



LEGEND

- CLAY AND SILT, LITTLE SAND, RED–BROWN (CL)
- SILT, SOME SAND, SOME CLAY, ORANGE–BROWN (ML)
- SILT AND SAND, GRAVEL ORANGE–BROWN (CM/SM)
- SILT, SAND, AND GRAVEL, ORANGE–BROWN (GM)
- LIMESTONE, GRAY–BROWN, ARGILLACEOUS (LMSN)

NOTE:
1) 39MW4 LITHOLOGY FROM ALLIANT TECHSYSTEMS (1997).
2) WATER LEVELS MEASURED FEBRUARY 2003

HORIZ. SCALE: 0 20 40

VERT. SCALE: 0 5 10

FILE: FIG 2-4.dwg PLOT: 10-3-03

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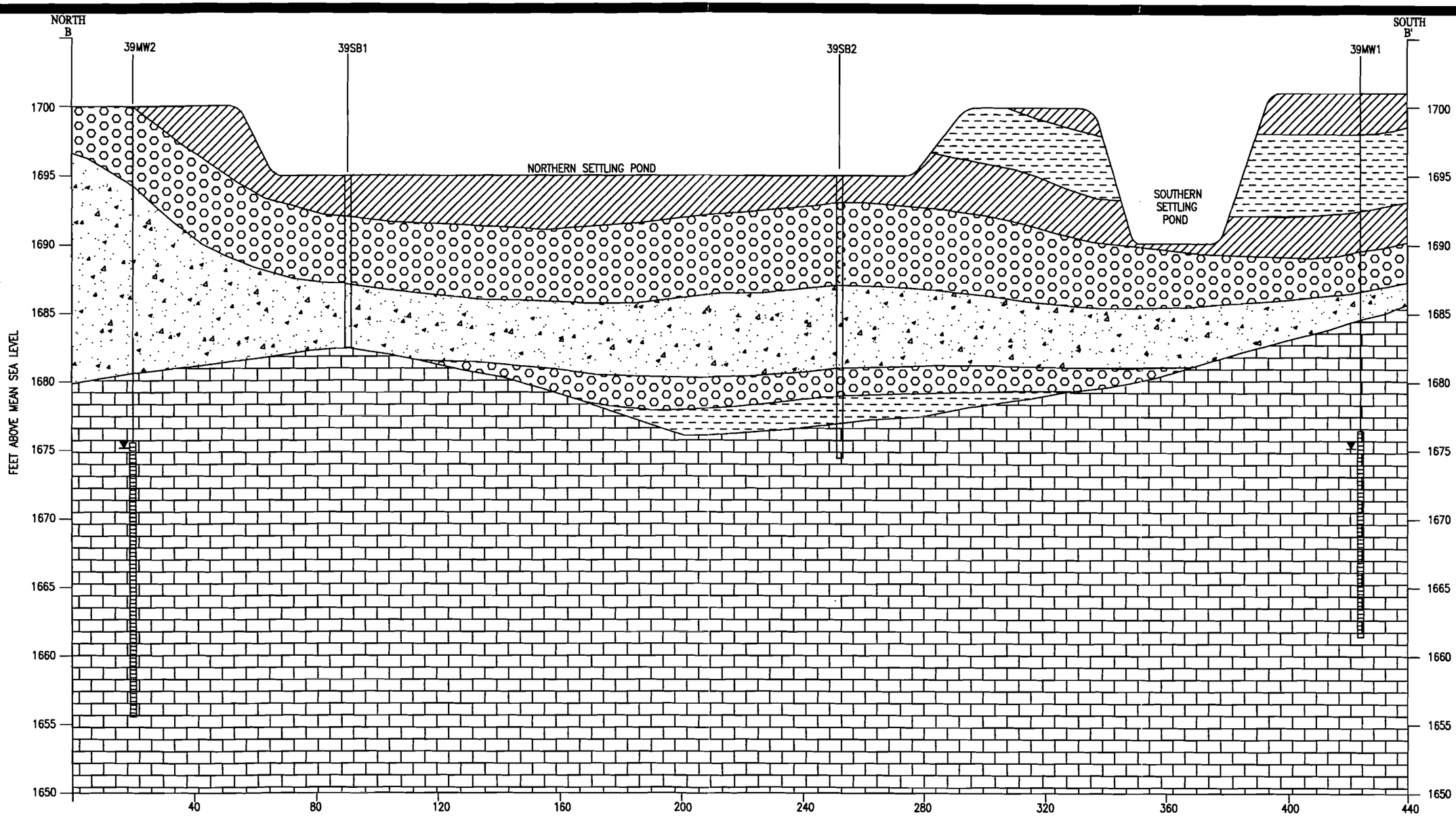
PREPARED BY: SHAW	TASK NO: 82987006200000
CHECKED BY: MT	SHAW DWG NO: FIG 2-4
DATE: REVISED SEPT. 2003	

FIGURE 2-4

SWMU 39
GEOLOGIC CROSS SECTION A-A'



LEGEND

- CLAY AND SILT, LITTLE SAND, RED–BROWN (CL)
- SILT, SOME SAND, SOME CLAY, ORANGE–BROWN (ML)
- SILT AND SAND, GRAVEL ORANGE–BROWN (CM/SM)
- SILT, SAND, AND GRAVEL, ORANGE–BROWN (GM)
- LIMESTONE, GRAY–BROWN, ARGILLACEOUS (LMSN)

NOTE:
1) 39MW1 AND 39MW2 LITHOLOGY FROM DAMES AND MOORE (1993).
2) WATER LEVELS MEASURED FEBRUARY 2003

HORIZ. SCALE: 0 20 40

VERT. SCALE: 0 5 10

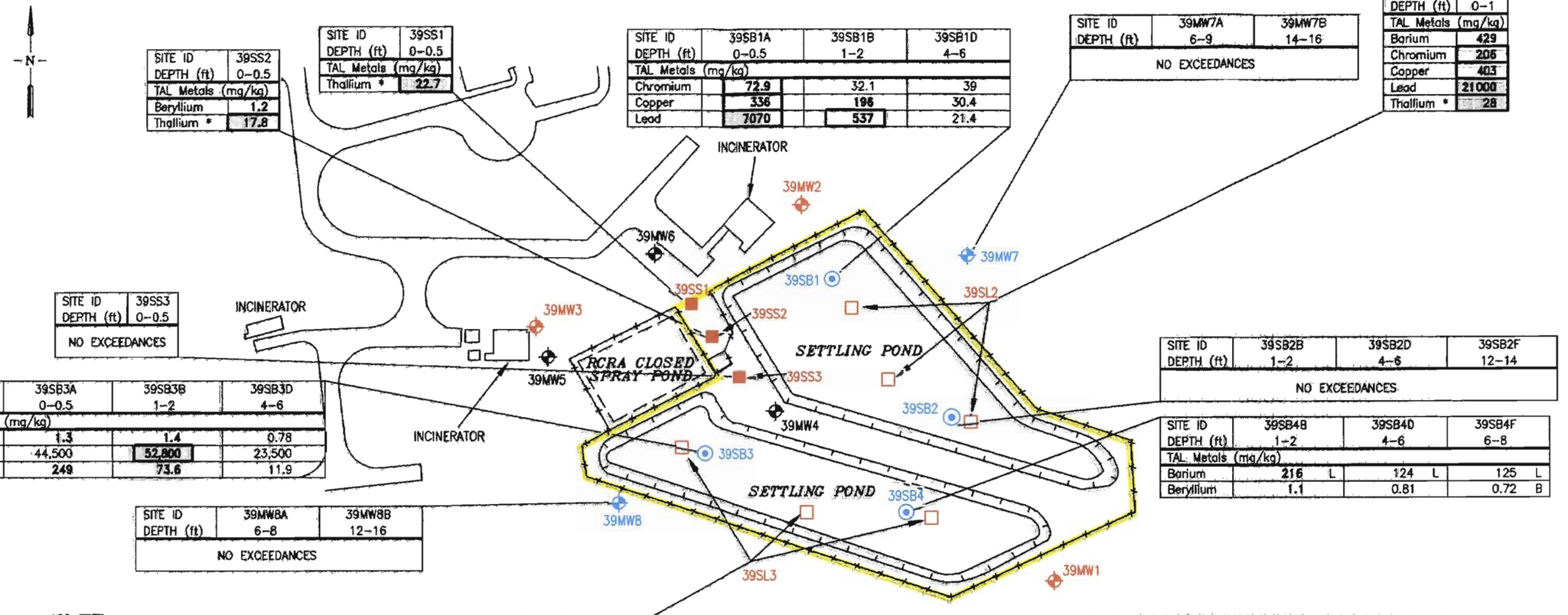
FILE: FIG 2-5.dwg PLOT: 10-3-03

RADFORD AAP

PREPARED BY: SHAW	TASK NO: 82987008200000
CHECKED BY: MT	SHAW DWG NO: FIG 2-5
DATE: REVISED SEPT. 2003	

FIGURE 2-5

SWMU 39
GEOLOGIC CROSS
SECTION B-B'



SITE ID	39SS2
DEPTH (ft)	0–0.5
TAL Metals (mg/kg)	
Beryllium	1.2
Thallium *	17.8

SITE ID	39SS1
DEPTH (ft)	0–0.5
TAL Metals (mg/kg)	
Thallium *	22.7

SITE ID	39SB1A	39SB1B	39SB1D
DEPTH (ft)	0–0.5	1–2	4–6
TAL Metals (mg/kg)			
Chromium	72.9	32.1	39
Copper	336	196	30.4
Lead	7070	537	21.4

SITE ID	39MW7A	39MW7B
DEPTH (ft)	6–9	14–16
NO EXCEEDANCES		

SITE ID	39SL2
DEPTH (ft)	0–1
TAL Metals (mg/kg)	
Barium	429
Chromium	206
Copper	403
Lead	21000
Thallium *	28

SITE ID	39SS3
DEPTH (ft)	0–0.5
NO EXCEEDANCES	

SITE ID	39SB2B	39SB2D	39SB2F
DEPTH (ft)	1–2	4–6	12–14
NO EXCEEDANCES			

SITE ID	39SB3A	39SB3B	39SB3D
DEPTH (ft)	0–0.5	1–2	4–6
TAL Metals (mg/kg)			
Beryllium	1.3	1.4	0.78
Iron	44,500	52,800	23,500
Lead	249	73.6	11.9

SITE ID	39SB4B	39SB4D	39SB4F
DEPTH (ft)	1–2	4–6	6–8
TAL Metals (mg/kg)			
Barium	216 L	124 L	125 L
Beryllium	1.1	0.81	0.72 B

SITE ID	39MW8A	39MW8B
DEPTH (ft)	6–8	12–16
NO EXCEEDANCES		

SITE ID	39SL3
DEPTH (ft)	0–1
Beryllium	1.16
Lead	33.4
Thallium *	32.3

Sample Summary

Previous Investigation	Contractor	TAL Metals SS	TAL Metals SB	TAL Metals SE	Explosives SS	Explosives SE	TCL SVOCs SS	TCL SVOCs SB	TCL SVOCs SE	PAHs SS	PAHs SB	TCLP Metals SB	Total
1992 VI	D&M	3	--	3C	3	3C	3	--	3C	--	--	--	18
1997 Closure of Spray Pond	ATK	8	16	--	--	--	8	16	--	--	--	--	48
1998 RFI	ICF Kaiser	2	14	--	--	--	2	14	--	2	14	8	56

LEGEND:

- 1992 VI SOIL SAMPLE (DAMES & MOORE)
- 1992 VI WASTE COMPOSITE SAMPLE (DAMES & MOORE)
- 1994 VI MONITORING WELL (DAMES & MOORE)
- 1997 RFI MONITORING WELL (ALLIANT TECHSYSTEMS)
- 1998 RFI MONITORING WELL (BORING) (ICF KAISER)
- 1998 RFI SOIL BORING (ICF KAISER)
- FENCE
- SITE BOUNDARY

NOTE:

J = ESTIMATED CONCENTRATION
L = ESTIMATED CONCENTRATION BIAS LOW
* CONSIDERED FALSE LABORATORY POSITIVES; SEE SECTION 2.3.1.2 FOR DETAILS
DARK BORDER = VALUE EXCEEDS THE RESIDENTIAL SCREENING LEVEL (USEPA; APRIL, 2004)
SHADING = VALUE EXCEEDS THE INDUSTRIAL SCREENING LEVEL (USEPA; APRIL, 2004)
BOLD = VALUE EXCEEDS THE BACKGROUND CRITERION (IT, 2001)
VALUES DETECTED BELOW BACKGROUND ARE NOT SHOWN

RADFORD AAP

FIGURE 2–6

SWMU 39
PREVIOUS INVESTIGATIONS
SAMPLING LOCATIONS
AND RESULTS

PREPARED BY: SHAW
CHECKED BY: MT
DATE: REVISED APRIL 2004
TASK NO: 826700820000
SHAW DWG NO: FIG 2–6

FILE: FIG2–6.dwg PLOT: 2–16–04

3.0 FIELD INVESTIGATION PROGRAM

3.1 Soil Sampling Procedures

Surface and subsurface soil samples were collected for chemical and physical analysis during 2002 RFI sampling activities at SWMU 39 (**Table 3-1**). A groundwater investigation is currently being conducted to address groundwater on a regional basis within the Horseshoe Area of RFAAP. Sampling locations were selected based on previous sample results, site visit observations, negotiations with regulators, and the CSM.

Table 3-1
2002 RFI Environmental Samples and Analyses

Media	Sample ID	Depth	Analyses	Purpose
Surface Soil	39SB05A	0–0.5 ft bgs	TCL VOCs*, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, TOC, grain size, pH	Further assess the potential horizontal and vertical migration of lead and thallium within the settling ponds and assess pond soil for previously untested analyte classes.
	39SB06A	0–0.5 ft bgs	TCL VOCs*, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans	
	39SS07	0–0.5 ft bgs	TCL VOCs*, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans	Confirm and delineate (bound) the horizontal extent of thallium concentrations previously detected in surface soil east of the RCRA closed spray pond
	39SS08	0–0.5 ft bgs	TAL metals	
	39SS09	0–0.5 ft bgs	TAL metals	Verify that elevated concentrations of metals are confined to the settling ponds
	39SS10	0–0.5 ft bgs	TAL metals	
	39SS11	0–0.5 ft bgs	TAL metals	
	39SS12	0-0.5 ft bgs	TAL metals	
Subsurface Soil	39SB05B	1–3 ft bgs	TCL VOCs, PCBs, explosives, TAL metals, dioxins/furans	Further assess the potential horizontal and vertical migration of lead and thallium within the settling ponds and assess pond soil for previously untested analyte classes.
	39SB05C	3–5 ft bgs	TCL VOCs, PCBs, explosives, TAL metals, dioxins/furans	
	39SB06B	1–3 ft bgs	TCL VOCs, PCBs, explosives, TAL metals, dioxins/furans	
	39SB06C	3–5 ft bgs	TCL VOCs, PCBs, explosives, TAL metals, dioxins/furans	

Refer to **Appendix A-1, Table A-1** for the preparation and analytical methodologies used.
* VOCs were collected from a depth of 0.5-1.0 ft

Upon retrieval of soil for sample processing, the soil was field screened for the presence of volatile organic vapors using a properly calibrated photoionization detector (PID). Field screening consisted of cutting a cross-sectional slice from the core or center of the sample with a decontaminated stainless steel trowel and inserting the PID probe. After the PID readings were recorded, a sample for VOC analysis was immediately collected from the appropriate interval using a disposable EnCore sampler.

Once the fraction for VOC analysis was collected, the soil recovered from the boring was classified by the site geologist and recorded in the field logbook. Soil for non-VOC analysis was then extracted from the appropriate interval, placed in a stainless steel bowl, and homogenized. The appropriate sample containers were filled, labeled, and placed into coolers with ice and maintained at 4 degrees Celsius (°C).

3.1.1 Surface Soil

One surface soil sample was collected within each settling pond, four surface soil samples were collected from the perimeter of the ponds, and two surface soil samples were collected near the former ISP during the 2002 RFI. As described in *Section 5.2.9* of the MWP (URS, 2003), surface soil samples were collected from 0 to 0.5 ft for non-VOC analyses. Surface soil samples for VOC analysis were collected from 0.5-1.0 ft. For combined analysis of previous sampling data (*Section 4.1.2* of this report), soil samples collected from 0 to 2 ft are considered surface soil.

Once the vegetative mat was removed at sampling locations 39SS07 though 39SS12 using a decontaminated spade shovel, soil from 0-0.5 ft was collected using a stainless steel trowel and placed in a stainless steel bowl. Because subsurface soil samples were proposed below surface soil samples 39SS05A and 39SS06A (within the former ponds), these samples were collected using direct push methodologies. Soil for VOC analysis was collected from 0.5-1.0 ft using an EnCore sampler. Following VOC collection, soil from the 0-0.5 ft interval was homogenized in a stainless steel bowl for the non-VOC fraction.

3.1.2 Subsurface Soil

Two subsurface soil samples (1-3 and 3-5 ft bgs) were collected from borings in each former pond. Subsurface soil samples were collected using a truck-mounted direct push Geoprobe. The direct push rig was equipped with 1.25-in diameter push rods; 4-ft long, 2-in diameter stainless steel open-tube macro-core samplers; and stainless steel cutting shoes. The macro-core samplers were lined with a dedicated 4 ft long, 1.5-in diameter Teflon sample tube. Using a hydraulic percussion hammer, the Geoprobe drove the open-tube macro-core sampler to the proposed sampling depth. Following the withdrawal of the macro-core and the removal of the Teflon tube, a cutting device was used to remove a 1-3/8-in section along the length of the tube to access the soil stratigraphic characterization and sample processing. Once adequate sample volume was achieved, the boring hole was backfilled with bentonite chips. In accordance with *Section 5.2.8.1* and SOP 20.3 of the MWP (URS, 2003), the bentonite chips were hydrated by adsorbing moisture from the ground; additional re-hydration was not performed. Excess soil cuttings remaining after sample processing were temporarily stored in a 55-gallon drum at an Installation-approved area.

3.2 Global Positioning System Activities

Sample location coordinates and elevations were obtained using a Trimble Pathfinder Pro XRS Global Positioning System (GPS). The Pathfinder Pro XRS system was used to obtain real-time position information with submeter accuracy and elevations at 1.5 to 2 times the horizontal accuracy. Horizontal position information was recorded in the U.S. State [Virginia (South)] Plane Coordinate System (measured in U.S. survey feet) using the North American Datum of 1983. The vertical control was measured in feet using the National Geodetic Vertical Datum of 1929. Position information will be entered into the Environmental Restoration Information System (ERIS) database. Sample location coordinates and elevations are presented in **Appendix C**.

3.3 Management of Investigative-derived Material

Activities were performed in accordance with Addendum 012, as approved by USEPA Region III and the VDEQ, regarding the identification, handling, and disposal of nonhazardous

investigative-derived materials (IDM). Material disposal was documented in the field logbook. Specific compliance issues that were confronted during investigative activities included the following:

- **Accumulation and storage.** IDM accumulated during field sampling activities included soil cuttings, decontamination water, direct push acetate liners, and personal protective equipment and clothing (PPE). Soil cuttings and decontamination water were stored in separate appropriately labeled 55-gallon steel drums. Direct push acetate liners and used PPE were stored together in 55-gallon drums. Containerized materials were stored at Installation-approved areas.
- **Material characterization.** Soil cuttings and decontamination water were sampled before disposal to assess waste characteristics, in accordance with 40 CFR 264 and Virginia Hazardous Waste Management Regulations. Based on analytical results, soil and decontamination water sampled were classified as nonhazardous materials.
- **Transporter, storage, and disposal facility.** Soil cuttings, acetate liners, and PPE were disposed of at Cloyds Mountain Landfill in Pulaski County, VA. Before disposal, waste profile results were provided to the Installation, IDM management subcontractor, and the disposal facility for review and approval. An alternate straight bill of lading was obtained before transport of IDM from the accumulation and storage areas to the disposal facility. Disposal records were provided to the Installation and are kept on file by Shaw.
- **Decontamination water.** Following analysis, the Installation and RFAAP Wastewater Treatment Plant engineers were provided with a copy of the decontamination water sample results for review. After receiving approval, decontamination water from both the MMA and the NRU was disposed into the collection system of the Wastewater Treatment Plant.

3.4 Quality Assurance

Quality assurance (QA) is defined as the overall system for assuring the reliability of data produced. The system integrates the quality planning, assessment, and improvement efforts of Shaw and its subcontractors, to provide the independent QA program necessary to establish and maintain an effective system for collection and analysis of environmental samples and related activities. The program encompasses the review and assessment of the documentation, data validation, and the data quality indicators including precision, accuracy, completeness (generation of usable and complete data), representativeness, comparability, and sensitivity.

The accuracy and integrity of RFI data were ensured through the implementation of internal quality control measures in accordance with MWP Addendum 012 (IT, 2002a), as approved by USEPA Region III and the VDEQ. QA and quality control (QC) activities, including field QC, laboratory QC, data management, and data validation were integrated into the investigation program to meet data quality objectives (DQOs) established for the RFI. The data were evaluated for each of the DQO indicators in **Appendix A-2, Table A-3** and found to meet the pre-established goals. Qualified data did not impact the data quality of the RFI. Complete details of the RFI QA/QC analysis and activities are presented in **Appendices A-2 and A-3**. Chemical data validation reports and analytical data are provided on a compact disc (CD) found at the back of this report.

3.5 Modifications to the Sampling Plan

In some cases, modifications to the Work Plan are necessary to adjust for field conditions as they occur during field sampling. One adjustment to MWP Addendum 012 (IT, 2002a) was necessary during sampling activities at SWMU 39, as described below.

The settling ponds are evaporation ponds that are normally dry except when influenced by rain events. No standing water was present in either pond during sampling activities; therefore, as specified in MWP Addendum 012, proposed surface water/sediment sample sets 39SW/SD01 and 39SW/SD02 were not collected in support of the field sampling program.

4.0 NATURE AND EXTENT OF CONTAMINATION

The following sections provide a discussion of the site conditions and the nature and extent of chemicals found in soil at SWMU 39, Wastewater Ponds from Propellant Incinerators. Chemical results from this report are compared to adjusted USEPA Region III industrial and residential RBCs (USEPA, 2004a), where non-carcinogenic analytes are adjusted downward to an HI of 0.1, as well as facility-wide background inorganic concentrations (IT, 2001), and other regulatory criteria. Industrial and residential RBCs were adjusted downward to an HI of 0.1 for non-carcinogenic compounds to ensure that chemicals with additive effects are not prematurely eliminated during screening. Current (April, 2004) RBC screening values and background 95% UTLs are presented for comparison in **Table 4-1**, **Table 4-2**, and **Figure 4-1** (oversized tables and figure; located at the end of this section). Analytical results for inorganics are indicated on the tables and figures as exceedances when they exceed both the background value and a screening value. Eliminating screening level exceedances that are below the background value allows site-specific constituents to be more clearly indicated on the tables and figures. The results of the 2002 RFI are presented separately. The combined analytical data from SWMU 39 investigations is discussed in *Section 4.2.2*.

4.1 RCRA Facility Investigation, Shaw, 2002

Surface Soil. Eight surface soil samples were collected from 0–0.5 ft bgs (0.5-1.0 ft bgs for VOCs) at SWMU 39. Four surface soil samples (39SS09, 39SS10, 39SS11, 39SS12) were collected from the perimeter of the settling ponds and analyzed for TAL metals to verify that elevated concentrations of metals are confined to the settling ponds. Two samples (39SB05A and 39SB06A), one from each pond, were analyzed for TCL VOCs, pesticides/PCBs, TAL metals, herbicides, explosives, and dioxins/furans to assess site surface soil for previously untested analyte classes. Sample 39SB05A was also analyzed for TOC, grain size and pH to assess the availability of constituents in soil. Samples 39SS07 and 39SS08 were positioned between the former ISP and the northern settling pond to confirm and delineate the horizontal extent of thallium concentrations previously detected in surface soil sample 39SS1 during the 1992 VI. Sample 39SS08 was analyzed for TAL metals. Sample 39SS07 was analyzed for TAL metals plus TCL VOCs, pesticides/PCBs, herbicides, explosives, and dioxins/furans to further assess surface soil outside the ponds for previously untested analyte classes.

Subsurface Soil. Four subsurface soil samples (39SB05B, 39SB05C, 39SB06B, 39SB06C) from two borings were collected from within the settling ponds and analyzed for TCL VOCs, PCBs, explosives, TAL metals, and dioxins/furans to further assess the potential vertical migration of constituents within the settling ponds and assess pond soil for previously untested analyte classes. Samples 39SB05B and 39SB05C were collected from boring 39SB05 advanced in the northern pond. Samples 39SB06B and 39SB06C were collected from boring 39SB06 advanced in the southern pond. Samples 39SB05B and 39SB06B were collected from depths of 1–3 ft bgs and samples 39SB05C and 39SB06C were collected from 3-5 ft bgs.

4.2 Analytical Results – RCRA Facility Investigation, Shaw, 2002

Eight surface soil samples (0-0.5 ft bgs) and four subsurface soil samples (1-3 and 3-5 ft bgs) were collected. Detected constituents are presented in **Tables 4-1 and 4-2**. Exceedances of regulatory screening levels and background are presented on **Figure 4-1**.

VOCs. Acetone was detected in one (39SS07) of the seven samples tested for VOCs. The concentration was less than the residential screening level.

Pesticides. Three surface soil samples were analyzed for pesticides. Eight pesticides were detected at concentrations below residential screening levels.

PCBs. PCBs were not detected in surface or subsurface soil.

Explosives. Two explosives compounds (2,4-dinitrotoluene and NG) were detected. No sample concentrations exceeded residential screening levels in surface or subsurface soil.

Herbicides. Three surface soil samples were analyzed for herbicides. Herbicides were not detected in the samples.

Dioxins/Furans. Twenty-five dioxins/furans were detected in the soil samples. Concentrations of 2,3,7,8-TCDD were below the residential screening level of 4.3 nanograms per kilogram (ng/kg). Analysis of dioxin-like compounds was treated according to procedures provided by USEPA and the World Health Organization (WHO) and toxicity equivalent (TE) numbers were calculated (USEPA, 1989b, 1994a; WHO, 1998). An explanation of the calculation of the TEs for dioxins/furans is discussed in *Section 6.1.1.* The cumulative TE for dioxins/furans (TCDD TE) (20.67 ng/kg) exceeded the industrial screening level of 19 ng/kg in surface soil sample 39SB05A, collected in the northern settling pond. The TCDD TE (4.53 ng/kg) for surface soil sample 39SB06A was above the residential screening level in the southern settling pond. Subsurface soil sample TCDD TEs were below the residential screening level.

TAL Metals. Chromium and copper exceeded residential screening levels in surface soil sample 39SB06A in the southern pond. Lead exceeded the industrial screening level in the two surface soil samples collected within the settling ponds (39SB05A: northern pond and 39SB06A: southern pond). Lead concentrations in these samples were 4,530 mg/kg and 16,500 mg/kg, respectively. The lead concentration (800 mg/kg) in subsurface soil sample 39SB05C (3-5 ft bgs) was equal to the industrial screening level, although the sample above it (39SB05B,1-3 ft bgs) had a lead concentration of 138 mg/kg, which is below the residential screening level. Lead concentrations in the remaining soil samples were below the residential screening level. Results from the two samples (39SS07 and 39SS08) collected adjacent to the 1992 VI samples (39SS2 and 39SS3) that indicated industrial exceedances of thallium, did not verify elevated thallium concentrations at these locations. Thallium concentrations in the 2002 samples were below the residential screening level.

Physical Testing. Surface soil sample 39SB05A was analyzed for TOC, grain size, and pH to assess the bioavailability and mobility of constituents in the soil. The TOC concentration was 4,560 mg/kg. Grain size analysis indicated that surface soil in the northern pond is silty sand, comprised of 59% sand and 41% silt and clay. The pH of surface soil measured at 39SB05A was 4.00. Discussions of how the physical and chemical properties affect the fate and persistence of contaminants in the impacted soil of the settling ponds are presented in *Section 5.0 – Contaminant Fate and Transport.*

4.2.1 Nature and Extent Analysis

This section evaluates the combined analytical data collected from previous investigations and the 2002 RFI. **Tables 4-1 and 4-2** present the 2002 RFI results for detected constituents. Previous investigation analytical data is presented on **Figure 2-6 and Appendix B-2, Tables B-1 through B-3**. **Figure 4-2** (oversized; located at the end of this section) presents exceedances of analytes from both the current and previous investigations. The combined chemical database from the SWMU 39 investigations is presented in **Table 4-3** (oversized; located at the end of this section).

PCBs and herbicides were not detected in soil samples inside or outside the ponds, indicating that these chemical parameters are not a concern at SWMU 39. SVOCs, PAHs, VOCs, pesticides, and explosives compounds were detected, but did not exceed residential screening levels inside or outside the ponds; therefore, these compounds are also not a concern at this site.

Results from the investigations at SWMU 39 indicate that soil in the northern and southern settling ponds was impacted by activities at the site. A summary of the exceedances within each of these areas is described below.

Northern Settling Pond. One composite, three surface soil, and six subsurface soil samples were collected in the northern settling pond. Subsurface soil samples were collected to a depth of 14 ft in the pond. Two metals (chromium and copper) exceeded residential screening levels in surface soil sample 39SB1A and composite sample 39SL2. There were no exceedances of either of these metals in subsurface samples. These results indicate both limited concentrations and vertical migration of these two metals. Two metals (lead and thallium) exceeded industrial screening levels in the pond. Lead was detected at concentrations greater than its industrial screening level in two surface soil samples (39SB1A and 39SB05A), composite sample 39SL2, and in one subsurface soil sample collected from 3-5 ft (39SB05C). There were no lead exceedances in two 4-6 ft depth interval samples and one 12-14 ft depth interval sample. Lead also exceeded its residential screening level in one subsurface soil sample (39SB1B) collected from 1-2 ft. Thallium exceeded its industrial screening level in the composite sample (39SL2). Thallium concentrations in the 1998 and 2002 RFI samples collected from northern settling pond were below the residential screening level, indicating that elevated concentrations of thallium detected during the 1992 VI are non-repeatable and therefore considered anomalous. There were no exceedances of individual dioxins/furans; however, the calculated TCDD TE for dioxins/furans exceeded the industrial screening level in surface soil sample 39SB05A. The TCDD TEs were below the residential screening level in subsurface soil samples below sample 39SB05A.

Southern Settling Pond. One composite, three surface soil, and six subsurface soil samples were collected in the southern settling pond. Subsurface soil samples were collected down to a depth of 8 ft in the pond. Two metals (chromium and copper) and the TCDD TE for dioxins/furans exceeded residential screening levels in surface soil sample 39SB06A. There were no exceedances of these compounds in subsurface soil samples, indicating limited vertical migration of these compounds. Three metals (lead, iron, and thallium) exceeded industrial screening levels in the pond. Lead was detected above the industrial screening level in surface soil sample 39SB06A. Iron exceeded its industrial screening level in sample 39SB3B (1-2 ft). Thallium exceeded its industrial screening level in composite sample 39SL3. Again, thallium results from the 1998 and 2002 RFI samples collected within the southern settling pond were below the residential screening level and did not verify elevated thallium concentrations detected during the 1992 VI. 1992 thallium results in the southern settling pond are considered non-repeatable and therefore anomalous. There were no residential or industrial screening level exceedances in subsurface samples below two feet.

Areas Outside of Settling Ponds. Ten surface soil and three subsurface soil samples were collected in areas outside the ponds to assess whether soil outside the ponds had been impacted by site activities. Subsurface soil samples were collected to a depth of 16 ft bgs. Thallium was the sole constituent found to exceed screening levels outside the settling ponds. Industrial screening level exceedances of thallium were reported in surface soil samples (39SS1 and 39SS2) collected in the area between the RCRA closed former ISP and the northern settling pond

in 1992. These sample results were not replicated in 2002 RFI samples (39SS07 and 39SS08) collected from surface soil adjacent to the VI samples. In addition, surface soil samples collected from around and in between the settling ponds contained concentrations of thallium below the residential screening level. These results and data from each of the soil samples collected outside the ponds indicate that soil outside the pond area has not been impacted by site activities.

4.2.1.1 Soil Screening Level Comparison

As shown in **Tables 4-1, 4-2,** and **Appendix B-2, Tables B-1 through B-3**, chemical concentrations detected in surface and subsurface soil samples collected from the SWMU 39 study area were compared to USEPA Region III Soil Screening Level (SSL) soil transfer to groundwater values, using a dilution attenuation factor (DAF) of 20 (USEPA, 2004a). As shown in the tables and summarized in **Table 4-3**, two TAL metals (chromium and thallium) and the TCDD TE for dioxins/furans were found to exceed SSLs.

Chromium was found to exceed its SSL of 42 mg/kg in three of the 33 samples collected from the site. Chromium concentrations ranged from 72.9 mg/kg in surface soil sample 39SB1A to 206 mg/kg in composite sample 39SL2. Thallium was found to exceed its SSL of 3.6 mg/kg in four of the 33 samples collected from the site. Thallium exceedances ranged from 17.8 mg/kg in surface soil sample 39SS2 to 32.3 mg/kg in composite sample 39SL3. The TCDD TE for dioxins/furans (20.67 ng/kg) exceeded the 2,3,7,8-TCDD SSL of 8.6 in surface soil sample 39SB05A. It should be noted that each of the SSL exceedances occurred exclusively in surface soil samples collected at the site. In accordance with the Soil Screening Guidance: User's Guide (USEPA, 1996a), SSL soil transfer to groundwater values were developed based on assumptions in the subsurface; therefore, the applicability of SSL soil to transfer values to surface soil concentrations is limited.

While SSL exceedances indicate a theoretical potential for impact to groundwater, empirical evidence in the form of actual groundwater chemical data, soil boring characterization and chemical analyses, soil characteristics/chemistry, and fate and transport analysis offer more concrete evidence of site conditions and potential impact to groundwater.

Groundwater data collected by Alliant TechSystems, Inc. (ATK) during August 2003 (ATK, 2003) from monitoring wells 39MW1, 39MW3, 39MW4, 39MW5, and 39MW6 at the site indicate that chromium and thallium are not impacting groundwater (**Appendix B-2, Table B-5**). Chromium and thallium were not detected in groundwater samples collected by ATK during the August 2003 quarterly sampling event. Most recent groundwater sampling data collected from the remaining wells at the site (39MW2, 39MW7, and 39MW8) during the 1998 RFI, indicates that chromium and thallium were detected below maximum contaminant levels (MCLs) and USEPA tap water screening levels (USEPA, 2004a). Data from these wells also demonstrate that chromium and thallium are not impacting groundwater at the site (**Appendix B-2, Table B-6**).

Although lead does not have and was not compared to a SSL soil transfer to groundwater value, groundwater sampling data from ATK (2003) and the 1998 RFI indicate that lead, similar to chromium and thallium, was not detected in groundwater samples collected from the site during the most recent groundwater sampling events. The lack of lead detections in groundwater indicates that lead is not impacting groundwater at SWMU 39.

Groundwater samples at SWMU 39 have not been analyzed for dioxins/furans; however, chemical results in soil demonstrate that individual dioxins/furans did not exceed residential

screening levels in surface or subsurface soil. TCDD TE exceedances are limited to surface soil. There were no SSL or residential screening level exceedances of these compounds in subsurface soil samples collected from the entire site.

4.2.1.2 Nature and Extent Conclusions

As shown on **Figure 4-2**, representative samples have been collected throughout the SWMU 39 study area to fully characterize the site. Chemical results indicate that VOCs, SVOCs, PAHs, pesticides, PCBs, herbicides, and explosives are not a concern at the study area. There were no exceedances of residential or industrial screening levels in surface or subsurface soil outside the ponds, except for two exceedances of thallium from the 1992 VI. Subsequent sampling at the same area and at other areas of the site, including the 1998 RFI and the 2002 RFI failed to replicate and validate these elevated concentrations of thallium.

There are residential exceedances of two metals (chromium and copper) in surface soil in the northern and southern settling ponds. There were no exceedances of these metals in subsurface soil samples indicating limited distribution and vertical migration. Three metals (lead, iron, and thallium) had industrial screening level exceedances. There was a single industrial exceedance of iron in surface soil in the southern pond. As discussed previously, exceedances of thallium documented in the 1992 VI could not be verified in subsequent sampling events. Lead is the major constituent presenting a concern, with industrial exceedances in surface soil in both ponds. Lead was also the single constituent to have a screening level exceedance in subsurface soil (at 3-5 ft). The lack of lead exceedances in other subsurface samples indicates limited vertical migration.

The sole organic compounds to have a screening level exceedance were dioxins/furans. Although no single dioxin/furan exhibited an exceedance, there was a single industrial exceedance of the TCDD TE for combined dioxins/furans in one surface soil sample in the northern pond and one residential exceedance of the TCDD TE in the southern settling pond. Samples collected below the surface soil interval (39SB5B,C & 39SB6B,C) did not show elevated levels of dioxins/furans, indicating that these constituents are not migrating vertically through the soil column.

4.3 Conceptual Site Model

A site-specific CSM was developed for SWMU 39 in MWP Addendum 012 (IT, 2002a) to identify potential contaminant sources, exposure pathways, and human and ecological receptors. Each media type potentially present at the site (i.e., surface and subsurface soil, sediment and surface water) was evaluated to assess whether human (site worker) or biotic (terrestrial, aquatic, and benthic) receptors would be impacted by contamination. Three exposure routes (ingestion, inhalation and dermal absorption) were evaluated for each media type. Historical site use information was employed to identify types of potential contamination and locations of potentially contaminated areas. Site topography and physical land features, such as creeks, or drainage ditches, were used to approximate contaminant migration pathways.

A CSM figure was also developed for SWMU 39 in MWP Addendum 012 (IT, 2002a), and as described in *Section 3.1*, sampling locations were selected based on previous sample results, site visit observations, negotiations with regulators, and the CSM. Based on the evaluation of the combined analytical data collected from previous investigations and the 2002 RFI (*Section 4.2.1*), changes to the CSM were required. Evaluation of site conditions indicated that the "ponds" are normally dry and water is not present in the ponds except during rain events. Therefore, no surface water samples were collected and the sediment samples collected from the

ponds were reclassified as soil samples. In addition, three additional human receptors (i.e., excavation worker and adult and child residents) were considered. The revised CSM is presented as **Table 4-4**.

Table 4-4
Potential Exposure Pathways and Receptors – SWMU 39

Media	Potentially Affected Media	Exposure Pathways and Media						Comments
		Humans			Biota			
		Maintenance Worker	Excavation Worker	Resident (adult/child)	Terrestrial	Aquatic	Benthic	
Surface Soil	Yes	IN, INH, DA	IN, INH, DA	IN, INH, DA	IN, INH, DA	---	---	Direct contact.
Surface Water	No	---	---	---	---	---	---	Standing water is not present in the ponds except during rain events. Therefore, it was concluded that surface water is not present at the site.
Sediment	No	---	---	---	---	---	---	Sediment samples were reclassified as soil samples as water is not present in the ponds except during rain events.
Subsurface Soil	Yes	IN, INH, DA	IN, INH, DA	IN, INH, DA	---	---	---	During construction activity, future land use.

* The environmental medium in the settling ponds is potentially affected and was classified as soil based on current site conditions.

Abbreviations: IN = ingestion, INH = inhalation, DA = dermal absorption

Tables 4-1 and 4-2
Master Table Legend

12 J	Shading and black font indicates an industrial RBC exceedance
12 J	Bold outline indicates a residential RBC exceedance.
12 **J**	Bold, underlined font indicates a background exceedance.
12 J	Shading and white font indicates a SSL exceedance.
12 J	Mixed shading indicates an industrial RBC and a SSL exceedance.
12 *12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

RBCs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene RBCs and SSL were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene.
Inorganic results below background UTLs are not indicated as exceedances on the table.
RBC = Risk Based Concentration (April, 2004).
RBC values in table are for the more conservative chromium VI
RBC values for chromium III are 150,000 (ind) and 12,000 (res), which were not exceeded
Lead screening values from Technical Review Workgroup for Lead: Adult Lead Model Frequently Asked Questions available online at http://www.epa.gov/superfund/programs/lead/adult.htm
µg/kg = micrograms per kilogram (parts per billion).
mg/kg = milligrams per kilogram (parts per million).
NA = not applicable.
NT = analyte not tested.

LQ = Lab Data Qualifiers

B = (organics) Blank contamination. Value detected in sample and associated blank.
B = (metals) Value <MRL and >MDL and is considered estimated.
E (metals) = Reported value is estimated because of the presence of interferences.
J = (organics) Value <MRL and >MDL and is considered estimated.
JP = Estimated value <CRQL or <RL and MDL
U = Analyte not-detected at the method reporting limit.

VQ = Validation Data Qualifiers:

B = blank contamination. Value detected in sample and associated blank.
J = estimated concentration
K = estimated concentration bias high
L = estimated concentration bias low
U = analyte not detected
UJ = estimated concentration non-detect
UL = estimated concentration non-detect bias low

Table 4-1
Analytes Detected in SWMU 39 Soil - 2002 RFI

Analyte				Sample ID	39SB05A					39SB05B					39SB05C					39SB06A					39SB06B					39SB06C				
				Sample Date	7/9/02					7/9/02					7/9/02					7/9/02					7/9/02					7/9/02				
				Sample Depth	0-0.5					1-3					3-5					0-0.5					1-3					3-5				
	i-RBC	r-RBC	Background	SSL Transfer	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																																	
Acetone	92000000	7000000	na	22000	5.8	U	UJ	*2.6*	*5.8*	5.4	U	UJ	*2.4*	*5.4*	5.3	U	UJ	*2.4*	*5.3*	5.5	U	UJ	*2.4*	*5.5*	4.9	U	UJ	*2.2*	*4.9*	5.5	U	UJ	*2.4*	*5.5*
Pesticides (ug/kg)																																	
4,4'-DDD	12000	2700	na	11000	0.778	U		*0.165*	*0.778*	NT					NT					0.816	U		*0.173*	*0.816*	NT					NT				
4,4'-DDT	8400	1900	na	1200	0.884		B	*0.275*	*0.778*	NT					NT					0.816	U		*0.289*	*0.816*	NT					NT				
alpha-Chlordane	8200	1800	na	920	0.778	U		*0.144*	*0.778*	NT					NT					1.35			*0.151*	*0.816*	NT					NT				
Endrin aldehyde	na	na	na	na	0.681	J	J	*0.393*	*0.778*	NT					NT					0.816	U	UL	*0.412*	*0.816*	NT					NT				
Endrin Ketone	na	na	na	na	0.778	U		*0.628*	*0.778*	NT					NT					2.82			*0.659*	*0.816*	NT					NT				
Endrin	31000	2300	na	5400	0.778	U		*0.187*	*0.778*	NT					NT					3.79			*0.196*	*0.816*	NT					NT				
gamma-Chlordane	8200	1800	na	920	0.778	U		*0.181*	*0.778*	NT					NT					1.41			*0.19*	*0.816*	NT					NT				
Methoxychlor	510000	39000	na	310000	0.778	U		*0.594*	*0.778*	NT					NT					0.816	U		*0.623*	*0.816*	NT					NT				
PCBs (mg/kg)	**None detected**																																
Explosives (mg/kg)																																	
2,4-Dinitrotoluene	200	16	na	0.57	0.2	U		*0.0163*	*0.2*	0.2	U		*0.0163*	*0.2*	0.2	U		*0.0163*	*0.2*	0.233			*0.0163*	*0.2*	0.2	U		*0.0163*	*0.2*	0.2	U		*0.0163*	*0.2*
Nitroglycerine	200	46	na	na	0.18	J	J	*0.117*	*0.35*	0.358	U		*0.119*	*0.358*	0.353	U		*0.118*	*0.353*	19.8			*0.122*	*0.367*	0.368	U		*0.123*	*0.368*	0.366	U		*0.122*	*0.366*
Herbicides (ug/kg)	**None detected**																																
Metals (mg/kg)																																	
Aluminum	100000	7800	40041	na	20300			*6.4*	*23.3*	21700			*6.58*	*23.8*	19200			*6.5*	*23.6*	18700			*6.8*	*24.5*	23800			*6.77*	*24.5*	25400			*6.73*	*24.4*
Antimony	41	3.1	na	13	0.4	B	B	*0.2*	*0.583*	0.596	U	UJ	*0.2*	*0.596*	0.589	U	UJ	*0.2*	*0.589*	0.52	B	B	*0.21*	*0.612*	0.613	U	UJ	*0.21*	*0.613*	0.61	U	UJ	*0.21*	*0.61*
Arsenic	1.9	0.43	15.8	0.026	1.12			*0.41*	*0.583*	0.43	B	J	*0.42*	*0.596*	0.618		J	*0.41*	*0.589*	1.13			*0.43*	*0.612*	2.77		J	*0.43*	*0.613*	1.26		J	*0.43*	*0.61*
Barium	7200	550	209	2100	113			*0.39*	*2.33*	117			*0.398*	*2.38*	106			*0.393*	*2.36*	197			*0.41*	*2.45*	135			*0.41*	*2.45*	137			*0.407*	*2.44*
Beryllium	200	16	1.02	1200	0.694			*0.0403*	*0.583*	**1.05**			*0.0411*	*0.596*	0.897			*0.0406*	*0.589*	0.785			*0.0422*	*0.612*	**1.13**			*0.0423*	*0.613*	**1.19**			*0.0421*	*0.61*
Cadmium	51	3.9	0.69	27	0.117	U		*0.055*	*0.117*	0.119	U	UJ	*0.057*	*0.119*	0.11	B	J	*0.056*	*0.118*	0.122	U		*0.058*	*0.122*	0.123	U	UJ	*0.058*	*0.123*	0.122	U	UJ	*0.058*	*0.122*
Calcium	na	na	na	na	263			*3.3*	*11.7*	878			*3.33*	*11.9*	781			*3.29*	*11.8*	521			*3.4*	*12.2*	787			*3.42*	*12.3*	1010			*3.4*	*12.2*
Chromium	310	23	65.3	42	51.2			*0.44*	*1.17*	34.3		J	*0.446*	*1.19*	34.6		J	*0.441*	*1.18*	25.1			*0.46*	*1.22*	39.8		J	*0.459*	*1.23*	42.1		J	*0.456*	*1.22*
Cobalt	2000	160	72.3	na	13			*0.94*	*5.83*	21.4			*0.964*	*5.96*	17.3			*0.953*	*5.89*	7.69			*0.99*	*6.12*	24			*0.993*	*6.13*	16.5			*0.987*	*6.1*
Copper	4100	310	53.5	11000	**308**			*0.72*	*2.33*	25.6			*0.735*	*2.38*	**54.7**			*0.727*	*2.36*	**375**			*0.76*	*2.45*	27.4			*0.757*	*2.45*	25.2			*0.752*	*2.44*
Iron	31000	2300	50962	na	30700		J	*3.9*	*5.83*	34400			*4*	*5.96*	29700			*3.96*	*5.89*	16300		J	*4.1*	*6.12*	38900			*4.12*	*6.13*	36800			*4.1*	*6.1*
Lead	800	400	26.8	na	**4530**			*4.3*	*11.7*	**138**			*4.39*	*11.9*	**800**			*4.33*	*11.8*	**16500**			*4.5*	*12.2*	26.4			*0.037*	*0.368*	22.6			*0.037*	*0.366*
Magnesium	na	na	na	na	4270			*2.8*	*11.7*	4740		J	*2.81*	*11.9*	3940		J	*2.78*	*11.8*	2280			*2.9*	*12.2*	3180		J	*2.9*	*12.3*	4230		J	*2.88*	*12.2*
Manganese	2000	160	2543	950	128		J	*0.065*	*1.17*	463			*0.0666*	*1.19*	478			*0.0658*	*1.18*	96.9		J	*0.068*	*1.22*	597			*0.0686*	*1.23*	302			*0.0682*	*1.22*
Mercury	31	2.3	0.13	na	0.048	B	L	*0.023*	*0.0583*	0.029	B	J	*0.024*	*0.0596*	0.026	B	J	*0.023*	*0.0589*	0.102		L	*0.024*	*0.0612*	0.032	B	J	*0.024*	*0.0613*	0.034	B	J	*0.024*	*0.061*
Nickel	2000	160	62.8	na	18.2			*1.1*	*4.67*	18.2		J	*1.09*	*4.77*	16.9		J	*1.08*	*4.71*	28.9			*1.1*	*4.9*	17.9		J	*1.12*	*4.91*	20.1		J	*1.11*	*4.88*
Potassium	na	na	na	na	2800			*39*	*350*	3090			*39.8*	*358*	2580			*39.3*	*353*	1410			*41*	*367*	2080			*41*	*368*	2910			*40.7*	*366*
Silver	510	39	na	31	0.86	B	B	*0.57*	*1.17*	1.19	U	UL	*0.586*	*1.19*	1.18	U	UL	*0.58*	*1.18*	0.98	B	B	*0.6*	*1.22*	1.23	U	UL	*0.604*	*1.23*	1.22	U	UL	*0.6*	*1.22*
Sodium	na	na	na	na	23.9		B	*4.4*	*23.3*	34.5			*4.45*	*23.8*	38			*4.39*	*23.6*	29.1		B	*4.6*	*24.5*	33.5			*4.58*	*24.5*	45.5			*4.55*	*24.4*
Thallium	7.2	0.55	2.11	3.6	0.22	B	J	*0.035*	*0.35*	0.24	B	J	*0.036*	*0.358*	0.19	B	J	*0.036*	*0.353*	0.14	B	J	*0.037*	*0.367*	0.18	B	J	*0.037*	*0.368*	0.2	B	J	*0.037*	*0.366*
Vanadium	100	7.8	108	73	58.1			*0.67*	*5.83*	59.7			*0.589*	*5.96*	50.8			*0.681*	*5.89*	40			*0.71*	*6.12*	63.5			*0.709*	*6.13*	63.4			*0.705*	*6.1*
Zinc	31000	2300	202	14000	71.3		J	*0.42*	*2.33*	68.1		J	*0.427*	*2.38*	57.8		J	*0.422*	*2.36*	69.9		J	*0.44*	*2.45*	79.5		J	*0.439*	*2.45*	72.4		J	*0.437*	*2.44*

Note: Refer to the Master Table Legend preceding Table 4-1 for a list of definitions and table notes.

Table 4-1
Analytes Detected in SWMU 39 Soil - 2002 RFI

Analyte				Sample ID	39SS07					39SS08					39SS09					39SS10					39SS11					39SS12				
				Sample Date	7/9/02					7/9/02					7/9/02					7/9/02					7/9/02					7/9/02				
				Sample Depth	0-0.5					0-0.5					0-0.5					0-0.5					0-0.5					0-0.5				
	i-RBC	r-RBC	Background	SSL Transfer	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																																	
Acetone	92000000	7000000	na	22000	49		B	2.2	5	NT					NT					NT					NT					NT				
Pesticides (ug/kg)																																	
4,4'-DDD	12000	2700	na	11000	0.31	J	J	0.156	0.736	NT					NT					NT					NT					NT				
4,4'-DDT	8400	1900	na	1200	0.736	U		0.26	0.736	NT					NT					NT					NT					NT				
alpha-Chlordane	8200	1800	na	920	0.736	U		0.136	0.736	NT					NT					NT					NT					NT				
Endrin aldehyde	na	na	na	na	0.736	U	UL	0.372	0.736	NT					NT					NT					NT					NT				
Endrin Ketone	na	na	na	na	0.736	U		0.594	0.736	NT					NT					NT					NT					NT				
Endrin	31000	2300	na	5400	0.736	U		0.177	0.736	NT					NT					NT					NT					NT				
gamma-Chlordane	8200	1800	na	920	0.736	U		0.171	0.736	NT					NT					NT					NT					NT				
Methoxychlor	510000	39000	na	310000	2.35			0.562	0.736	NT					NT					NT					NT					NT				
PCBs (mg/kg)	**None detected**																																
Explosives (mg/kg)																																	
2,4-Dinitrotoluene	200	16	na	0.57	0.2	U		0.0163	0.2	NT					NT					NT					NT					NT				
Nitroglycerine	200	46	na	na	0.331	U		0.11	0.331	NT					NT					NT					NT					NT				
Herbicides (ug/kg)	**None detected**																																
Metals (mg/kg)																																	
Aluminum	100000	7800	40041	na	10800			6.1	22.1	13700			6.2	22.6	35100			6.8	24.5	19200			6.3	22.8	18900			6.4	23.1	18400			6.1	22.1
Antimony	41	3.1	na	13	0.22	B	B	0.19	0.552	0.29	B	B	0.19	0.564	0.612	U	UL	0.21	0.612	0.57	U	UL	0.19	0.57	0.579	U	UL	0.19	0.579	0.553	U	UL	0.19	0.553
Arsenic	1.9	0.43	15.8	0.026	7.24			0.39	0.552	7.26			0.39	0.564	5.16			0.43	0.612	1.52			0.4	0.57	0.935			0.4	0.579	1.01			0.39	0.553
Barium	7200	550	209	2100	163			0.37	2.21	178			0.38	2.26	130			0.41	2.45	144			0.38	2.28	159			0.39	2.31	157			0.37	2.21
Beryllium	200	16	1.02	1200	0.925			0.0381	0.552	0.958			0.0389	0.564	**1.12**			0.0422	0.612	0.951			0.0393	0.57	0.82			0.0399	0.579	0.813			0.0382	0.553
Cadmium	51	3.9	0.69	27	0.486		J	0.052	0.11	**0.711**		**J**	0.054	0.113	0.11	B	J	0.058	0.122	0.1	B	J	0.054	0.114	0.08	B	J	0.055	0.116	0.269		J	0.053	0.111
Calcium	na	na	na	na	1020			3.1	11	1140			3.2	11.3	1600			3.4	12.2	2260			3.2	11.4	1880			3.2	11.6	4310			3.1	11.1
Chromium	310	23	65.3	42	14.4			0.41	1.1	17.1			0.42	1.13	36.5			0.46	1.22	31.2			0.43	1.14	29.1			0.43	1.16	30.4			0.41	1.11
Cobalt	2000	160	72.3	na	13.3			0.89	5.52	12.5			0.91	5.64	13.2			0.99	6.12	29			0.92	5.7	14.3			0.94	5.79	14.9			0.9	5.53
Copper	4100	310	53.5	11000	20.5			0.68	2.21	19			0.7	2.26	28.3			0.76	2.45	19.3			0.7	2.28	14.2			0.71	2.31	17.4			0.68	2.21
Iron	31000	2300	50962	na	26300		J	3.7	5.52	26300		J	3.8	5.64	33300		J	4.1	6.12	24400		J	3.8	5.7	19600		J	3.9	5.79	20500		J	3.7	5.53
Lead	800	400	26.8	na	**30.2**		**J**	0.033	0.331	26.2		J	0.034	0.339	**63**		**J**	0.037	0.367	**99.2**			4.2	11.4	**36.6**		**J**	0.035	0.347	**85**		**J**	0.033	0.332
Magnesium	na	na	na	na	1270			2.6	11	1420			2.7	11.3	3640			2.9	12.2	2860			2.7	11.4	2840			2.7	11.6	4450			2.6	11.1
Manganese	2000	160	2543	950	603		J	0.062	1.1	544		J	0.063	1.13	532		J	0.068	1.22	1380		J	0.064	1.14	682		J	0.065	1.16	744		J	0.062	1.11
Mercury	31	2.3	0.13	na	0.036	B	L	0.022	0.0552	0.029	B	L	0.022	0.0564	0.0982		L	0.024	0.0612	0.039	B	L	0.023	0.057	0.034	B	L	0.023	0.0579	0.03	B	L	0.022	0.0553
Nickel	2000	160	62.8	na	37.4			1	4.42	38.1			1	4.51	22			1.1	4.9	14.3			1	4.56	15.6			1.1	4.63	14.8			1	4.42
Potassium	na	na	na	na	1400			37	331	2380			38	339	2520			41	367	1810			38	342	1920			39	347	1870			37	332
Silver	510	39	na	31	0.72	B	B	0.54	1.1	0.66	B	B	0.56	1.13	0.86	B	B	0.6	1.22	0.79	B	B	0.56	1.14	0.76	B	B	0.57	1.16	0.88	B	B	0.54	1.11
Sodium	na	na	na	na	31.5			4.1	22.1	71.2			4.2	22.6	42.4			4.6	24.5	26.3		B	4.3	22.8	37.7			4.3	23.1	35.5			4.1	22.1
Thallium	7.2	0.55	2.11	3.6	0.14	B	J	0.033	0.331	0.13	B	J	0.034	0.339	0.27	B	J	0.037	0.367	0.18	B	J	0.034	0.342	0.14	B	J	0.035	0.347	0.16	B	J	0.033	0.332
Vanadium	100	7.8	108	73	21.9			0.64	5.52	26.5			0.65	5.64	64.2			0.71	6.12	46			0.66	5.7	36.2			0.67	5.79	37.6			0.64	5.53
Zinc	31000	2300	202	14000	164		J	0.4	2.21	158		J	0.4	2.26	81.4		J	0.44	2.45	58.2		J	0.41	2.28	60		J	0.41	2.31	**301**		**J**	0.4	2.21

Note: Refer to the Master Table Legend preceding Table 4-1 for a list of definitions and table notes.

Table 4-2
Dioxins/Furans Detected in SWMU 39 Soil - 2002 RFI

Analyte	Sample ID			39SB05A					39SB05B					39SB05C					39SB06A					39SB06B					39SB06C					39SS07				
	Sample Date			7/9/02					7/9/02					7/9/02					7/9/02					7/9/02					7/9/02					7/9/02				
	Sample Depth			0-0.5					1-3					3-5					0-0.5					1-3					3-5					0-0.5				
	i-RBC	r-RBC	SSL Transfer	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
Dioxins/Furans (ng/kg)																																						
2,3,7,8-TCDF	na	na	na	3.526		J	*0.19*	*0.388*	0.122	U		*0.19*	*0.122*	0.455		J	*0.19*	*0.082*	0.731		J	*0.19*	*0.127*	0.108	U		*0.19*	*0.108*	0.111	U		*0.19*	*0.111*	0.393			*0.19*	*0.031*
2,3,7,8-TCDD	19	4.3	8.6	0.354			*0.13*	*0.029*	0.126	U		*0.13*	*0.126*	0.097	U		*0.13*	*0.097*	0.172	X	J	*0.13*	*0.037*	0.127	U		*0.13*	*0.127*	0.136	U		*0.13*	*0.136*	0.033	U		*0.13*	*0.033*
1,2,3,7,8-PECDD	na	na	na	3.034			*0.19*	*0.051*	0.17	U		*0.19*	*0.17*	0.54			*0.19*	*0.135*	0.738			*0.19*	*0.045*	0.17	U		*0.19*	*0.17*	0.189	U		*0.19*	*0.189*	0.12			*0.19*	*0.036*
1,2,3,4,7,8-HXCDD	na	na	na	5.465			*0.53*	*0.05*	0.263	U		*0.53*	*0.263*	0.558			*0.53*	*0.173*	1.752			*0.53*	*0.058*	0.329	U		*0.53*	*0.329*	0.289	U		*0.53*	*0.289*	0.293			*0.53*	*0.044*
1,2,3,6,7,8-HXCDD	na	na	na	8.192			*0.57*	*0.037*	0.206	U		*0.57*	*0.206*	1.051	X	J	*0.57*	*0.136*	2.847			*0.57*	*0.042*	0.258	U		*0.57*	*0.258*	0.226	U		*0.57*	*0.226*	0.39			*0.57*	*0.033*
1,2,3,7,8,9-HXCDD	460	100	na	14.94			*0.68*	*0.041*	0.2	U		*0.68*	*0.2*	1.336			*0.68*	*0.131*	4.248			*0.68*	*0.047*	0.919			*0.68*	*0.25*	0.219	U		*0.68*	*0.219*	0.674			*0.68*	*0.036*
1,2,3,4,6,7,8-HPCDD	na	na	na	104.3	B		*0.63*	*0.031*	11.27			*0.63*	*0.418*	12.2			*0.63*	*0.277*	56.77	B		*0.63*	*0.05*	33.8			*0.63*	*0.387*	16.04			*0.63*	*0.514*	10.23	B		*0.63*	*0.038*
OCDD	na	na	na	2869	B	J	*6.86*	*0.032*	1714	B		*6.86*	*0.18*	647	B		*6.86*	*0.159*	2085	B	J	*6.86*	*0.041*	7745	B		*6.86*	*0.144*	2438	B		*6.86*	*0.235*	269.2	B	J	*6.86*	*0.029*
1,2,3,7,8-PECDF	na	na	na	4.783			*0.28*	*0.034*	0.124	U		*0.28*	*0.124*	0.649			*0.28*	*0.104*	0.708			*0.28*	*0.023*	0.111	U		*0.28*	*0.111*	0.117	U		*0.28*	*0.117*	0.193			*0.28*	*0.035*
2,3,4,7,8-PECDF	na	na	na	10.29			*0.56*	*0.037*	0.13	U		*0.56*	*0.13*	1.211			*0.56*	*0.109*	1.526			*0.56*	*0.025*	0.116	U		*0.56*	*0.116*	0.122	U		*0.56*	*0.122*	0.535	1	J	*0.56*	*0.038*
1,2,3,4,7,8-HXCDF	na	na	na	35.24	I	J	*0.34*	*0.049*	0.385	X	J	*0.34*	*0.134*	3.447			*0.34*	*0.128*	4.58			*0.34*	*0.026*	0.129	U		*0.34*	*0.129*	0.13	U		*0.34*	*0.13*	0.45			*0.34*	*0.023*
1,2,3,6,7,8-HXCDF	na	na	na	11.86			*0.49*	*0.047*	0.13	U		*0.49*	*0.13*	1.831			*0.49*	*0.125*	1.768			*0.49*	*0.025*	0.126	U		*0.49*	*0.126*	0.126	U		*0.49*	*0.126*	0.119			*0.49*	*0.022*
2,3,4,6,7,8-HXCDF	na	na	na	19.83			*0.47*	*0.062*	0.259			*0.47*	*0.153*	1.662			*0.47*	*0.146*	3.014			*0.47*	*0.033*	0.147	U		*0.47*	*0.147*	0.148	U		*0.47*	*0.148*	0.131			*0.47*	*0.029*
1,2,3,7,8,9-HXCDF	na	na	na	0.765			*0.25*	*0.071*	0.154	U		*0.25*	*0.154*	0.147	U		*0.25*	*0.147*	0.2			*0.25*	*0.037*	0.148	U		*0.25*	*0.148*	0.149	U		*0.25*	*0.149*	0.033	U		*0.25*	*0.033*
1,2,3,4,6,7,8-HPCDF	na	na	na	54.36	B		*0.33*	*0.022*	0.561	X	B	*0.33*	*0.132*	5.548			*0.33*	*0.138*	12.46	B		*0.33*	*0.023*	0.268		B	*0.33*	*0.155*	0.694		B	*0.33*	*0.168*	1.374	BX	J	*0.33*	*0.022*
1,2,3,4,7,8,9-HPCDF	na	na	na	4.301			*0.5*	*0.033*	0.171	U		*0.5*	*0.171*	0.461	X	J	*0.5*	*0.179*	1.038			*0.5*	*0.035*	0.2	U		*0.5*	*0.2*	0.217	U		*0.5*	*0.217*	0.176			*0.5*	*0.033*
OCDF	na	na	na	30.84	B	J	*0.79*	*0.025*	1.163			*0.79*	*0.304*	3.123			*0.79*	*0.265*	15.14	B	J	*0.79*	*0.029*	0.932			*0.79*	*0.25*	2.203			*0.79*	*0.376*	2.792	B	J	*0.79*	*0.019*
TOTAL TCDD	na	na	na	17.67				*0.029*	0.126	U			*0.126*	0.677				*0.097*	3.478				*0.037*	0.127	U			*0.127*	0.136	U			*0.136*	0.671				*0.033*
TOTAL PECDD	na	na	na	35.79				*0.051*	0.17	U			*0.17*	2.523				*0.135*	7.501				*0.045*	0.17	U			*0.17*	0.189	U			*0.189*	0.311				*0.036*
TOTAL HXCDD	na	na	na	121.2				*0.037*	1.603				*0.2*	8.125				*0.131*	37.25				*0.042*	5.848				*0.25*	1.956				*0.219*	3.859				*0.033*
TOTAL HPCDD	na	na	na	202.3				*0.031*	17.98				*0.418*	24.33				*0.277*	113.4				*0.05*	75.23				*0.387*	28.53				*0.514*	20.62				*0.038*
TOTAL TCDF	na	na	na	57.31				*0.028*	0.122	U			*0.122*	7.949				*0.092*	12				*0.029*	0.108	U			*0.108*	0.111	U			*0.111*	0.928				*0.031*
TOTAL PECDF	na	na	na	72.86				*0.034*	0.483				*0.124*	10.23				*0.104*	15.61				*0.023*	0.111	U			*0.111*	0.117	U			*0.117*	1.271				*0.035*
TOTAL HXCDF	na	na	na	127.2				*0.047*	0.259				*0.13*	13.24				*0.125*	22.7				*0.025*	0.126	U			*0.126*	0.126	U			*0.126*	1.737				*0.022*
TOTAL HPCDF	na	na	na	84.39				*0.022*	0.531				*0.132*	7.01				*0.138*	24.32				*0.023*	0.749				*0.155*	2.345				*0.168*	2.257				*0.022*
TCDD TE	19	4.3	8.6						0.8306					2.571					4.535					1.694					0.9452					0.8234				

Note: Refer to the Master Table Legend preceding Table 4-1 for a list of definitions and table notes.

Table 4-3
SWMU 39 Soil Sampling Summary

Analyte	i-RBC	r-RBC	Background	SSL Transfer	# of i-RBC Exceedances	# of r-RBC Exceedances	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)													
Acetone	92000000	7000000	na	22000	0	0	na	0	1	7	49	49	39SS07
PAHs (ug/kg)													
Chrysene	390000	87000	na	150000	0	0	na	0	1	16	2	2	39SB3A
Indeno(1,2,3-cd)pyrene	3900	870	na	13000	0	0	na	0	1	16	6.9	6.9	39SB1A
Pyrene	3100000	230000	na	680000	0	0	na	0	1	16	1	1	39SB3A
SVOCs (ug/kg)													
Bis(2-ethylhexyl)phthalate	200000	46000	na	2900000	0	0	na	0	1	21	67	67	39MW8B
Di-n-butylphthalate	10000000	780000	na	5000000	0	0	na	0	2	21	820	1600	39SL2
Diethylphthalate	82000000	6300000	na	450000	0	0	na	0	1	21	68	68	39SB1A
Fluoranthene	4100000	310000	na	6300000	0	0	na	0	1	21	140	140	39SL2
Phenanthrene	3100000	230000	na	680000	0	0	na	0	1	21	140	140	39SL2
Pyrene	3100000	230000	na	680000	0	0	na	0	1	21	250	250	39SL2
Pesticides (ug/kg)													
4,4'-DDD	12000	2700	na	11000	0	0	na	0	1	3	0.31	0.31	39SS07
4,4'-DDT	8400	1900	na	1200	0	0	na	0	1	3	0.884	0.884	39SB05A
alpha-Chlordane	8200	1800	na	920	0	0	na	0	1	3	1.35	1.35	39SB06A
Endrin aldehyde	na	na	na	na	na	na	na	na	1	3	0.681	0.681	39SB05A
Endrin Ketone	na	na	na	na	na	na	na	na	1	3	2.82	2.82	39SB06A
Endrin	31000	2300	na	5400	0	0	na	0	1	3	3.79	3.79	39SB06A
gamma-Chlordane	8200	1800	na	920	0	0	na	0	1	3	1.41	1.41	39SB06A
Methoxychlor	510000	39000	na	310000	0	0	na	0	1	3	2.35	2.35	39SS07
PCBs (mg/kg)	***None detected***												
Explosives (mg/kg)													
2,4-Dinitrotoluene	200	16	na	0.57	0	0	na	0	1	12	0.233	0.233	39SB06A
Nitroglycerine	200	46	na	na	0	0	na	na	2	12	0.18	19.8	39SB06A
Herbicides (ug/kg)	***None detected***												
Dioxins/Furans (ng/kg)													
2,3,7,8-TCDF	na	na	na	na	na	na	na	na	4	7	0.344	3.526	39SB05A
2,3,7,8-TCDD	19	4.3	na	8.6	0	0	na	0	2	7	0.172	0.354	39SB05A
1,2,3,7,8-PECDD	na	na	na	na	na	na	na	na	4	7	0.12	3.034	39SB05A
1,2,3,4,7,8-HXCDD	na	na	na	na	na	na	na	na	4	7	0.293	5.465	39SB05A
1,2,3,6,7,8-HXCDD	na	na	na	na	na	na	na	na	4	7	0.39	8.192	39SB05A
1,2,3,7,8,9-HXCDD	460	100	na	na	0	0	na	na	5	7	0.674	14.94	39SB05A
1,2,3,4,6,7,8-HPCDD	na	na	na	na	na	na	na	na	7	7	10.23	104.3	39SB05A
OCDD	na	na	na	na	na	na	na	na	7	7	269.2	7745	39SB06B
1,2,3,7,8-PECDF	na	na	na	na	na	na	na	na	4	7	0.193	4.783	39SB05A
2,3,4,7,8-PECDF	na	na	na	na	na	na	na	na	4	7	0.535	10.29	39SB05A
1,2,3,4,7,8-HXCDF	na	na	na	na	na	na	na	na	5	7	0.385	35.24	39SB05A
1,2,3,6,7,8-HXCDF	na	na	na	na	na	na	na	na	4	7	0.119	11.86	39SB05A
2,3,4,6,7,8-HXCDF	na	na	na	na	na	na	na	na	5	7	0.131	19.83	39SB05A
1,2,3,7,8,9-HXCDF	na	na	na	na	na	na	na	na	2	7	0.2	0.765	39SB05A
1,2,3,4,6,7,8-HPCDF	na	na	na	na	na	na	na	na	7	7	0.268	54.36	39SB05A
1,2,3,4,7,8,9-HPCDF	na	na	na	na	na	na	na	na	4	7	0.176	4.301	39SB05A
OCDF	na	na	na	na	na	na	na	na	7	7	0.932	30.84	39SB05A
TOTAL TCDD	na	na	na	na	na	na	na	na	4	7	0.671	17.67	39SB05A
TOTAL PECDD	na	na	na	na	na	na	na	na	4	7	0.311	35.79	39SB05A
TOTAL HXCDD	na	na	na	na	na	na	na	na	7	7	1.603	121.2	39SB05A

Table 4-3
SWMU 39 Soil Sampling Summary

Analyte	i-RBC	r-RBC	Background	SSL Transfer	# of i-RBC Exceedances	# of r-RBC Exceedances	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
TOTAL HPCDD	na	na	na	na	na	na	na	na	7	7	17.98	202.3	39SB05A
TOTAL TCDF	na	na	na	na	na	na	na	na	4	7	0.928	57.31	39SB05A
TOTAL PECDF	na	na	na	na	na	na	na	na	5	7	0.483	72.86	39SB05A
TOTAL HXCDF	na	na	na	na	na	na	na	na	5	7	0.259	127.2	39SB05A
TOTAL HPCDF	na	na	na	na	na	na	na	na	7	7	0.531	84.39	39SB05A
TCDD TE	19	4.3	na	8.6	1	1	na	1	7	7	0.8185	20.67	39SB05A
Metals (mg/kg)													
Aluminum	100000	7800	40041	na	0	0	0	na	33	33	5510	37400	39SB3B
Antimony	41	3.1	na	13	0	0	na	0	14	33	0.22	1.5	39SB1A
Arsenic	1.9	0.43	15.8	0.026	0	0	0	0	33	33	0.43	9.2	39SB2F
Barium	7200	550	209	2100	0	0	2	0	33	33	37.8	216	39SB4B
Beryllium	200	16	1.02	1200	0	0	9	0	32	33	0.39	1.4	39SB3B
Cadmium	51	3.9	0.69	27	0	0	1	0	7	33	0.08	0.711	39SS08
Calcium	na	na	na	na	na	na	na	na	33	33	263	85800	39MW8B
Chromium	310	23	65.3	42	0	3	3	3	33	33	14.4	206*	39SL2
Cobalt	2000	160	72.3	na	0	0	0	na	33	33	5	29	39SS10
Copper	4100	310	53.5	11000	0	3	6	0	33	33	11.4	403*	39SL2
Iron	31000	2300	50962	na	1	1	1	na	33	33	16300	52800	39SB3B
Lead	800	400	26.8	na	5	6	15	na	32	33	4.9	21000*	39SL2
Magnesium	na	na	na	na	na	na	na	na	33	33	1270	51000	39MW8B
Manganese	2000	160	2543	950	0	0	0	0	33	33	96.9	1380	39SS10
Mercury	31	2.3	0.13	na	0	0	0	na	12	33	0.026	0.102	39SB06A
Nickel	2000	160	62.8	na	0	0	0	na	33	33	8.4	57.2*	39SL2
Potassium	na	na	na	na	na	na	na	na	33	33	670	4490	39SB2F
Selenium	510	39	na	19	0	0	na	0	4	33	0.6	1.2	39SB4B
Silver	510	39	na	31	0	0	na	0	12	33	0.66	1.4	39SS1
Sodium	na	na	na	na	na	na	na	na	33	33	23.9	363	39MW8B
Thallium	7.2	0.55	2.11	3.6	4	4	4	4	21	33	0.13	32.3*	39SL3
Vanadium	100	7.8	108	73	0	0	0	0	33	33	15.4	92.7	39SB3B
Zinc	31000	2300	202	14000	0	0	1	0	33	33	22.6	301	39SS12

Notes: 1) QA/QC samples were not included in totals

2) RBCs (USEPA; April, 2004) were adjusted downward to a HQ of 0.1

* Maximum result is from a composite sample collected in the settling ponds. The true maximum is likely to be higher.

SAMPLE ID	39SB06A	39SB06B	39SB06C
DEPTH (ft. bgs)	0–0.5	1–3	3–5
TAL Metals (mg/kg)			
Beryllium	0.785	**1.13**	**1.19**
Chromium	**95.1**	39.8 J	42.1 J
Copper	**375**	27.4	25.2
Lead	**16,500**	26.4	22.6
Dioxins/Furans (ng/kg)			
TCDD TE	4.53	1.65	0.94

SAMPLE ID	39SS07
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**30.2** J

SAMPLE ID	39SS08
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Cadmium	**0.71** J

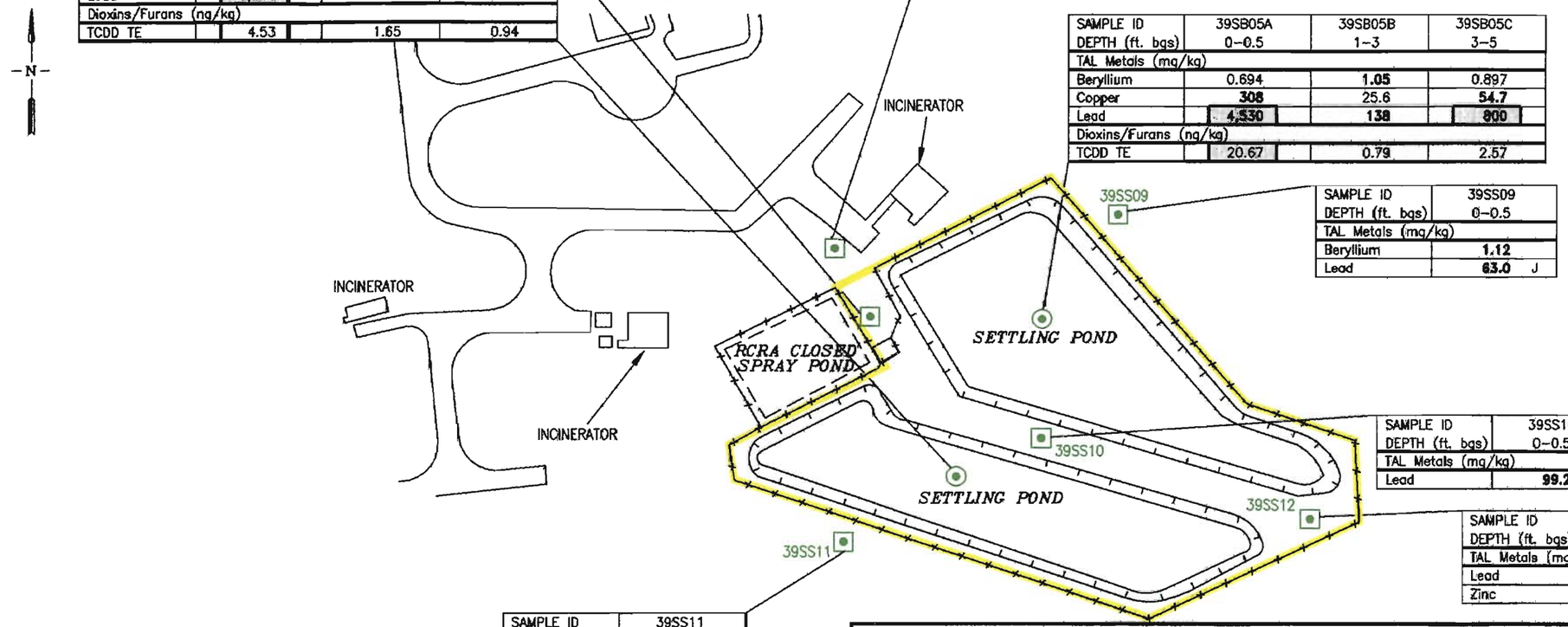
SAMPLE ID	39SB05A	39SB05B	39SB05C
DEPTH (ft. bgs)	0–0.5	1–3	3–5
TAL Metals (mg/kg)			
Beryllium	0.694	**1.05**	0.897
Copper	**308**	25.6	**54.7**
Lead	**4,530**	**138**	**800**
Dioxins/Furans (ng/kg)			
TCDD TE	20.67	0.79	2.57

SAMPLE ID	39SS09
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Beryllium	**1.12**
Lead	**63.0** J

SAMPLE ID	39SS10
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**99.2**

SAMPLE ID	39SS12
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**85.0** J
Zinc	**301** J

SAMPLE ID	39SS11
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**36.6** J



Sample Summary

Previous Investigation	Contractor	TAL Metals			VOCs		SVOCs			PAHs		Explosives			Pest		PCBs		Herb		Dioxins/Furans		Total
		SS	SB	SD	SS	SB	SS	SB	SD	SS	SB	SS	SB	SD	SS	SB	SS	SB	SS	SB	SS	SB	
1992 VI	D&M	3	---	3C	---	---	3	---	3C	---	---	3	---	3C	---	---	---	---	---	---	---	---	18
1997 Closure of Spray Pond	ATK	8	16	---	---	---	8	16	---	---	---	---	---	---	---	---	---	---	---	---	---	---	48
1998 RFI	ICF Kaiser	2	14	---	---	---	2	14	---	2	14	---	---	---	---	---	---	---	---	---	---	---	56
2002 RFI	Shaw	8	4	---	3	4	---	---	---	---	---	3	4	---	3	---	3	4	3	---	3	4	46

LEGEND:

- FENCE
- 2002 RFI SOIL BORING LOCATION (SHAW)
- 2002 RFI SURFACE SOIL LOCATION (SHAW)
- SITE BOUNDARY

NOTE:

J = ESTIMATED CONCENTRATION
DARK BORDER = VALUE EXCEEDS THE RESIDENTIAL SCREENING LEVEL (USEPA; APRIL, 2004)
SHADING = VALUE EXCEEDS THE INDUSTRIAL SCREENING LEVEL (USEPA; APRIL, 2004)
BOLD = VALUE EXCEEDS THE BACKGROUND CRITERION (IT, 2001)
VALUES DETECTED BELOW BACKGROUND ARE NOT SHOWN

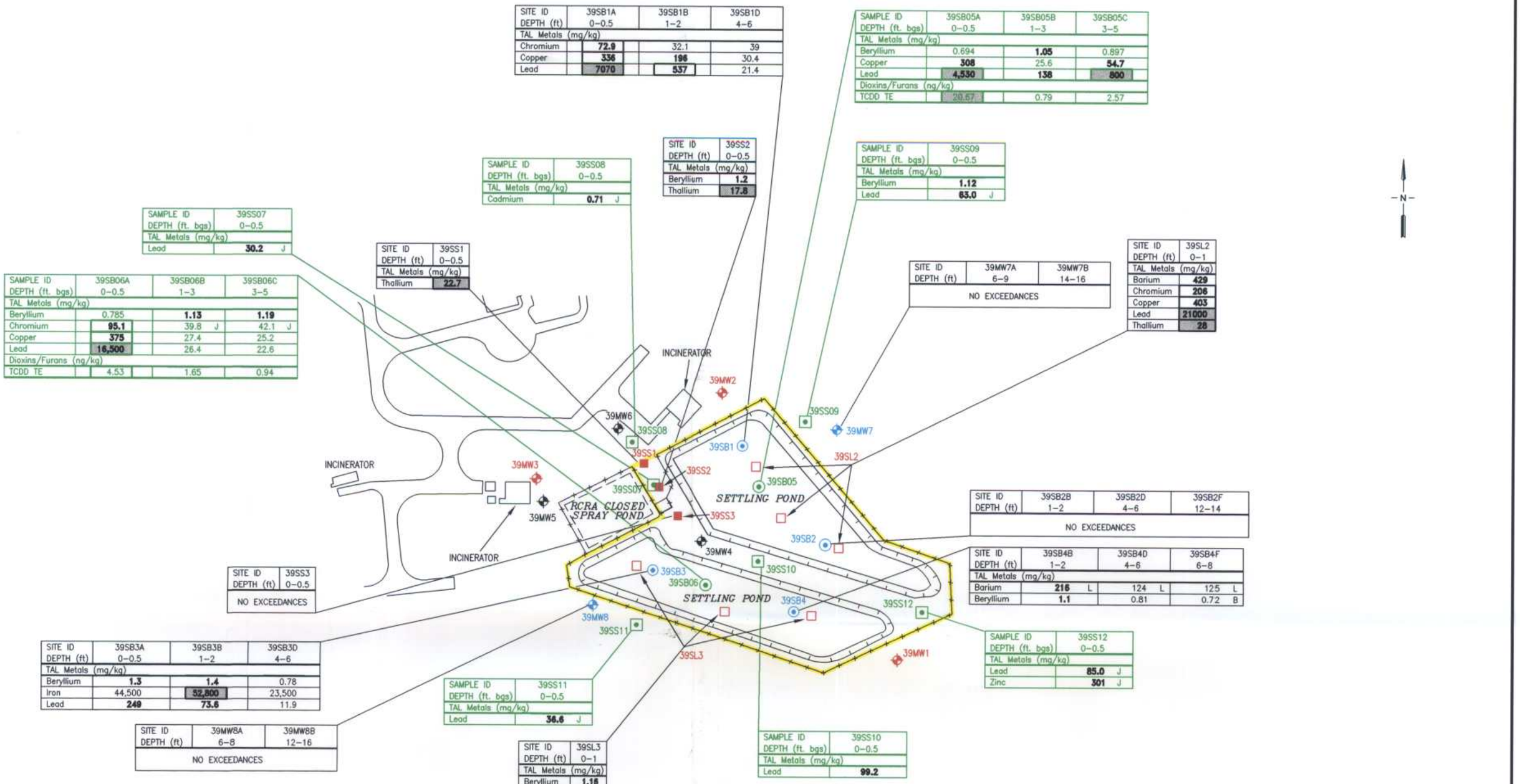
RADFORD AAP

FIGURE 4–1

SWMU 39
2002 RFI SOIL
SAMPLING LOCATIONS
AND RESULTS

PREPARED BY: SHAW	TASK NO: 8298700820000
CHECKED BY: MT	SHAW DWG NO: FIG 4–1
DATE: REVISED APRIL 2004	

FILE: RFI4-1.dwg PLOT: 11-20-03



SITE ID	39SB1A	39SB1B	39SB1D
DEPTH (ft)	0–0.5	1–2	4–6
TAL Metals (mg/kg)			
Chromium	**72.9**	32.1	39
Copper	**336**	**196**	30.4
Lead	**7070**	**537**	21.4

SAMPLE ID	39SB05A	39SB05B	39SB05C
DEPTH (ft. bgs)	0–0.5	1–3	3–5
TAL Metals (mg/kg)			
Beryllium	0.694	**1.05**	0.897
Copper	**308**	25.6	**54.7**
Lead	**4,530**	**138**	**800**
Dioxins/Furans (ng/kg)			
TCDD TE	20.67	0.79	2.57

SITE ID	39SS2
DEPTH (ft)	0–0.5
TAL Metals (mg/kg)	
Beryllium	**1.2**
Thallium	**17.8**

SAMPLE ID	39SS08
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Cadmium	**0.71** J

SAMPLE ID	39SS09
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Beryllium	**1.12**
Lead	**63.0** J

SAMPLE ID	39SS07
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**30.2** J

SITE ID	39SS1
DEPTH (ft)	0–0.5
TAL Metals (mg/kg)	
Thallium	**22.7**

SITE ID	39MW7A	39MW7B
DEPTH (ft)	6–9	14–16
NO EXCEEDANCES		

SITE ID	39SL2
DEPTH (ft)	0–1
TAL Metals (mg/kg)	
Barium	**429**
Chromium	**206**
Copper	**403**
Lead	**21000**
Thallium	**28**

SAMPLE ID	39SB06A	39SB06B	39SB06C
DEPTH (ft. bgs)	0–0.5	1–3	3–5
TAL Metals (mg/kg)			
Beryllium	0.785	**1.13**	**1.19**
Chromium	**95.1**	39.8 J	42.1 J
Copper	**375**	27.4	25.2
Lead	**16,500**	26.4	22.6
Dioxins/Furans (ng/kg)			
TCDD TE	4.53	1.65	0.94

SITE ID	39SB2B	39SB2D	39SB2F
DEPTH (ft)	1–2	4–6	12–14
NO EXCEEDANCES			

SITE ID	39SB4B	39SB4D	39SB4F
DEPTH (ft)	1–2	4–6	6–8
TAL Metals (mg/kg)			
Barium	**216** L	124 L	125 L
Beryllium	**1.1**	0.81	0.72 B

SITE ID	39SS3
DEPTH (ft)	0–0.5
NO EXCEEDANCES	

SAMPLE ID	39SS12
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**85.0** J
Zinc	**301** J

SITE ID	39SB3A	39SB3B	39SB3D
DEPTH (ft)	0–0.5	1–2	4–6
TAL Metals (mg/kg)			
Beryllium	**1.3**	**1.4**	0.78
Iron	44,500	**52,800**	23,500
Lead	**249**	**73.6**	11.9

SAMPLE ID	39SS11
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**38.6** J

SITE ID	39MW8A	39MW8B
DEPTH (ft)	6–8	12–16
NO EXCEEDANCES		

SITE ID	39SL3
DEPTH (ft)	0–1
TAL Metals (mg/kg)	
Beryllium	**1.16**
Lead	**33.4**
Thallium	**32.3**

SAMPLE ID	39SS10
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**99.2**

Sample Summary

Previous Investigation	Contractor	TAL Metals			VOCs		SVOCs			PAHs		Explosives			Pest		PCBs		Herb		Dioxins/Furans		Total
		SS	SB	SD	SS	SB	SS	SB	SD	SS	SB	SS	SB	SD	SS	SB	SS	SB	SS	SB	SS	SB	
1992 VI	D&M	3	--	3C	--	--	3	--	3C	--	--	3	--	3C	--	--	--	--	--	--	--	--	18
1997 Closure of Spray Pond	ATK	8	16	--	--	--	8	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	48
1998 RFI	ICF Kaiser	2	14	--	--	--	2	14	--	2	14	--	--	--	--	--	--	--	--	--	--	--	56
2002 RFI	Shaw	8	4	--	3	4	--	--	--	--	--	3	4	--	3	--	3	4	3	--	3	4	46

LEGEND:

- 1992 VI SOIL SAMPLE (DAMES & MOORE)
- 1992 VI WASTE COMPOSITE SAMPLE (DAMES & MOORE)
- 1994 VI MONITORING WELL (DAMES & MOORE)
- 1997 RFI MONITORING WELL (ALLIANT TECHSYSTEMS)
- 1998 RFI MONITORING WELL (BORING) (ICF KAISER)
- 1998 RFI SOIL BORING (ICF KAISER)
- FENCE
- 2002 RFI SOIL BORING LOCATION (SHAW)
- 2002 RFI SURFACE SOIL LOCATION (SHAW)
- SITE BOUNDARY

NOTE:

J = ESTIMATED CONCENTRATION

L = ESTIMATED CONCENTRATION BIAS LOW

DARK BORDER = VALUE EXCEEDS THE RESIDENTIAL SCREENING LEVEL (USEPA; APRIL, 2004)

SHADING = VALUE EXCEEDS THE INDUSTRIAL SCREENING LEVEL (USEPA; APRIL, 2004)

BOLD = VALUE EXCEEDS THE BACKGROUND CRITERION (IT, 2001)

VALUES DETECTED BELOW BACKGROUND ARE NOT SHOWN

0 100 FEET

SCALE

RADFORD AAP

FIGURE 4-2

SWMU 39
VI AND RFI
SAMPLING LOCATIONS
AND RESULTS

PREPARED BY: SHAW	TASK NO: 829570082200000
CHECKED BY: MT	SHAW DWG NO: FIG 4-2
DATE: REVISED APRIL 2004	

FILE: F04-2.dwg PLOT: 11-20-03

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5.0 CONTAMINANT FATE AND TRANSPORT

This section presents a discussion of the fate and transport of the chemicals identified in the nature and extent assessment as exceeding both the residential screening levels (USEPA, 2004a) and the established background concentrations (IT, 2001). Physical and chemical properties of the impacted media and of the contaminant(s) affect the fate and persistence of contamination in the environment (Rosenblatt et al., 1975). A general discussion of the physical properties and mechanisms which may govern the fate of contaminants in the environment, and a discussion of contaminant transport is presented in **Appendix D**.

Four metals (chromium, copper, iron, and lead) were detected in soil above residential screening levels and established background concentrations (IT, 2001). Vanadium was also detected at a concentration above its respective residential screening level. While vanadium was detected below the established background concentration, during the statistical background evaluation performed for the risk assessment (the reader is referred to *Section 6.0*), it was established that vanadium is present at SWMU 39 at levels statistically greater than background. Therefore, a discussion of the fate and transport of vanadium is presented herein.

Thallium was reported at concentrations exceeding background, residential, and industrial screening levels in composite samples (39SL2 and 39SL3) collected from both settling ponds and in two surface soil samples (39SS1 and 39SS2) collected near the RCRA closed spray pond (former ISP) during the 1992 VI. Subsequent investigations were unable to duplicate these elevated concentrations in soil near the RCRA closed spray pond (former ISP) or in soil in the settling ponds. In addition, there is no history of the use of thallium in or near SWMU 39 and, as discussed in *Section 2.3.1.2*, it is further believed that the detections are the result of false laboratory positives. Therefore, a discussion of the fate and transport of thallium is not discussed in this section.

The TE for dioxins/furans was also detected above the residential screening criterion for 2,3,7,8-TCDD. The fate and transport of these constituents are presented in the following sections.

5.1 Inorganic Compounds

Metal constituents, including chromium, copper, iron, lead, thallium, and vanadium, were detected in soil above residential screening levels and background concentrations at SWMU 39. Since most metals are indigenous to the earth, they are usually found at varying concentration levels in most environmental media. The majority of the metals are non-toxic at the concentrations found in site soil, while other metals may be toxic at the concentrations found on site. Non-toxic metals such as magnesium are required for the growth of young animals and plants, while heavy metals such as lead may inhibit their growth. Some metals build up in animal tissue (e.g., zinc accumulation in fish) while some metals accumulate in plants (e.g., vanadium).

In soil, metal contaminants are dissolved in the soil solution, adsorbed or ion-exchanged on inorganic soil constituents, complexed with soluble soil organic matter, and precipitated as pure or mixed solids. Metals in the soil solution are subject to movement with soil water and may be transported through the vadose zone to groundwater, taken up by plants and aquatic organisms or volatilized. Unlike organic constituents, metals cannot be degraded, however, some metals such as arsenic and chromium can be transformed among various oxidation states altering their mobility and toxicity. Metal contaminants participate in chemical reactions with the solid soil

phase. Immobilization of metals by adsorption, ion exchange, complexation and precipitation can prevent the movement of metal contaminants to groundwater. Changes in soil conditions, such as degradation of organic matrices and changes in pH, redox potential or soil solution composition, due to various remediation schemes or to natural weathering processes, also may change metal mobility in soil.

Fate and transportation mechanisms of the metals with concentrations found to exceed residential screening levels and background concentrations are discussed in more detail in the following sections.

5.1.1 Chromium

Chromium (Cr) was detected above the Cr^{+6} residential screening level (23 mg/kg) and background concentration (65.3 mg/kg) in three soil samples at concentrations ranging from 72.9 mg/kg (39SB1A from 0-0.5 ft) to 206 mg/kg (39SL2 from 0-1 ft). Residential screening level exceedances are limited to the top one foot of soil in the two settling ponds. Chromium was not detected above the industrial screening level (310 mg/kg) in the 33 samples collected from the site. Because chromium was not speciated during analysis, the screening level for Cr^{+6} was applied as a conservative measure. The USEPA Region III Residential RBC for Cr^{+3} is 120,000 mg/kg. No samples contained concentrations of chromium that exceeded the Cr^{+3} USEPA Region III Residential RBC.

Chromium exists in two valence states in the environment: trivalent (Cr^{+3}) or hexavalent (Cr^{+6}). Typically, Cr^{+3} in an aqueous environment would be associated with particles, while Cr^{+6} would remain in solution. Cr^{+3}, a positively charged particle, is the most thermodynamically stable form of chromium under common environmental conditions. Trivalent chromium has a strong tendency to sorb to negatively charged soil particles. As a result, Cr^{+3} is generally immobile and remains close to the origin of deposition. In addition, adsorption of Cr^{+3} will occur at slightly acidic soil pHs. Cr^{+6} is also positively charged, however, it commonly occurs in the environment within negatively charged compounds: chromate (CrO_4^{-2}) and dichromate (CrO_7^{-2}). Negatively charged chromium compounds are less likely to sorb to soil because soil particles are negatively charged (USEPA, 1997d). As a result, Cr^{+6} tends to be mobile in the environment. Cr^{+6} that does sorb to soil will likely be reduced to Cr^{+3} by organic matter (USEPA, 1998b).

Analytical results from SWMU 39 show that chromium concentrations decrease rapidly with depth. Chromium concentrations did not exceed the background screening level (IT, 2001) in subsurface soil or samples collected outside the settling ponds, indicating the limited mobility (within the top 1 ft bgs) of chromium at the SWMU 39 study area.

5.1.2 Copper

Copper (Cu) was detected above the residential screening level (310 mg/kg) and established background concentration (53.5 mg/kg) in three surface soil samples (39SL2, 39SB1A, and 39SB06A). Concentrations ranged from 336 mg/kg (39SB1A) to 403 mg/kg (39SL2). Residential screening level exceedances are limited to the top one foot of soil in the two settling ponds. Copper did not exceed the industrial screening level (4,100 mg/kg) in the 33 samples collected from the site.

Copper is strongly sorbed by soil particles (e.g., clays, metal oxides, and organic matter). Copper binds to soil much more strongly than other divalent cations, and the distribution of copper in the soil solution is less affected by pH than other metals (Gerritse and Van Driel,

1984). The slightly acidic soil condition (pH = 4.0) prevalent at SWMU 39 favors the solubility of Cu, thereby, promoting its mobility. The adsorption of Cu generally increases with increasing pH. Like other heavy metals, the movement of Cu in soil is also influenced by the permeability of the soil and the amount of clay, lime, and hydrous iron oxides present. These factors tend to attenuate the mobility of Cu through adsorption and cation exchange.

Volatilization of copper happens to a slight degree, but is insignificant relative to other processes that aid in the reduction of copper concentrations. It sorbs significantly to suspended to organic materials and bed sediments, thus reducing its mobility. Much of copper discharged to waterways is in particulate matter and settles out, precipitates out, or adsorbs to organic matter, hydrous iron and manganese oxides, and clay in sediment or in the water column. A significant fraction of the copper is adsorbed within the first hour, and in most cases, equilibrium is obtained with 24 hours (Harrison and Bishop, 1984).

Analytical results from SWMU 39 show that copper (similar to chromium) concentrations decrease rapidly with depth. Copper concentrations did not exceed the residential screening level in subsurface soil or samples collected outside the settling ponds, indicating the limited mobility of copper at the SWMU 39 study area.

5.1.3 Iron

Iron (Fe) was detected above the residential (2,300 mg/kg) and industrial (31,000 mg/kg) screening level in one single soil sample (39SB3B) at a concentration of 52,800 mg/kg. The established background value for iron is 50,962 mg/kg (IT, 2001). This sample was collected at a depth of 1-2 ft in the southern settling pond. A subsurface sample (39SB3D) was collected below sample 39SB3B from 4-6 ft that did not contain iron above the residential screening level, indicating that migration has not occurred to a significant degree.

Iron is an abundant element that contains very stable nuclei. Iron is the second most abundant metal in the earth's crust (second to aluminum) and is the fourth most abundant element, by weight, making up the crust of the earth. Important ores include Hematite (Fe_2O_3), Magnetite (Fe_3O_4), Limonite [$FeO(OH).xH_2O$] and Siderite ($FeCO_3$). Common iron is a mixture of four isotopes. Iron is a vital constituent of plant and animal life, and appears in hemoglobin. The pure metal is not often encountered in commerce, but is usually alloyed with carbon or other metals. The pure metal is very reactive chemically, and rapidly corrodes, especially in moist air or at elevated temperatures.

Corrosion (chemical and biological) of iron at SWMU 39 is the primary environmental degradation process. Corrosion of iron is an electrochemical phenomenon in which ions go into solution (anodic reaction) and the electrons generated by the reaction diffuse through the metal to the cathode where they are consumed (cathodic reaction). Biologically induced corrosion occurs when microorganisms are able to initiate, facilitate, or accelerate the corrosion reaction without changing the electrochemical nature of the process.

Evaluation of the physical data and the lack of iron detections in surface soil indicate that iron is undergoing corrosion reactions at the SWMU 39 study area. Iron is migrating from the surface to the subsurface where it is not anticipated to impact human health or ecological receptors.

5.1.4 Lead

Lead (Pb) was detected above its residential screening level (400 mg/kg), industrial screening level (800 mg/kg), and background (26.8 mg/kg) in four settling pond surface soil samples

(39SL2, 39SB1A, 39SB05A, and 39SB06A) at concentrations ranging from 4,530 mg/kg (39SB05A) to 21,000 mg/kg (39SL2). In addition, one settling pond subsurface soil sample (39SB05C: 3-5 ft) contained lead at a concentration exceeding the lead industrial screening level. One pond soil sample (39SB1B: 1-2 ft) contained a lead concentration of 537 mg/kg, exceeding its residential comparison criterion value of 400 mg/kg. The residential screening level for lead was not exceeded in samples collected outside the settling ponds. Lead screening level exceedances occurred in the northern settling pond with the exception of 39SB06A, which was collected from the southern settling pond.

The most common form of lead found in nature is Pb^{+2}, although lead also exists to a lesser extent as Pb^{+4} and in the organic form with up to four Pb-carbon bonds (USEPA, 1997d). Most lead deposited on surface soil is retained and eventually becomes mixed into the surface layer. The migration of lead in the subsurface environment is controlled by the solubility of lead complexes and adsorption to aquifer materials (USEPA, 1997d). Adsorption to soil greatly limits the mobility of lead in the environment. Lead may be immobilized by ion exchange with hydrous oxides or clays or by chelation with humic or fulvic acids in the soil (USEPA, 1997d). This appears to be occurring within the settling ponds.

Adsorption of lead increases with increasing pH with most lead precipitating out at a pH greater than 6 (USEPA, 1990). The pH of the surface soil where lead was detected (39SB05) above its industrial screening level is 4.0. Adsorption of lead also increases as the amount of total organic carbon in the soil increases, thereby decreasing its mobility. The soil at this sample location consists of silt and clay.

Lead has been consistently detected at elevated concentrations in surface soil within the settling ponds, but not at 1 ft below the pond surface. One of 14 subsurface soil samples (39SB05C) had a lead concentration greater than the industrial screening level. These results indicate that although the soil pH is slightly acidic, lead is forming insoluble compounds and adsorbing to surface soil, which limits its mobility.

Lead is the single verified metal that appears to have impacted the surface soil of both settling ponds. Concentrations in soil decrease rapidly with depth indicating that vertical migration of lead is limited. The silt and clay soil is retarding vertical movement through adsorbtion and low permeability. The pH of a surface soil sample collected from the northern settling pond was 4.00 (39SB05A). The slightly acidic pH in site soil would favor the precipitation of lead onto surface soil, excluding influence from acidic rainfall. Analysis of the results from surface soil samples collected adjacent to the settling ponds indicates that horizontal migration of lead is not occurring.

5.1.5 Vanadium

Vanadium (V) was detected in each of the surface and subsurface soil samples above its residential screening level of 55 mg/kg. The majority of the samples also exceeded the industrial screening level of 31 mg/kg. The concentrations detected ranged from 21.9 mg/kg (39SS07) to 92.7 mg/kg (39SB3B). None of these samples exceeded the established vanadium background concentration of 108 mg/kg (IT, 2001). However, during the statistical background evaluation performed for the risk assessment (presented in *Section 6.0*), it was established that vanadium is present at SWMU 39 at levels statistically greater than background.

The behavior of vanadium in soil is not yet fully understood (Mermut et al., 1996). The mobility of vanadium in soil is affected by pH (ATSDR, 1992b). Vanadium is fairly mobile in neutral or alkaline soil relative to other metals, but its mobility decreases in acidic soil (ATSDR, 1992b). In the presence of humic acids, mobile metavanadate anions can be converted to the immobile vanadyl cations resulting in local accumulation of vanadium (ATSDR, 1992b). Under oxidizing, unsaturated conditions some mobility is observed, but under reducing, saturated conditions vanadium is immobile (ATSDR, 1992b). Vanadium may be important in soil with high iron oxides and soil experiencing redox reactions, as this element has four oxidation states (Mermut et al., 1996). It occurs in iron oxides and is also adsorbed by silicate clay materials (Mermut et al., 1996). Clay soil has more vanadium than other soil (Mermut et al., 1996). When mafic rocks weather in a humid climate, the vanadium remains in the trivalent state or is weakly oxidized to the relatively insoluble tetravalent state (Hilliard, 1992). In either case, the vanadium is captured along with aluminum in the residual clays (Hilliard, 1992).

5.2 Organic Compounds

5.2.1 Dioxins/Furans

The concentration of dioxin/furan isomers detected at SWMU 39 were used to calculate the 2,3,7,8-TCDD TE, as described in *Section 6.1.1*. The calculated value was compared with the residential and industrial screening criteria for 2,3,7,8-TCDD (4.3 and 19 ng/kg, respectively). One surface soil sample collected from the northern settling pond (39SB05A) contained the 2,3,7,8-TCDD TE (20.67 ng/kg) above the industrial screening level. The 2,3,7,8-TCDD TE (4.53 ng/kg) also exceeded the residential screening criterion (4.3 ng/kg) in surface soil sample 39SB06A collected from the southern settling pond. It is likely that the settling ponds received ash from the propellant incinerator. Dioxin/furan contamination appears to be limited to surface soil within the settling ponds.

Dioxins/furans make up a family of chemicals with related properties and toxicity. There are 75 different forms of dioxins, while there are 135 different furans. Dioxins/furans are not manufactured or used. Instead, these groups of chemicals are formed unintentionally in two ways: (1) as a chemical contaminant of industrial processes involving chlorine or bromine, or (2) by burning organic matter in the presence of chlorine. The principal sources of dioxins/furans in the environment are combustion and incineration, chemical manufacturing, pulp and paper mills, and metal refining and smelting. The source of the chlorine for the dioxin/furans present at SWMU39 was likely the chlorinated slurry water in the propellant mix that was burned in the incinerators.

Several research studies have indicated that dioxins/furans act like a hormone, with effects that include neurotoxicity; immunotoxicity; and reproductive, developmental, and endocrine toxicity, including diabetes. Additional evidence exists that exposure to dioxins/furans at high levels for long periods of time causes cancer in humans (Gibbs, 1995).

Dioxins and furans share many physical properties, several of which influence how these compounds will behave in the environment. Dioxin and dioxin-like chemicals are not very water soluble. For example, the water solubility of TCDD, the most toxic dioxin, is 2.0×10^{-4} milligrams per liter (mg/L) at 25°C. Dioxins/furans also have low vapor pressures [e.g., 1.0×10^{-6} millimeters mercury (mm Hg) for TCDD at 25°C], which means that these compounds do not readily volatilize to the atmosphere. Dioxins and furans have high K_{oc} values (i.e., $3.30 \times 10^{+6}$ for

TCDD) indicating that dioxins and furans have high sorption potentials and will not tend to leach into groundwater or surface water runoff.

These groups of compounds also have high K_{ow} values (i.e., log K_{ow} of 6.72 for TCDD). The K_{ow} value gives an indication of how a compound will preferentially distribute into a solvent (i.e., n-octanol) or water, and is basically a measure of hydrophobic characteristics. Chemicals with high K_{ow} values, such as dioxins and furans, are relatively hydrophobic and will tend to sorb to soil rather than partitioning into the polar water phase.

Dioxins and furans with four or more chlorine atoms (i.e., OCDD and HpCDF) are extremely stable, with photolysis as the single significant degradation process. In the photodecomposition process, lower chlorinated congeners are formed (Crosby et al., 1971; Miller et al., 1989). Higher chlorinated congeners will have lower rates of decomposition. In addition, in or on solid phases, photochemical transformation results in a preferential loss of chlorine on the 1, 4, 6, and 9 positions leading to the formation of more toxic compounds (Lamparski et al., 1980; Nestrick et al., 1980). Since sunlight penetration becomes restricted in subsurface soil, photolysis of dioxins and furans will predominantly occur in the top layer of soil. For example, the dioxin concentration in the top one-eighth of inch of the contaminated soil at Times Beach, Missouri, was decreased 50 percent by photodegradation over a 16-month period, but the dioxin concentrations below this depth did not change.

In summary, dioxins and furans appear to be relatively immobile in soil due to their strong sorption behavior and limited water solubility. In soil systems, photolysis is the most significant degradation mechanism for dioxins/furans. However, degradation rates tend to be extremely slow and confined to the surface layer of the soil.

6.0 HUMAN HEALTH RISK ASSESSMENT

The HHRA has been prepared to evaluate the probability and magnitude of potential adverse effects on human health associated with actual or potential exposure to site-related chemicals at SWMU 39.

The HHRA is consistent with Section 300.430(d)(4) of the National Contingency Plan (NCP) (40 CFR 300), which directs that an HHRA be conducted "to characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to groundwater or surface water, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain." This section of the NCP was applied to the HHRA in which human health effects associated with site-related chemicals in surface soil and subsurface soil were evaluated. This HHRA is consistent with USEPA guidance and standards (USEPA, 1986a,b; 1989a; 1991a,b; 1992a,b,c; 1995a,b; 1997a,b; 1998a; 2001a,b; 2004a,b). In addition, site-specific guidance was applied, as appropriate. This guidance included the *RFAAP Final Master Work Plan* (URS, 2003) and the *RFAAP Site Screening Process* (USEPA, 2001c). The exposure media and exposure pathways that will be quantitatively evaluated in the HHRA are summarized in **Table 6-1**.

The HHRA is organized as follows:

- Data Summary and Selection of Chemicals of Potential Concern (COPCs) (*Section 6.1*). The chemicals detected in environmental media are identified and discussed. The data are summarized by presenting the frequency of detection and the range of detected concentrations in site-related samples, and the concentrations in background samples. In addition, COPCs are selected for quantitative evaluation in the HHRA based on a review of the data and a comparison to appropriate screening levels.
- Human Health Exposure Assessment (*Section 6.2*). The potential pathways by which individuals may be exposed to COPCs are discussed, and exposure pathways are selected for further evaluation. The chemical concentrations at the points of potential exposure are presented for each complete exposure pathway. Standard exposure factors and health-protective assumptions are used to assess the magnitude, frequency, and duration of exposure for each pathway, and potential exposures (intakes) are then estimated.
- Human Health Toxicity Assessment (*Section 6.3*). The potential toxicity of chemicals to humans and the chemical-specific health effects criteria to be used in the quantitative assessment are presented.
- Human Health Risk Characterization (*Section 6.4*). Quantitative risk estimates are calculated for each complete exposure pathway by combining the toxicity criteria with estimated intakes of potentially exposed individuals.
- Uncertainties in the HHRA (*Section 6.5*). Major sources of uncertainty in the HHRA are discussed.
- HHRA Summary (*Section 6.6*). The HHRA is briefly summarized.

6.1 Data Summary and Selection of COPCs

This section of the HHRA discusses the methodologies used to summarize the data for the HHRA (*Section 6.1.1*) and to select COPCs for detailed evaluation in the HHRA (*Section 6.1.2*).

Table 6-1
Selection of Exposure Pathways

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current	Groundwater	Groundwater	SWMU 39	None	None	None	On-site	None	Groundwater is being addressed under MWP Work Plan Addendum 009, "Horseshoe Area Groundwater Study" (IT, 2002b).
	Total Soil (Surface and Subsurface)	Total Soil (Surface and Subsurface)	SWMU 39	None	None	None	On-site	None	Current excavation or construction activities are not occurring at SWMU 39.
Current and Future	Surface Soil	Surface Soil	SWMU 39	Maintenance Worker	Adult	Ingestion	On-site	Quant	Maintenance workers could contact surface soil at SWMU 39 and be exposed to COPCs via incidental ingestion.
						Dermal	On-site	Quant	Maintenance workers could contact surface soil at SWMU 39 and be exposed to COPCs via dermal absorption.
				Trespasser	Adolescent	Ingestion	On-site	None	Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser.
						Dermal	On-site	None	Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser.
		Air	SWMU 39	Maintenance Worker	Adult	Inhalation	On-site	Quant	Maintenance workers could be exposed to airborne volatiles or particulate matter released from surface soil at SWMU 39.
				Trespasser	Adolescent	Inhalation	On-site	None	Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser.
Future	Total Soil (Surface and Subsurface)	Total Soil (Surface and Subsurface)	SWMU 39	Maintenance Worker	Adult	Ingestion	On-site	Quant	Maintenance workers could contact soil at SWMU 39 and be exposed to COPCs via incidental ingestion.
						Dermal	On-site	Quant	Maintenance workers could contact soil at SWMU 39 and be exposed to COPCs via dermal absorption.
				Excavation Worker	Adult	Ingestion	On-site	Quant	Excavation workers could contact soil at SWMU 39 and be exposed to COPCs via incidental ingestion.
						Dermal	On-site	Quant	Excavation workers could contact soil at SWMU 39 and be exposed to COPCs via dermal absorption.
				Resident	Adult	Ingestion	On-site	Quant	If SWMU 39 were to be further developed for residential purposes, residents could be exposed to COPCs in total soil via ingestion. The residential scenario is not considered to be a reasonably anticipated land use; however, it is being included in this evaluation to meet "clean closure" requirements under RCRA.
						Dermal	On-site	Quant	If SWMU 39 were to be further developed for residential purposes, residents could be exposed to COPCs in total soil via dermal absorption.
					Child	Ingestion	On-site	Quant	If SWMU 39 were to be further developed for residential purposes, residents could be exposed to COPCs in total soil via ingestion. The residential scenario is not considered to be a reasonably anticipated land use; however, it is being included in this evaluation to meet "clean closure" requirements under RCRA.
						Dermal	On-site	Quant	If SWMU 39 were to be further developed for residential purposes, residents could be exposed to COPCs in total soil via dermal absorption.
				Trespasser	Adolescent	Ingestion	On-site	None	Given the industrial nature of the site, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser.
						Dermal	On-site	None	Given the industrial nature of the site, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser.

Table 6-1
Selection of Exposure Pathways

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future (con't)	Total Soil (Surface and Subsurface)	Air	SWMU 39	Maintenance Worker	Adult	Inhalation	On-site	Quant	Maintenance workers could be exposed to airborne volatiles or particulate matter released from soils at SWMU 39.
				Excavation Worker	Adult	Inhalation	On-site	Quant	Excavation workers could be exposed to airborne volatiles or particulate matter released from soils at SWMU 39.
				Resident	Adult	Inhalation	On-site	Quant	If SWMU 39 were to be further developed for residential purposes, residents could be exposed to airborne volatiles or particulate matter released from total soil.
					Child	Inhalation	On-site	Quant	If SWMU 39 were to be further developed for residential purposes, residents could be exposed to airborne volatiles or particulate matter released from total soil.
				Trespasser	Adolescent	Inhalation	On-site	None	Given the industrial nature of the site, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser.

The summarization of data and selection of human health COPCs are then presented for the sampled medium at SWMU 39 in *Section 6.1.3*. Finally, a summary of the COPCs selected in each medium is provided in *Section 6.1.4*.

6.1.1 Methodology for Data Summary

The first step of the HHRA process was to summarize the analytical data collected at SWMU 39. Detailed discussions of the QA/QC activities implemented during the collection of the data are provided in **Appendix A-2**.

The following steps, which are in accordance with USEPA (1989a) guidance, were used to summarize the analytical data for this HHRA:

- Analytical data collected between February 1992 and July 2002 were summarized by environmental medium (i.e., surface soil and total soil). In general, surface soil was defined as soil samples that were collected from 0 to 2 ft. Total soil consisted of surface soil and subsurface soil, assuming that soil would mix as a result of potential disturbance (e.g., excavation, construction) in the future. Subsurface soil samples were collected between 2 to 10 ft bgs. In addition, the samples were divided into groups that describe conditions relevant to potential exposure by receptors or were pertinent to site environmental factors.

- The qualification and validation of the analytical data included a comparison of the site data to corresponding blank (laboratory, equipment rinse, field, and trip) concentration data. If the detected concentration in a site sample was less than ten times (for common laboratory contaminants) or five times (for other compounds) the concentration in the corresponding blank sample, the sample was qualified with a "B." According to USEPA Region III guidance (USEPA, 1995c; 2000b), it cannot be unequivocally stated that the result is not "non-detected" at that concentration. Therefore, B-qualified data are typically eliminated from the data set.

  Data sets for this HHRA were evaluated for B-qualified data on an "analyte-by-analyte" basis. Because of the amount of B-qualified data reported for some analytes, one-half of the sample quantitation limit (SQL) was used as a proxy value for B-qualified data points to address potential uncertainty associated with eliminating these data. If the proportion of B-qualified results in the data set for SWMU 39 was greater than 50 percent, one-half of the SQL was used to represent the concentration. If the proportion of B-qualified results in the data set was less than 50 percent, the B-qualified data for the analyte were eliminated. (The exception to this approach was the dioxin/furan results used to estimate a 2,3,7,8-TCDD toxicity equivalent concentration). For screening purposes, the B-qualified data were included in calculations of the dioxin toxicity equivalence (TCDD TE), as described in the sections below.

- Data that were considered estimated values (e.g., J-qualified) were used in the HHRA without modification.

- Arithmetic mean chemical concentrations were calculated by averaging the detected concentrations with one-half the SQL of non-detects. One-half of the SQL is typically used in assessments (USEPA, 1989a) when averaging non-detect concentrations, because the actual value can be between zero and a value just below the SQL. In accordance with USEPA Region III guidance (USEPA, 1995c), this procedure was used even when the non-detect SQL was two or more times higher than the maximum detected concentration

in that medium. The uncertainties associated with this methodology will be discussed in *Section 6.5*.

- Data from duplicate samples were averaged together and treated as one result. If a chemical was detected in one of two duplicate samples, one-half of the SQL was used for the non-detected value and averaged together with the detected result.
- Frequency of detection was calculated as the number of samples in which the chemical was detected over the total number of samples analyzed. The frequency of detection was assessed after the exclusion of B-qualified data, and after the treatment of duplicate sample data. Because samples were sometimes analyzed for different sets of analytes, the frequencies of detection varied by analyte. Frequency of detection, however, was not used as a selection criterion for COPCs in this HHRA.
- If a constituent was analyzed by two different methods, results from the most sensitive analytical method were generally used.

Dioxin-like compounds were treated according to procedures provided by USEPA and WHO (USEPA, 1989b, 1994a; WHO, 1998). Dioxin-like compounds (PCDDs and PCDFs) are present in the environmental media as complex mixtures. PCDDs and PCDFs consist of a family of approximately 75 and 135 congeners, respectively. To simplify the task of screening PCDDs/PCDFs for evaluation in this risk assessment, these compounds were evaluated with respect to a single member of this class of compounds. The concentration of each congener was evaluated on the basis of its concentration relative to that of 2,3,7,8-TCDD, which has been shown to be the most potent congener of the class of PCDDs/PCDFs. This procedure is described in the following steps:

1. For each sample, the detected concentration of each congener was multiplied by a toxicity equivalence factor (TEF) to derive a 2,3,7,8-TCDD equivalent (TCDD TE) concentration (USEPA, 1989b). If the value for a particular congener was reported as a "non-detect" (ND), then the reported detection limit was used to represent a conservative concentration for the congener. If the result for a particular congener was B-qualified, then the result was conservatively retained for the calculation (Note: three results were B-qualified).
2. To calculate the 2,3,7,8 TCDD TE for each sample, the TCDD TEs for individual congeners were summed. The TEF values for each congener are listed in **Table 6-2** (WHO, 1998).
3. The total TCDD TE values for each medium were summarized by selecting the maximum and minimum TCDD TEs across each of the samples for that medium.

6.1.2 Methodology for Selection of COPCs for Human Health

Once the sampling data for SWMU 39 were grouped and summarized, COPCs for the HHRA were selected. The purpose of selecting COPCs is to identify those chemicals that are present as a result of past activities at the site and most likely to be of concern to human health. Therefore, the screening process eliminates from the HHRA:

- those chemicals present in surface soil and total soil at concentrations below conservative health-based screening levels, represented by the USEPA Region III RBCs corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2004a);

Table 6-2
Toxicity Equivalency Factors (TEFs)

Congener	TEF
Dioxins	
2,3,7,8-TCDD or TCDD	1.0
HxCDD	0.1
2,3,7,8-HpCDD or HpCDD	0.01
OCDD	0.0001
PeCDD	1.0
Furans	
TCDFs	0.1
HxCDF	0.1
2,3,7,8-HpCDF or HpCDF	0.01
OCDF	0.0001
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5

- those chemicals present in surface soil and total soil at concentrations below conservative health-based screening levels, represented by the USEPA Region III RBCs corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2004a), and;
- those chemicals that are essential human nutrients (i.e., calcium, magnesium, potassium, and sodium) and unlikely to pose risks to human health.

The following methodologies were used to eliminate chemicals detected at maximum concentrations below screening levels from quantitative evaluation in the HHRA, and to compare inorganic chemicals detected above screening levels to background concentrations. The RBCs used for this HHRA are presented in **Table 6-3**.

6.1.2.1 Comparison of Detected Chemicals to Relevant Health-Based Levels

The maximum concentrations of detected chemicals were compared to RBCs (USEPA, 2004a), in accordance with Region III guidance. The RBCs presented in the USEPA Region III RBC table are health-protective chemical concentrations that are back-calculated using conservative exposure parameters and either carcinogenic toxicity criteria and a $1x10^{-6}$ target risk level, or noncarcinogenic toxicity criteria and an HI of 1.0 (whichever results in a lower RBC).

For the purposes of this HHRA, RBCs that were back-calculated using carcinogenic toxicity criteria were used directly as screening criteria, whereas RBCs that were back-calculated using noncarcinogenic toxicity criteria were adjusted downward by a factor of 10 in order to add a ten-fold measure of safety (i.e., to ensure that compounds that could combine to result in an HI greater than 1 for a specific target organ/critical effect were not eliminated from the assessment). If the maximum detected on-site chemical concentration was less than the RBC (or adjusted RBC for noncarcinogenic chemicals), the probability of developing cancer would be less than 1 in 1 million, and adverse noncarcinogenic effects would not be expected to occur. As a result,

Table 6-3
USEPA Region III RBCs for Chemicals Detected at SWMU 39

Chemical	USEPA Region III RBC (a) Residential Soil (organics - mg/kg; inorganics - mg/kg)
Organics	
bis(2-Ethylhexyl)phthalate	4.6E+01
alpha-Chlordane (b)	1.8E+00
gamma-Chlordane (b)	1.8E+00
4,4'-DDD	2.7E+00
Diethyl phthalate	6.3E+03
Di-n-butyl phthalate	7.8E+02
2,4-Dinitrotoluene	9.4E-01
Endrin	2.4E+00
Endrin aldehyde (c)	2.4E+00
Endrin ketone (c)	2.4E+00
Methoxychlor	3.9E+01
Nitroglycerine	4.6E+01
TCDD Toxicity Equivalent	4.3E-06
Inorganics	
Aluminum	7.8E+03
Antimony	3.1E+00
Arsenic	4.3E-01
Barium	5.5E+02
Beryllium	1.6E+01
Cadmium (d)	3.9E+00
Calcium (e)	1.0E+06
Chromium (f)	2.4E+01
Cobalt	1.6E+02
Copper	3.1E+02
Iron	2.3E+03
Lead (g)	4.0E+02
Magnesium (e)	1.0E+06
Manganese (h)	1.6E+02
Mercury (i)	2.3E+00
Nickel	1.6E+02
Potassium (e)	1.0E+06
Selenium	3.9E+01
Silver	3.9E+01
Sodium (e)	1.0E+06
Thallium	5.5E-01
Vanadium	7.8E+00
Zinc	2.3E+03

(a) USEPA Region III residential soil RBCs are used as screening values for soil (USEPA, 2004a). RBCs for noncarcinogenic chemicals are conservatively based on a hazard quotient of 0.1, following USEPA Region III guidance.

(b) The RBC for chlordane was used.

(c) The RBC for endrin was used.

(d) The soil RBC based on tap water was used because it is a more conservative value.

(e) Value is a Recommended Daily Allowance (RDA) level for essential human nutrients.

(f) The RBC for chromium VI was used as the screening criterion, although not all of the chromium at the site will be in this form.

(g) Because lead does not have an RBC, the 400 mg/kg residential screening level (USEPA, 1994a)

(h) The RBC for non-food was used.

(i) For soil, the RBC for mercuric chloride was used.

those chemicals detected at levels greater than RBCs (or adjusted RBCs) were retained for evaluation.

Although current and future land-uses at SWMU 39 are most likely to be industrial in nature (see *Section 6.2*), residential (rather than industrial) soil RBCs were used for comparisons to soil concentrations. Because the resident scenario was evaluated for this HHRA, residential soil RBCs were used to screen chemicals in soil as a conservative measure.

RBCs are not available for lead. For screening purposes, however, the maximum detected lead concentrations in soil were conservatively compared to USEPA's residential SSL of 400 mg/kg (USEPA, 1994b). Per 40 CFR 745, the lead concentration of 400 mg/kg applies to areas where children play. Lead was selected for further evaluation in the HHRA where maximum detected concentrations (MDCs) of lead exceed screening levels.

6.1.2.2 Comparison of Essential Human Nutrients to Allowable Daily Intakes

The maximum concentrations of the four essential human nutrients that do not have RBCs (i.e., calcium, magnesium, potassium, and sodium) were compared to dietary Allowable Daily Intakes (ADIs). As recommended in both the *Site Screening Process* (USEPA, 2001c) and the *Final Master Work Plan* (URS, 2003) the essential nutrients calcium, magnesium, potassium and sodium were eliminated as COPCs. Although iron is also an essential nutrient, there is an RBC available for iron. It is noted in the *Site Screening Process* (USEPA, 2001c), however, that if iron concentrations in soil or water result in a hazard quotient (HQ) of 0.5 or greater, then a "margin of exposure" evaluation would be performed. Risks from exposure to iron would be characterized by comparing estimated iron intake to the Recommended Daily Allowance (RDA) and concentrations known to cause effects in children (USEPA, 1996d).

6.1.2.3 Comparison of Inorganic Compounds to Background Levels

Comparisons between detected site concentrations and background concentrations were also conducted in the HHRA for information purposes. Background data for SWMU 39 soil was obtained from the Facility-Wide Background Study Report (FWBSR) (IT, 2001). Inorganic chemicals detected at concentrations exceeding screening levels, but within background levels, were noted as being within background levels, but were still carried through the risk calculation in the HHRA. In addition, COPCs that are present at concentrations within background range will be qualitatively addressed in the HHRAs.

For the HHRA, the evaluation of site concentrations to background concentrations was achieved using two methods of comparison. First, the maximum detected concentration for each inorganic constituent was compared to the background UTL, as established in the FWBSR. A brief description of background determination is provided in *Section 2.3.1.4* and the background UTLs are presenting in **Table 2-1**. A detailed discussion can be found in the FWBSR (IT, 2001).

The second method involved the statistical comparison of site concentrations to background concentrations to evaluate whether the populations were similar. This approach paralleled the methodology applied to population comparisons for the FWBSR. The data sets were first evaluated to assess whether data were normally distributed. The site data sets and background data sets were tested individually.

The Shapiro-Wilk test or W test (Gilbert, 1987) was used for data sets with sample sizes equal to or less than 50 to evaluate whether or not a data set has been drawn from a population that is normally distributed. By conducting this test on the natural logarithm of each data value, the W

test was used to evaluate whether or not the sample was drawn from an underlying lognormal distribution. The null hypothesis for this test is:

H_o: The population has a normal (lognormal when the data is transformed) distribution.

versus

H_A: The population does not have a normal (lognormal when the data is transformed) distribution.

If H_o is rejected, then H_A is accepted.

The Shapiro-Francia test was used for data sets with sample sizes greater than 50 to evaluate whether or not a data set has been drawn from a population that is normally distributed.. Like the Shapiro-Wilk test, the Shapiro-Francia test statistic (W′) can be calculated using the natural logarithm of each data value. This approach is used to evaluate whether or not the sample was drawn from an underlying lognormal distribution. The null hypothesis for this test is:

H_o: The population has normal (lognormal when data is transformed) distribution.

versus

H_A: The population does not have a normal (lognormal when data is transformed) distribution.

If H_o is rejected, then H_A is accepted.

If these tests indicated that the data sets did not follow a normal distribution, data points were log-transformed and the tests were used to assess whether the data were lognormally distributed.

When data were found to follow a normal distribution, the F-test was applied to assess whether there was a statistical difference between the variances of the two groups. When data from both the site and background data sets were log-normally distributed, the F-test was applied to log-transformed data. An alpha of 0.05 was selected for this test. The null hypothesis for this test is:

H_o: The populations have equivalent variances ($\sigma = \sigma$)

versus

H_A: The populations do not have equivalent variances ($\sigma \neq \sigma$)

Results from the F-test were used to identify the appropriate t-test. For example, when the variances were found to be similar, the t-test was calculated using equal variances. Conversely, t-tests were calculated using unequal variances when the F-test demonstrated that the variances between the data sets were not similar.

The t-test was used to assess whether the means of the data sets for the site concentrations were similar or greater than the background concentrations. If the t-test indicated that the means between the two data groups were similar, site concentrations were considered to be within or below background levels. If the t-test indicated that the mean for the site data set was greater than the mean for the background data set, then site concentrations were considered to be above background concentrations. By conducting this test on the natural logarithms at each data value, the T-test was used to evaluate whether there is no difference between two population means with equal variances from a combined data set that is lognormally distributed. An alpha of 0.05 was selected for this test. The null hypothesis for this test is:

H_o: The populations have equal means ($\mu_1 = \mu_2$)

versus

H_A: The mean of the site data set is greater than the mean of the background data set ($\mu_1 > \mu_2$)

When site and background data sets had different distributions or did not pass the normal or lognormal distribution test, the Mann-Whitney U test was used to assess whether the medians of the data sets for the site concentrations were similar or greater than the background concentrations. The Mann-Whitney U test is a nonparametric test that involves ranking the data. This test is not dependent upon the distribution of the data. If the Mann-Whitney U test indicated that the medians between the two data groups were similar, site concentrations were considered to be within or below background levels. If the Mann-Whitney U indicated that the median for the site data set was greater than the mean for the background concentrations, then site concentrations were considered to be above background concentrations. The null hypothesis for this test is:

H_o: The populations have equal medians set ($U_1 = U_2$)

versus

H_A: The median of the site data set is greater than the median of the background data set ($U_1 > U_2$)

Based on these evaluations, chemicals were eliminated from further quantitative evaluation if they met both of the following conditions:

1. The maximum detected concentration was below the UTL, and
2. Based on statistical comparisons, site concentrations are within or below background concentrations.

The results of these analyses are included in **Appendix E-2**. For surface soil, arsenic and manganese exceeded screening criterion but were shown to be within background concentrations. For total soil, manganese exceeded screening criteria but was shown to be within background concentrations. As stated previously, inorganic chemicals detected at concentrations exceeding RBCs or ADIs, but within background levels, were not eliminated from the

quantitative evaluation in the HHRA. These inorganic chemicals were included in the risk calculations, in addition to being qualitatively addressed in the HHRA.

6.1.3 Data Summary and Selection of COPCs for Sampled Media

The following sections describe the environmental samples collected at SWMU 39, the sample groupings selected for the HHRA, and the COPCs selected within each of the sample groupings. In addition, the background data obtained from the FWBSR (IT, 2001) for each medium are discussed. Summary tables present chemical data by timeframe, medium, and data grouping and contain parameters such as the range of detected concentrations, location of the MDC, frequency of detection, screening criteria, and the 95% UTL of the background concentrations. The tables presenting the summarized data and selected COPCs are included in **Appendix E-1, Tables E-1 and E-3**.

As described in *Section 2.1*, SWMU 39 includes two unlined earthen ponds and is located in the north-central section of the Horseshoe Area, adjacent to and associated with the Hazardous Waste Incinerators (SWMU 14). The earthen settling ponds received scrubber and precooler quench water from incinerator exhaust. SWMU 39 is also adjacent to a RCRA-closed concrete-lined spray pond (HWMU 39). The ISP is not part of this HHRA.

6.1.3.1 Surface Soil

The earthen ponds were intended to receive scrubber and precooler quench water from incinerator exhaust. Water is not present in the ponds except during heavy rain, snow melt or other precipitation events. Furthermore, there was no water present during sampling. Therefore, the soil samples that were collected from the ponds were evaluated as soil rather than sediment. Surface soil samples (i.e., samples collected from the 0 to 2 ft soil interval) included in the HHRA for evaluation are shown in **Table 6-4**. A total of 19 surface soil samples collected in February 1992, April 1998, and July 2002 at SWMU 39 were evaluated in the HHRA. Surface soil samples were analyzed for VOCs, SVOCs, PAHs, pesticides, herbicides, PCBs, TAL metals, and explosives. It is noted that two samples were collected from 1 to 3 foot interval (39SB05B and 39SB06B). These samples were included as surface soil in the HHRA to be consistent with the sample grouping for the SLERA. Although collected, composite samples were not in the risk assessment.

Summaries of the ranges of detected concentrations, locations of the maximum detected concentrations, and frequencies of detection of chemicals in the surface soil evaluated in the HHRA are presented in **Appendix E-1, Table E-1**. Surface soil COPCs were selected by comparing maximum concentrations of detected chemicals to residential soil RBCs and by comparing maximum concentrations of essential human nutrients to ADIs. Comparisons between detected site concentrations and background concentrations were also conducted (**Appendix E-2**). Inorganic chemicals detected at concentrations exceeding screening levels, but within background levels, were carried through the quantitative risk assessment and addressed in the risk characterization, if applicable (*Section 6.4*).

As shown in **Appendix E-1, Table E-1**, 23 inorganics were detected in surface soil at SWMU 39. Nine inorganics were detected at concentrations above residential soil RBCs, or other screening criteria, and were selected as COPCs. These inorganics include: aluminum, arsenic, chromium, copper, iron, lead, manganese, thallium, and vanadium. Arsenic and manganese were determined to be within background concentrations. Eleven organic compounds were detected but none were detected at concentrations above residential soil RBCs, and none were selected as

Table 6-4
SWMU 39 Sample Groupings

SURFACE SOIL			
SWMU 39	39SB05A	39SB3A	39SS10
	39SB05B	39SB3B	39SS11
	39SB06A	39SB4B	39SS12
	39SB06B	39SS07	39SS1
	39SB1A	39SS08	39SS2
	39SB1B	39SS09	39SS3
	39SB2B		
SUBSURFACE SOIL			
SWMU 39	39MW7A	39SB06C	39SB3D
	39MW8A	39SB1D	39SB4D
	39SB05C	39SB2D	39SB4F

a COPC. Seventeen dioxin/furan congeners were detected. The TCDD TE exceeded the residential soil RBC and dioxins/furans were selected as COPCs for surface soil.

Chemicals that were not detected in at least one medium have not been included in the HHRA. The detection limits for the non-detected constituents were screened against the RBCs to ensure that the range of detection limits was generally low enough to detect constituents that would exceed RBCs. The maximum detection limits for these constituents were compared to RBCs. The results of the screening are included as **Appendix E-1, Table E-2**. One hundred forty-six (146) organic compounds were reported as non-detected. The maximum detection limits for 21 compounds were above the RBCs: aldrin; alpha-BHC; dieldrin; heptachlor epoxide; MCPA; MCPP; toxaphene; Aroclor 1221; Aroclor 1232; Aroclor 1242; Aroclor 1248; Aroclor 1254; Aroclor 1260; 3,3'-dichlorobenzidine; 4,6-dinitro-o-cresol; benzidine; benzo(a)pyrene; dibenz(a,h)anthracene; hexachlorobenzene; n-nitroso-di-methylamine; and, n-nitroso-di-n-propylamine. Ten chemicals had no RBCs to be compared against. These included: PETN; dichloroprop; 2-nitrophenol; 3&4-methylphenol; bis(2-chloroethoxy)methane; p-chloro-m-cresol; 4-bromophenyl phenylether; 4-chlorophenyl phenylether; 4-methyl-2-pentanone; and, p&m-xylene.

6.1.3.2 Total Soil

Total soil samples (i.e., surface soil and subsurface soil samples collected from the 0 to 10 ft soil interval) included in the HHRA for evaluation are shown in **Table 6-4**. A total of 19 surface and 9 subsurface soil samples collected in February 1992, April 1998, and July 2002 at SWMU 39 were evaluated in the HHRA. Surface and subsurface soil samples were analyzed for VOCs, SVOCs, PAHs, pesticides, herbicides, PCBs, metals, and explosives.

Summaries of the ranges of detected concentrations, locations of the MDCs, and frequencies of detection of chemicals in total soil evaluated in the HHRA are presented in **Appendix E-1, Table E-3**. Total soil COPCs were selected by comparing maximum concentrations of detected chemicals to residential soil RBCs and by comparing maximum concentrations of essential human nutrients to ADIs. Comparisons between detected site concentrations and background concentrations were also conducted (**Appendix E-2**). Inorganic chemicals detected at concentrations exceeding screening levels, but within background levels, were carried through the quantitative risk assessment and addressed in the risk characterization, if applicable (*Section 6.4*).

As shown in **Appendix E-1, Table E-3**, 23 inorganics were detected in total soil at SWMU 39. Nine inorganics were detected at concentrations above residential soil RBCs, or other screening criteria, and were selected as COPCs. These inorganics include: aluminum, arsenic, chromium, copper, iron, lead, manganese, thallium, and vanadium. Manganese was determined to be within background concentrations. Twelve organic compounds were detected but none were detected at concentrations above residential soil RBCs, and none were selected as a COPC. Seventeen dioxin/furan congeners were detected. The TCDD TE exceeded the residential soil RBC and dioxins/furans were selected as COPCs for surface soil.

Chemicals that were not detected in at least one medium have not been included in the HHRA. The detection limits for the non-detected constituents were screened against the RBCs to ensure that the range of detection limits was generally low enough to detect constituents that would exceed RBCs. The maximum detection limits for these constituents were compared to RBCs. The results of the screening are included as **Appendix E-1, Table E-4**. One hundred forty-five (145) organic compounds were reported as non-detected. The maximum detection limits for 21

compounds were above the RBCs: aldrin; alpha-BHC; dieldrin; heptachlor epoxide; MCPA; MCPP; toxaphene; Aroclor 1221; Aroclor 1232; Aroclor 1242; Aroclor 1248; Aroclor 1254; Aroclor 1260; 3,3'-dichlorobenzidine; 4,6-dinitro-o-cresol; benzidine; benzo(a)pyrene; dibenz(a,h)anthracene; hexachlorobenzene; n-nitroso-di-methylamine; and, n-nitroso-di-n-propylamine. Ten chemicals had no RBCs to be compared against. These included: PETN; dichloroprop; 2-nitrophenol; 3&4-methylphenol; bis(2-chloroethoxy)methane; p-chloro-m-cresol; 4-bromophenyl phenylether; 4-chlorophenyl phenylether; 4-methyl-2-pentanone; and, p&m-xylene.

6.1.4 Summary of Chemicals Selected as COPCs

COPCs selected at SWMU 39 are summarized in **Table 6-5**. Contamination at this site is primarily due to inorganics and dioxins/furans.

6.2 Human Health Exposure Assessment

In this section, the potential pathways by which individuals may be exposed to the COPCs in each environmental medium are identified and exposures are quantified. A discussion of potential current and future exposure pathways through which populations could be exposed to chemicals at or originating from SWMU 39 is presented in *Section 6.2.1*.

For each pathway selected for quantitative evaluation, the chemical concentrations at the points of exposure are estimated (*Section 6.2.2*), and the methodology for calculating potential chemical intakes for each pathway selected for quantitative evaluation is discussed (*Section 6.2.3*).

6.2.1 Potential Human Exposure Pathways

An exposure pathway describes the course a chemical takes from the source to the exposed individual, and is defined by four elements:

- a source and mechanism of chemical release to the environment;
- an environmental transport medium (e.g., groundwater) for the released chemical;
- a point of potential contact with the contaminated medium (referred to as the exposure point); and,
- an exposure route (e.g., ingestion) at the contact point.

An exposure pathway is considered complete when each of the four elements is present. In risk assessments, complete exposure pathways are quantitatively evaluated.

When conducting an exposure assessment, USEPA (1989a, 1991b) guidance requires that plausible exposures under both current and future land-use scenarios be evaluated in an HHRA. Accordingly, potential human exposure pathways are identified for current and potential future land-use conditions at SWMU 39 in the following sections. The current land-use scenario is based on conditions, as they currently exist, while the future land-use scenario evaluates potential risks that may be associated with possible changes in site use, assuming no remedial action occurs.

The potential exposure pathways through which humans could currently be exposed to contamination resulting from past activities at SWMU 39 are discussed below. **Table 6-1** presents an exposure pathway analysis for potential current/future land-use conditions, indicating the exposure media, exposure points, potential receptors, and exposure routes. This table also indicates whether a quantitative analysis was conducted for the pathway and the rationale for selection or exclusion of the pathway.

Table 6-5
Summary of Chemicals of Potential Concern
at SWMU 39

Chemical (a)	Surface Soil	Total Soil
Organics		
alpha-Chlordane		
gamma-Chlordane		
bis(2-Ethylhexyl)phthalate		
4,4'-DDD		
Diethyl phthalate		
Di-n-butyl phthalate		
2,4-Dinitrotoluene		
Endrin		
Endrin aldehyde		
Endrin ketone		
Methoxychlor		
Nitroglycerin		
TCDD TE	X	X
Inorganics		
Aluminum	X	X
Antimony		
Arsenic	X	X
Barium		
Beryllium		
Cadmium		
Calcium		
Chromium	X	X
Cobalt		
Copper	X	X
Iron	X	X
Lead	X	X
Magnesium		
Manganese	X	X
Mercury		
Nickel		
Potassium		
Selenium		
Silver		
Sodium		
Thallium	X	X
Vanadium	X	X
Zinc		

(a) Chemicals detected in all media at SWMU 39.

Shaded cells indicate that the chemical lacks toxicity criteria and cannot be quantitatively evaluated.

X = Selected as a COPC.

Receptor Characterization. The area around MMA is not highly developed and land use in the vicinity of the facility is mostly rural, with less rugged areas having been primarily used for agriculture. Residential and recreational areas are located adjacent to the facility (IT, 2001). It is unlikely, however, that the uses of land within MMA will change significantly in the future. The MMA contains numerous buildings and facilities, and it is likely that the area (including SWMU 39) will remain industrial in nature.

SWMU 39 is not currently in use and a portion of this site is fenced. It was conservatively assumed, however, that maintenance workers are the most likely receptors at the site. If future development occurs, excavation workers could be receptors. Therefore, maintenance worker and excavation worker exposures at SWMU 39 were evaluated in the HHRA.

Due to security at the Installation (e.g., strict security at entry gates, guard towers, barbed-wire fences), it is not likely that children would be able to trespass at the Installation. It would also be difficult for an adolescent to trespass at the site. Even if an older adolescent were able to evade security measures, it would be difficult to do so on a routine basis. Therefore, a trespasser scenario was not evaluated. However, hypothetical future exposures to children were considered in the residential scenario described below. The exposure parameters for residents are more conservative than those for children trespassers. Also, the maintenance worker scenario that is being evaluated would be similar to the limited exposure that an adolescent trespasser could experience at the site and would be protective of the trespasser.

Since land use is expected to remain industrial, a residential scenario is not considered to be a reasonably anticipated land use. However, the residential scenario was evaluated to meet "clean closure" requirements under RCRA. Therefore, adult resident and child resident exposures at SWMU 39 were evaluated in the HHRA.

Exposure Pathway Identification. The exposure pathways associated with maintenance and excavation workers at SWMU 39 were identified based on consideration of the sources and releases of chemicals. The exposure pathways considered for evaluation under current land-use conditions are described below.

Groundwater. Due to the nature of groundwater at the Installation, it is difficult to associate specific sites with groundwater exposures. Groundwater at the site is being addressed in MWP Work Plan Addendum 009, "Horseshoe Area Groundwater Study" (IT, 2002b). Therefore, groundwater exposures were not evaluated in this HHRA.

Surface Soil. Human exposures to chemicals in surface soil could occur by direct contact and subsequent dermal absorption and/or incidental ingestion of COPCs. As a result, maintenance worker exposures to COPCs in surface soil via incidental ingestion and dermal absorption were evaluated under current land-use conditions for SWMU 39. Because current land-use of the site does not include residents, adult and child resident exposures to chemicals in surface soil would not occur. Therefore, residential exposures to chemicals in surface soil were not evaluated under current land-use conditions.

Total Soil. Because ground-intrusive or construction/excavation activities are not currently taking place, potential excavation worker exposures to chemicals in surface and subsurface soil (i.e., total soil) would not occur. In addition, it is not likely that maintenance workers would have the opportunity to be exposed to total soil when on-site; thus, exposures to chemicals in total soil were not evaluated under current land-use conditions. Because current land-use of the site does not include residents, adult and child resident exposures to chemicals in surface and

subsurface soil (i.e., total soil) would not occur. Therefore, residential exposures to chemicals in total soil were not evaluated under current land-use conditions.

Air. Airborne releases of COPCs can occur via the wind entrainment of chemicals on dust particles. Maintenance workers could potentially be exposed to airborne chemicals released from soil at SWMU 39. Excavation worker and residential exposures were not evaluated under current land-use conditions.

6.2.1.1 Summary of Potential Exposure Pathways under Current Land-Use Conditions

In summary, the potential exposure pathways that were quantitatively evaluated under current land-use conditions are incidental ingestion, dermal absorption, and inhalation of chemicals in surface soil at SWMU 39 by a maintenance worker.

6.2.1.2 Potential Exposure Pathways under Future Land-Use Conditions

According to USEPA (1995a), a risk assessment evaluating potential future exposures should reflect the most reasonably anticipated future land uses. The potential future exposure pathways through which humans could be exposed to environmental media at SWMU 39 are discussed below. **Table 6-1** presents an exposure pathway analysis for potential future land-use conditions, indicating the exposure media, exposure points, potential receptors, and exposure routes. This table also indicates whether a quantitative analysis was conducted for the pathway and the rationale for selection or exclusion of the pathway.

As described in *Section 6.2.1*, future land use at SWMU 39 is expected to remain industrial. Maintenance workers are considered the most likely receptors to potential contamination at SWMU 39. Given the industrial nature of the site, the maintenance worker scenario would be protective of exposures to trespassers. If future development occurs, excavation workers could also be receptors. Assuming that future construction/excavation activities could occur, future maintenance worker and excavation worker exposures to surface and subsurface soil at SWMU 39 were evaluated in the HHRA. It is assumed that surface and subsurface soil would mix as a result of these activities. Therefore, future exposures to these sites were evaluated as exposures to total soil.

Although it is unlikely, the site could potentially be used for residential land-use in the future; therefore, hypothetical residential exposures were evaluated.

Groundwater. Due to the nature of groundwater at the Installation, it is difficult to associate specific sites with groundwater exposures. Groundwater at the site is being addressed in MWP Work Plan Addendum 009, "Horseshoe Area Groundwater Study" (IT, 2002b). Therefore, groundwater exposures were not evaluated in this HHRA.

Surface Soil. Maintenance worker exposures to surface soil under future industrial land-use conditions will be the same as those described under current industrial land-use conditions. Excavation worker exposures to surface soil were not evaluated in the HHRA because excavation worker exposures would involve both surface and subsurface soil (i.e., total soil) that would be mixed during construction/excavation activities. Resident exposures to surface soil were not evaluated in the HHRA because it was assumed that both surface and subsurface soil (i.e., total soil) would have become mixed during construction/excavation activities for the future development area.

Total Soil. Future development at SWMU 39 could result in exposures to individuals performing excavation activities via contact with chemicals in total soil. In addition,

maintenance workers may contact soil after the site has been disturbed and soil has been dispersed after construction or excavation activities. Therefore, potential incidental ingestion and dermal absorption exposures to chemicals in total soil by maintenance workers and excavation workers were evaluated. Although future residential development of this site is unlikely, the residential scenario was evaluated for total soil. Hypothetical future residents may contact soil after the site has been developed and soil has been dispersed after construction or excavation activities. Therefore, potential incidental ingestion and dermal absorption exposures to chemicals in total soil by residents were evaluated. (It is assumed that surface and subsurface soil would mix as a result of construction/excavation activities and future exposures to the site were evaluated as exposures to total soil.)

Air. Airborne releases of COPCs can occur via wind entrainment of chemicals on dust particles. Maintenance and excavation workers and residents could potentially be exposed to airborne chemicals released from soil at SWMU 39.

6.2.1.3 Summary of Potential Exposure Pathways under Future Land-Use Conditions

In summary, the following exposure pathways were selected for quantitative evaluation under future land-use conditions:

- Incidental ingestion, dermal absorption, and inhalation of chemicals in surface soil at SWMU 39 by a maintenance worker;
- Incidental ingestion, dermal absorption, and inhalation of chemicals in total soil at SWMU 39 by a maintenance worker;
- Incidental ingestion, dermal absorption, and inhalation of chemicals in total soil at SWMU 39 by an excavation worker; and,
- Incidental ingestion, dermal absorption, and inhalation of chemicals in total soil at SWMU 39 by a resident (adult and child).

6.2.2 Determination of Exposure Point Concentrations

To evaluate the magnitude of exposures and risks that may be experienced by an individual, the concentration of the COPCs in the exposure medium must be known or estimated. This concentration is referred to as an exposure point concentration (EPC). The EPCs used in the HHRA are based on the data summarized in *Section 6.1.1*, and were assessed for each of the selected COPCs. EPCs for surface soil and total soil are shown in **Appendix E-1, Tables E-5 and E-6**.

The approach used to estimate EPCs in the media sampled at SWMU 39 follows that recommended by USEPA (1989a, 1992a, 2002a) guidance. According to this guidance, the most appropriate measurement of central tendency for exposure to environmental chemical concentrations is the arithmetic mean. To account for uncertainty associated with this value, USEPA guidance requires the use of the 95% upper confidence limit (UCL) on the arithmetic mean concentration for the estimation of the Reasonable Maximum Exposure (RME) risk. The term RME is defined as the maximum exposure that is reasonably expected to occur at a site (USEPA, 1989a). The RME concentration of each COPC in each medium was assumed to represent the concentration to which receptors could be exposed at these sites. The exception to this approach was lead. As further described in *Section 6.3.2*, lead was evaluated using a variation of the Integrated Exposure Uptake Biokinetic (IEUBK) Model. Because the IEUBK model is a probabilistic model, the arithmetic mean is used in the quantitative evaluation of lead.

Because of the uncertainty associated with characterizing contamination in environmental media, the 95% UCL of the mean has been estimated for chemicals selected as COPCs. In general, outliers are included in the calculation of the UCL because high values in environmental data are seldom true statistical outliers. Inclusion of outliers increases the overall conservatism of the risk estimate and the likelihood of rejecting the null hypothesis (H_o) (i.e., there are no chemical stressors at the site).

Data sets have been tested for normality and lognormality based on the Shapiro-Wilk test (USEPA, 1992a). Statistical analysis has been performed on chemicals selected as COPCs. If statistical tests support the assumption that the data set is normally distributed, the UCL for a normal distribution is calculated. If the statistical analysis shows the data to be lognormally distributed, the UCL is calculated for a lognormal distribution. It should be noted that the designation of normal or lognormal data distributions also included data sets that were "close" to their respective categorizations, i.e., within 5 percent of being categorized as normal or lognormal, using the Shapiro-Wilk test criterion. This is a conservative approach, especially for those data sets that are close to being lognormal, as the lognormal UCL equation (Gilbert, 1987) generally overestimates the UCL, compared with the alternative bootstrap method. If a data set passes both the normal and lognormal distribution tests, the distribution with the best fit (i.e., the distribution with the value that is closest to the critical value) is selected.

The UCL is calculated for a normal distribution as follows (USEPA, 1992a):

$$UCL = \bar{x} + t_{1-\alpha,n-1}\, x\, (s/\sqrt{n})$$

where:

$\bar{x}$ = sample arithmetic mean
t = critical value for student's t distribution
$1-\alpha$ = 0.05 (95% confidence limit for a one-tailed test)
n = number of samples in the set
s = sample standard deviation.

The UCL is calculated for a lognormal distribution as follows (Gilbert, 1987):

$$UCL = e^{\left(\bar{y} + (0.5 \bullet s_{\bar{y}}^2) + \left[H_{0.95} \bullet \frac{s_y}{(n-1)^{0.5}}\right]\right)}$$

where:

$\bar{y}$ = 3y/n=sample arithmetic mean of the log-transformed data, y = ln x
s_y = sample standard deviation of the log-transformed data
n = number of samples in the data set
$H_{0.95}$ = value for computing the one-sided 95% UCL on a lognormal mean from standard statistical tables (Land, 1975).

A nonparametric confidence limit is used when the data set fits neither a normal nor a lognormal distribution. The "bootstrap" method (Efron, 1981), a nonparametric method recommended by USEPA for censored data (USEPA, 2002a), was used to calculate 95% UCLs on the arithmetic means for these COPC data. This method, which estimates the UCL by simulation, is a

computer-based replacement method for assigning measures of accuracy to statistical estimates. This method does not require assumptions regarding the statistical distribution of the underlying population (Efron, 1981). Bootstrap 95% UCLs were calculated as follows (Efron, 1981; Efron and Tibshirani, 1993):

1. The data set was randomly resampled with replacement;
2. The arithmetic mean of the resampled data set was estimated;
3. Based on guidance from USEPA (2002a), "thousands of iterations" are recommended for the bootstrap method. Therefore, steps 1 and 2 were performed 5,000 times and a new data set of 5,000 resampled means was created; and,
4. The 95th percentile of the resampled mean data set created during Step 3 was selected. Per Efron and Tibshirani (1993), the 95th percentile of the resampled mean data set is a good approximation to the 95% UCL on the mean of the original data set.

6.2.3 Quantification of Dose Due to Chemical Exposures

This section describes the development of the exposure estimates (chemical doses) that serve as the basis of the risk estimates in *Section 6.4*. To estimate doses, EPCs for each COPC are combined with information describing the extent, frequency, and duration of exposure for each potential receptor of concern. This section presents an overview of the approaches and equations used in quantifying exposures and specific details relevant to each selected exposure pathway. The approaches used to quantify exposures are consistent with guidance provided by USEPA (1989a; 1991a; 1992a,b,c; 2004b).

Methodology for Deriving Dose Estimates. For the exposure pathways that involve ingestion or dermal contact, quantification of exposure involves the estimation of an average daily dose (ADD), expressed in units of mg chemical/kg body weight per day (mg/kg-day). Dose can be defined as an exposure rate to a chemical assessed over an exposure period per unit body weight, and is calculated similarly for ingestion and dermal absorption pathways. There are, however, significant differences in the meaning and terms used to describe doses for the ingestion pathways as compared to the dermal absorption pathways. For the ingestion exposure pathways, the doses calculated in this assessment are referred to as "potential doses." The potential dose is the amount of chemical ingested and available for uptake in the body, and is analogous to the administered dose in a dose-response toxicity experiment. For the dermal absorption pathways, the estimated dose is referred to as an "internal dose," and reflects the amount of chemical that has been absorbed into the body and is available for interaction with biologically important tissues.

ADDs are estimated differently for chemicals exhibiting noncarcinogenic and carcinogenic effects, because different toxicity criteria are available for carcinogenic effects and noncarcinogenic effects of chemicals (see *Section 6.3, Human Health Toxicity Assessment*). ADDs for noncarcinogens are averaged over the duration of exposure and, following USEPA (2004b) guidance, are given the acronym ADD for average daily doses. ADDs for carcinogens are averaged over a lifetime, and are given the acronym LADD for lifetime average daily doses.

The ADDs and LADDs are estimated using EPCs of chemicals together with exposure parameters that specifically describe the exposure pathway. ADDs and LADDs for each pathway were derived by combining the selected EPC (based on the maximum or on the 95% UCL on the mean concentration) of each chemical with reasonable maximum values describing the extent, frequency, and duration of exposure (USEPA, 1989a; 1992c; 2001a, 2004b).

The following sections present the equations and exposure parameters used in the HHRA to estimate potential doses ($ADDs_{pot}$ and $LADDs_{pot}$) for ingestion exposures, internal doses ($ADDs_{int}$ and $LADDs_{int}$) for dermal absorption exposures, and ($ADDs_{pot}$ and $LADDs_{pot}$) for inhalation exposures. It was assumed that the chemical concentrations in the media evaluated would remain constant over the exposure period.

The particulate emission factor (PEF) used to calculate the particulate inhalation ADDs and LADDs was calculated based on an equation provided by USEPA (1996a), and is shown below. It should be noted that one of the inputs for calculating the PEF is the Q/C value, which represents both local climatic conditions and the size of the contaminated area. Q/C values are provided by USEPA (1996a) for 29 different cities in the United States and for contaminated areas ranging from 0.5 to 30 acres. For this HHRA, Q/C value representing climatic conditions for Zone VII, Huntington, WV was selected. A site-specific PEF value was calculated to account for the approximate size of the site (2.6 acres). Based on a 2-acre site, a Q/C value of 41.83 was selected to represent the SWMU 39 study area.

The variable for vegetative cover used to calculate the PEF accounts for the percentage of ground cover (e.g., pavement, gravel, or vegetation) that potentially inhibits the release of VOCs and particulate matter from soil into ambient air. Although the majority of the site is currently covered, the fraction of the vegetative cover was conservatively assumed to be 50 percent to allow for potential changes to site conditions in the future. USEPA's default value was used to represent the mean annual wind speed [4.69 meters/second (m/s)].

Using the following equation and the assumptions described above, a PEF of 6.06×10^8 m^3/kg was calculated for SWMU 39.

$$PEF = \frac{Q}{C} * \frac{3{,}600 \frac{sec}{hr}}{0.036 * (1 - V) * \left(\frac{U_m}{U_t}\right)^3 * F(x)}$$

where:

PEF =	particulate emission factor (m^3/kg)
$\frac{Q}{C}$ =	inverse of the mean concentration at the center of a 2-acre source (equal to 41.83 $g/m^2 \cdot sec$ per kg/m^3) for Climatic Zone VII, Huntington, WV (USEPA, 1996a)
V =	fraction of vegetative cover (assumed to be 50 percent, default)
U_m =	mean annual windspeed (4.69 m/sec, default)
U_t =	equivalent threshold value of windspeed at 7 m (11.32 m/sec, default)
F(x) =	function dependent on Um/Ut derived using Cowherd et al. (as cited in USEPA, 1996a)

Current and Future Maintenance Worker Dose Equations and Exposure Parameters for Soil. The potential chemical doses for current and future maintenance worker exposures to surface soil and total soil at SWMU 39 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 6.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in the *Section 6.4*.

Incidental Ingestion of Soil by Maintenance Workers. The exposure for incidental ingestion of COPCs in soil by workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-7 and E-8**. Where relevant, standard adult parameters were used to characterize worker exposures, since most workers are adults (> 18 years of age).

Workers were assumed to be exposed to soil 50 days/year, based on the assumption that maintenance/inspection activities are conducted 1 day/week based on a 5-day work week for 50 weeks/year (workers were assumed to spend 2 weeks a year on vacation). Duration of exposure for workers was assumed to be 25 years, a USEPA (1991a) upper-bound default estimate of the time spent working in one location. The body weight value used for workers was 70 kg, the standard USEPA (1991a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for workers was assumed to be 100 mg/day, a standard USEPA (2001a) default value for exposure to adults in the workplace. It was conservatively assumed that soil ingested during the workday by workers would originate in the sampled areas; however, most maintenance workers would likely visit other portions of the Installation. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by Maintenance Workers. The internal dose due to dermal absorption of COPCs in soil by workers was estimated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-7 and E-8**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and amount of chemical absorbed through the skin from soil. It was assumed that a worker's head, hands and forearms would be exposed to soil, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data from USEPA (1997b), and averaging across gender and age, it was estimated that the exposed skin surface area for workers would be 3,300 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50^{th} percentile values for similar activities (USEPA, 1997b; 2001a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. For a chemical to be absorbed through the skin from soil, it must be released from the soil matrix, pass through the layers of the skin, and enter into the systemic circulation. This series of events is dependent on a number of factors including the characteristics of the chemical, the concentration in the applied dose, the site of exposure, inter-individual variability, and characteristics of soil (e.g., particle size and organic carbon content). Data regarding the amount of specific chemicals that may be absorbed through the skin under conditions normally encountered in the environment (and assumed to occur for this assessment) are lacking. While a number of approaches have been developed to estimate absorption of compounds from the soil matrix, the resulting dose estimates are highly uncertain (USEPA, 1992c, 2004b). Chemical-specific dermal absorption factors were used to estimate absorption of COPCs from soil (USEPA, 2004b). If chemical-specific information was not available, class-specific dermal absorption values were applied (USEPA, 1995b, 2003a). The dermal absorption factors include arsenic (3.0 percent), other inorganics (1 percent), and dioxins (3 percent).

Inhalation of Particulates from Soil by Maintenance Workers. The exposure for inhalation of COPCs in soil by maintenance workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-9 and E-10**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a maintenance worker.

The inhalation rate of 2.5 m^3 per hour for maintenance workers was derived by dividing the adult daily rate of 20 m^3/day (USEPA, 1991a) by an 8-hour workday. The exposure time is 8 hours per day. It was conservatively assumed that soil inhaled during the visit would originate in the sampled areas; however, it is unlikely that a worker would spend the entire day at just one location on the Installation every day.

Future Excavation Worker Dose Equations and Exposure Parameters for Soil. The potential chemical doses for future excavation worker exposures to total soil at SWMU 39 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 6.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables in the Risk Characterization section (*Section 6.4*).

Incidental Ingestion of Soil by Excavation Workers. The exposure for incidental ingestion of COPCs in soil by excavation workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-8**. Excavation workers were assumed to be exposed to soil 250 days/year, a standard USEPA (2001a) default assumption assuming a 5-day work week for 50 weeks/year (workers were assumed to spend 2 weeks a year on vacation). Duration of exposure for excavation workers was assumed to be 1 year, a standard USEPA default (2001a). The body weight value used for excavation workers was 70 kg, the standard USEPA (1991a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 1 year was used for noncarcinogenic COPCs.

The daily soil ingestion rate for excavation workers was assumed to be 330 mg/day, a standard USEPA (2001a) default value for exposure to construction workers. It was conservatively assumed that soil ingested during the workday by workers would originate in the sampled areas; however, most maintenance workers would likely visit other portions of the Installation. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by Excavation Workers. The internal dose due to dermal absorption of COPCs in total soil by excavation workers was estimated using the equation and the exposure parameters presented in **Appendix E-1, Table E-8**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by an excavation worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that an excavation worker's head, hands, and forearms would be exposed to soil, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data from USEPA (USEPA Tables 6-2 and 6-3; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for excavation workers would be 3,300 cm^2. The soil-to-skin

adherence factor was assumed to be 0.3 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 2001a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from soil.

Inhalation of Particulates from Soil by Excavation Workers. The exposure for inhalation of COPCs in total soil by excavation workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-10**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by an excavation worker.

The inhalation rate of 2.5 m^3 per hour for excavation workers was derived by dividing the adult daily rate of 20 m^3/day (USEPA, 1991a) by an 8-hour workday. The exposure time is 8 hours per day. It was conservatively assumed that soil inhaled during the visit would originate in the sampled areas.

Future Adult Resident Dose Equations and Exposure Parameters for Soil. The potential chemical doses for future hypothetical adult resident exposures to total soil at SWMU 39 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 6.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in the Risk Characterization section (*Section 6.4*).

Incidental Ingestion of Soil by Adult Residents. The exposure for incidental ingestion of COPCs in total soil by adult residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-8**. Standard parameters were used to characterize adult exposures (> 18 years of age).

Adult residents were assumed to be exposed to surface soil 350 days/year, a standard USEPA (1991a) default assumption assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation). Duration of exposure for residents was assumed to be 30 years, a USEPA (1991a) upper-bound default estimate of the time spent residing in one location. The body weight value used for adult residents was 70 kg, the standard USEPA (1991a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 30 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for adult residents was assumed to be 100 mg/day, a standard USEPA (1991a) default value for exposure to soil for the residential scenario. It was conservatively assumed that soil ingested during time at home by residents would originate in the sampled areas. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by Adult Residents. The internal dose due to dermal absorption of COPCs in total soil by adult residents was estimated using the equation and the exposure parameters presented in **Appendix E-1, Table E-8**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by an adult resident.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a resident's head, hands, arms, and lower legs would be exposed to soil. Using data from USEPA (Tables 6-2 and 6-3; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for adult residents would be 5,700 cm^2. The soil-to-skin adherence factor was assumed to be 0.07 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997b, 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from soil.

Inhalation of Particulates from Soil by Adult Residents. The exposure for inhalation of COPCs in soil by adult residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-10**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by an adult resident.

The inhalation rate of 0.83 m^3 per hour for adult residents was derived by dividing the adult daily rate of 20 m^3/day (USEPA, 1991a) by 24 hours per day. The exposure time is 1 hour per day based on the average time an adult spends outside (1.5 hours/day; USEPA, 1997b) with the exception of the three coldest months of the year. It was conservatively assumed that soil inhaled at the residence would originate in the sampled areas.

Future Child Resident Dose Equations and Exposure Parameters for Soil. The potential chemical doses for future hypothetical child resident exposures to soil at SWMU 39 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 6.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 6.4*.

Incidental Ingestion of Soil by Child Residents. The exposure for incidental ingestion of COPCs in soil by child residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-8**. Standard parameters were used to characterize exposures by children of 6 years of age or less.

Child residents were assumed to be exposed to surface soil 350 days/year, a standard USEPA (1991a) default assumption assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation). Duration of exposure for children was assumed to be 6 years (USEPA, 1991a). The body weight value used for child residents was 15 kg, the standard USEPA (1991a) default value for a child's body weight averaged over 0 to 6 years of age. An averaging time of 70 years was used for carcinogenic COPCs, while 6 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for child residents was assumed to be 200 mg/day, a standard USEPA (1991a) default value for exposure to soil for the children of 6 years of age and under. It was conservatively assumed that soil ingested during time at home by child residents would originate in the sampled areas. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

Dermal Absorption of Chemicals in Soil by Child Residents. The internal dose due to dermal absorption of COPCs in soil by child residents was estimated using the equation and the exposure parameters presented in **Appendix E-1, Table E-8**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a child resident.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a child's head, hands, forearms, lower legs, and feet would be exposed to soil. Using data from USEPA (USEPA Tables 6-6, 6-7, 6-8; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for child residents would be 2,800 cm^2. The soil-to-skin adherence factor was assumed to be 0.2 mg/cm^2-event, based on 50th percentile values for similar activities (USEPA, 1997b, 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2004b) were used to estimate absorption of COPCs from soil.

Inhalation of Particulates from Soil by Child Residents. The exposure for inhalation of COPCs in soil by child residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-10**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a child resident.

The inhalation rate of 1 m^3 per hour for child residents was based on the recommended value for light activities (USEPA Table 5-23; USEPA, 1997b). The exposure time is 1 hour per day. It was assumed that children under the age of 6 years year old are likely to be accompanied or supervised by an adult during their time spent outdoors. Therefore, the exposure time was assumed to be equivalent to that of the adult resident. It was conservatively assumed that soil inhaled at the residence would originate in the sampled areas.

6.3 Human Health Toxicity Assessment

The general methodology for the classification of health effects and the development of health effects criteria is described in *Section 6.3.1* to provide the analytical framework for the characterization of human health risks. In *Section 6.3.2*, the health effects criteria, or toxicity values, used to derive estimates of risk are presented. These values are combined with dose information for each complete exposure pathway quantitatively evaluated to predict potential risks associated with exposures to COPCs in environmental media at SWMU 39 *(Section 6.4)*.

The methodology used for classifying health effects from exposure to chemicals is recommended by USEPA (1986a,b; 1989a; 1997b; 2004c). The health effects analysis considers chronic (long-term) exposures. Using the following hierarchy (USEPA, 2003b), the chronic toxicity criteria were obtained from:

- Tier 1 – Integrated Risk Information System (IRIS) (USEPA, 2004c).
- Tier 2 – Provisional Peer Reviewed Toxicity Values (PPRTVs) - as developed on a chemical-specific basis by the Office of Research and Development/National Center for

Environmental Assessment/Superfund Health Risk Technical Support Center (STSC) (USEPA, 2004d).

- Tier 3 – Other Toxicity Values – including additional USEPA and non-USEPA sources of toxicity information. This tier includes the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997a).

6.3.1 Health Effects Classification and Criteria Development

According to USEPA's science policy, there are two primary approaches to developing toxicity values or health criteria. The non-threshold approach is based on USEPA's scientific policy position that a small number of molecular events can evoke changes in a single cell, or a small number of cells. This is described as a non-threshold initiator mechanism, because there is essentially no level of exposure (i.e., a threshold) to a constituent that will not result in some finite possibility of causing an adverse effect. Another assumption stemming from USEPA's science policy is that the dose-response curve is linear at low doses. For most carcinogens, toxicity values are based on the non-threshold approach.

The threshold approach is based on the assumption that organisms have repair and detoxification capabilities that must be exceeded by some critical concentration (threshold) before the adverse effect is manifested. For example, an organ can have a large number of cells performing the same or similar functions that must be significantly depleted before the effect on the organ is realized. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without an appreciable risk of adverse effects. Toxicity values for noncarcinogenic effects are based on the threshold approach. Furthermore, as additional information regarding the mechanisms of toxicity becomes available, the threshold approach does apply to some carcinogens (e.g., chloroform).

Health Effects Criteria for Potential Carcinogens. For carcinogens, USEPA estimates the excess lifetime cancer risks associated with various levels of exposure by developing cancer slope factors (CSFs) and unit risks. CSFs are expressed in terms of reciprocal dose, as units of $(\text{mg chemical/kg body weight-day})^{-1}$, which describes the upper-bound increase in an individual's risk of developing cancer over a 70-year lifetime per unit of exposure. Unit risks are expressed either as a reciprocal air concentration, in units of $(\mu g/m^3)^{-1}$, or as a reciprocal drinking water concentration, in units of $(\mu g/L)^{-1}$. Similarly, they are defined as the excess probability of an individual developing cancer over a 70-year lifetime as a result of exposure to one unit of concentration in air or water. Because regulatory efforts are geared to be protective of public health, including even the most sensitive members of the population, the CSFs are derived using conservative assumptions.

CSFs and unit risks are derived from the results of human epidemiological studies or chronic animal bioassays. The animal studies usually must be conducted using relatively high doses to detect possible adverse effects. Because humans are expected to be exposed to doses lower than those used in the animal studies, the potential cancer risks at lower doses are estimated by using mathematical models. The data from animal studies are typically fitted to the linearized multistage model to obtain a dose-response relationship. In general, after the data are fit to the dose-response model, the 95% UCL of the slope of the resulting dose-response relationship at low doses is calculated. This upper-bound limit is subjected to various adjustments, and an interspecies scaling factor is applied to derive the slope factor or unit risk for humans. Thus, the actual risks associated with a given intake of a potential carcinogen quantitatively evaluated based on animal data are generally regarded as not likely to exceed the risks estimated using

these CSFs or unit risks, and they may be as low as zero (USEPA, 1986a). Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves. These models provide rough, but plausible, estimates of the upper limits on lifetime risk. CSFs and unit risks based on human epidemiological data are derived using conservative assumptions and, as such, they too are unlikely to underestimate risks for a given level of exposure.

Weight-of-evidence categories represent an assessment of the amount and quality of the data, which support the finding that specific chemicals and elements can cause cancer in humans. Although USEPA's guidelines for carcinogen risk assessment (USEPA, 1996c, 1999a, 2003c) propose a weight-of-evidence narrative, IRIS currently uses the original alphanumeric classification. Under the existing guidelines (USEPA, 1986a), chemicals are classified as either Group A, Group B1, Group B2, Group C, Group D, or Group E. Group A includes those substances for which high-quality studies have demonstrated a relationship between the exposure to the substance in question and the development of cancer in human populations. Groups B1, B2, and C represent chemicals with limited (B1) or insufficient (B2) human evidence of carcinogenicity, and sufficient (B1, B2) or insufficient (C) animal data. Group D substances are those for which there is insufficient or no evidence of carcinogenicity in humans or animals, while Group E substances are those for which no evidence of carcinogenicity is available in adequate human or animal studies.

Health Effects Criteria for Noncarcinogens. Health effects criteria for chemicals exhibiting noncarcinogenic effects are generally developed using verified risk reference doses (RfDs) and reference concentrations (RfCs). These are developed by USEPA and listed in IRIS (USEPA, 2004c), or can be obtained from HEAST (USEPA, 1997a) and supplements. The RfD is expressed in units of dose (mg chemical/kg body weight-day) and is usually derived either from human studies involving workplace exposures or from animal studies. The RfDs are estimates (with uncertainty spanning perhaps several orders of magnitude) of the daily exposure to the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is used as a reference point for gauging the potential effects of exposures. Usually, exposures (as chemical intakes or doses) that are less than the RfD are not likely to be associated with adverse health effects. As the frequency and/or magnitude of the exposures exceeding the RfD increase, the probability of adverse effects in a human population increases.

RfDs are developed for both chronic and subchronic exposures. Chronic RfDs are presented in IRIS or HEAST and are intended for use in evaluating exposures of durations greater than seven years. Subchronic RfDs are developed by USEPA's NCEA and are used to characterize the potential for the occurrence of noncarcinogenic effects associated with short-term exposures [two weeks to seven years as defined by USEPA (1989a)]. The subchronic RfDs are developed similarly to chronic RfDs, and are typically equal to chronic RfDs or are one order of magnitude greater (less stringent). The subchronic RfDs are presented in HEAST, but they are no longer being reviewed and updated in the same manner as IRIS. Because there is greater uncertainty associated with the subchronic RfDs, chronic RfDs have been used in this HHRA.

The RfDs are derived using uncertainty factors that reflect scientific judgment regarding the various types of data used to estimate the RfD. RfDs are typically estimated from no observable adverse effect levels (NOAELs) or lowest observable adverse effect levels (LOAELs) in human or animal studies. Uncertainty factors, generally 10-fold factors, are intended to account for:

- The variation in sensitivity among members of the human population;

- The uncertainty in extrapolating animal data to the case of humans;
- The uncertainty in extrapolating from data obtained in a study that is less-than-lifetime exposure;
- The uncertainty in using LOAEL data, when necessary, rather than NOAEL data; and,
- The inability of a single study to adequately address every possible adverse outcome in humans.

To derive RfDs, NOAELs or LOAELs are divided by one or more uncertainty factors, as appropriate. When taken together, these uncertainty factors may confer an extra margin of safety of up to a factor of 10,000 below an LOAEL. In some cases, modifying factors are also applied to RfDs to take into account other uncertainties in the toxicity database and reflect the professional judgment of those reviewing the database. The net result is that RfDs are generally considered to provide a conservative estimate of the likelihood of adverse noncarcinogenic effects.

6.3.2 Health Effects Criteria for COPCs

Health effects criteria for chronic exposures to COPCs via the oral route of exposure are presented in **Appendix E-1, Tables E-11 and E-12**. Health effects criteria for chronic exposures to the COPCs in soil via the inhalation of particulate matter and volatiles are presented in **Appendix E-1, Tables E-13 and E-14**. The following chemical-specific guidance was also used.

Chromium. The toxic effects associated with chromium are dependent upon its valence state (USEPA, 1998b). Two common forms of chromium are trivalent chromium (chromium III) and hexavalent chromium (chromium VI). Chromium III is the predominant form of chromium in nature and is the less toxic of the two forms. Hexavalent chromium is the more toxic form of chromium and is considered to be a Class A carcinogen via the route of inhalation. The speciation of hexavalent chromium (Cr VI) is not routinely performed during a sampling program due to the very short holding time and the unique stability issues associated with hexavalent chromium (i.e., it tends to change valence states very easily after sample collection). Unless there is convincing evidence that hexavalent chromium may be present at a site (such as its for control of scale in non-contact cooling water piping for a power plant or a chromium plating operation), it is generally not included in an analytical program. For SWMU 39, hexavalent chromium analyses were not performed for the environmental media samples.

It was assumed that the majority of the chromium that was detected at the site would be in the trivalent form. Hexavalent chromium is relatively unstable in the environment and is typically converted to trivalent chromium. As stated in Water-Related Environmental Fate of 129 Priority Pollutants (USEPA, 1979), hexavalent chromium or Cr(VI) is a moderately strong oxidizing agent and reacts with reducing materials to form trivalent chromium or Cr(III). Chemical speciation is an important fate process for chromium and in aquatic environments. Cr(VI), if present, would be expected to remain in a soluble form, while trivalent chromium would be expected to hydrolyze and precipitate as Cr(OH)3. Cr(III) the most stable form under reducing conditions normally found in natural waters and sediments, and when in solution at pH greater than 5, quickly precipitates due to formation of the insoluble hydroxide or oxide.

Cr (III) is the stable form of chromium in soil (FRTR, 2002). Cr (III) hydroxy compounds precipitate at pH 4.5 and complete precipitation of the hydroxy species occurs at pH 5.5. In contrast to Cr (VI), Cr (III) is relatively immobile in soil. Although one sample was analyzed for pH at SWMU 39 (pH = 4.0), pH analyses for soil at other sites at the Installation indicate that

soil pH would tend to favor precipitation. For example, pH values for soil at NRU ranged from approximately 4.7 to 7.5.

Because of its anionic nature, Cr (VI) associates with soil surfaces at positively charged exchange sites (FRTR, 2002). This association decreases with increasing soil pH. Regardless of pH and redox potential, most Cr(VI) in soil is reduced to Cr(III). Soil organic matter and iron (Fe II) minerals donate electrons in this reaction. The reduction reaction in the presence of organic matter proceeds at a slow rate under normal environmental pH and temperatures, but the rate of reaction increases with decreasing soil pH.

A number of studies have been conducted with respect to the fate and transport of chromium in soil. For example, the objectives of a study conducted by the Oak Ridge National Laboratory (Jardine et al., 1999), were to investigate the impact of coupled hydrologic and geochemical processes on the fate and transport of Cr(VI) in undisturbed soil cores. The reduction of Cr(VI) to Cr(III) was dramatically more significant on soil with higher levels of surface-bound natural organic matter. This indicated that natural organic matter was serving as a suitable reductant during Cr(VI) transport even in the presence of potentially competing geochemical oxidation reactions involving chromium. In another example, seven organic amendments (e.g, composts, manures) were investigated for their effects on the reduction of Cr(VI) in a mineral soil low in organic matter contact (Bolan et al., 2003). Addition of organic amendments enhanced the rate of reduction of Cr(VI) to Cr(III) in the soil. Finally, it was found that the distribution of metal contaminants such as chromium in soil can be strongly localized by transport limitations and redox gradients within soil aggregates (Tokunaga et al., 2001). Shifts in characteristic redox potential and the extent of Cr(VI) reduction to Cr(III) were related to organic matter availability.

Although one single sample was analyzed for TOC at SWMU 39 (TOC = 4,560 mg/kg), this result is within the range of results for other sites at the Installation. For example, the TOC values for the NRU sites ranged from 1,880 to 29,400 mg/kg for surface soil. Increasing chromium concentrations are associated with increasing levels of organic matter. Even if trace amounts of Cr(VI) were present at the site, the environmental conditions at RFAAP, including typical precipitation events over the years, would tend to favor the conversion of this form of chromium to the more stable (less toxic) trivalent state. For these reasons, it was assumed that toxicity associated with chromium would be most accurately represented by the use of chromium III toxicity data.

Iron. In accordance with the *Site Screening Process* for RFAAP (USEPA, 2001c), a "margin of exposure" evaluation was performed in cases where iron concentrations in soil or water resulted in an HQ greater than 0.5. Hazards associated with exposures to iron were characterized by comparing the estimated iron intake with the RDA and concentrations known to cause adverse effects in children (USEPA, 1996d).

Lead. Quantitative oral toxicity criteria were available from IRIS (USEPA, 2004c), HEAST (USEPA, 1997a), or USEPA's NCEA for the majority of the COPCs, with the exception of lead, which was selected as a COPC in surface and subsurface soil at SWMU 39. An interim approach to assessing risks associated with adult exposures to lead was developed by USEPA's Technical Review Workgroup for Lead (USEPA, 2003d). This methodology is a variation of the IEUBK model used to evaluate lead exposures to children. The adult lead model is used to evaluate risks associated with nonresidential adult exposures to lead in soil. The model focuses on estimating fetal blood concentrations in women exposed to lead in soil (USEPA, 2003d). It was used in this HHRA to be protective of potentially sensitive receptors within an industrial or

commercial worker population. For the purpose of this HHRA, it was assumed that the worker would be potentially exposed to surface or total soil at SWMU 39. Because the lead model is a probabilistic model, several of the USEPA default parameters are based on central tendency (i.e., average) values (USEPA, 2003d). Therefore, the arithmetic means for surface and total soil served as input values for the soil concentrations.

Because exposure parameters have not been developed for intermittent occupational exposures such as maintenance work, the default soil ingestion rate of 50 mg/day and an exposure frequency of 219 days/year were assumed for the maintenance worker. The geometric standard deviation (GSD) is a measure of the inter-individual variability in blood lead concentrations in a population whose members are exposed to the same nonresidential environmental lead levels. This value reflects the homogeneity or heterogeneity of the exposed population with respect to socioeconomic, ethnic, and geographic factors. A GSD of 2.2 was used as the mid-range value of updated GSD values (2.1 to 2.3) from the *Blood Lead Concentrations of U.S. Adult Females: Summary Statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III)* (USEPA, 2002b). Although the worker population at Radford would be expected to be relatively homogeneous, this value accounts for potential differences in future worker populations. The baseline blood lead concentration is intended to represent the best estimate of a reasonable central value of blood lead concentration in women of child-bearing age who are not exposed to lead-contaminated nonresidential soil or dust at the site (USEPA, 2003d). In this analysis, geometric means are used for this purpose. A baseline blood lead concentration of 1.6 µg/dl was used as the mid-range value of updated values (1.5 to 1.7 µg/dl) from NHANES III (USEPA, 2002b).

USEPA has provided additional guidance regarding exposure parameters for the excavation workers (USEPA, 2004e). The soil ingestion rate of 100 mg/day was used as a reasonable value for workers with contact-intense exposures to soil. An exposure frequency of 250 days/year was assumed because the excavation worker would be expected to have full-time soil exposures during the entire period of exposure (i.e., one year). As described the maintenance worker, a GSD of 2.2 was used as the mid-range value of updated GSD values and a baseline blood lead concentration 1.6 µg/dl was used as the mid-range value of updated values (1.5 to 1.7 µg/dl) from NHANES III (USEPA, 2002b).

Spreadsheets for the Adult Lead Model (USEPA, 2003e) were used to calculate blood lead concentrations for surface and total soil for the maintenance worker and total soil for the excavation worker. The input parameters are presented in **Appendix E-1, Tables E-15a, E-16a, and E-17a,** respectively. The spreadsheets are provided as **Tables E-15b, E-16b, and E-17b** and discussed as part of the risk characterization in *Section 6.4*. The model results are expressed as the predicted geometric mean blood lead level and the percent of the population potentially experiencing concentrations above 10 µg/dl (below which adverse manifestations are not expected).

The potential risks associated with residential exposures to lead are addressed using the IEUBK Lead Model for Windows®, Version 1.0, Build 261 (USEPA, 1994c, 2002c, 2004f). The IEUBK model was designed to provide predictions of the probability of elevated blood lead levels for children. This model addresses three components of environmental risk assessments: the multimedia nature of exposures to lead, lead pharmacokinetics, and significant variability in exposure and risk, through estimation of probability distributions of blood lead levels for children exposed to similar environmental concentrations. The arithmetic mean of the lead concentration in total soil and an assumed lead concentration in groundwater (15 µg/L) were

used in conjunction with the default input parameters to represent site-specific exposures to lead. The predicted geometric mean blood lead level and the percent of the population potentially experiencing concentrations above 10 µg/dl (below which adverse manifestations are not expected) are provided in *Section 6.4* and **Appendix E-1, Table E-18.** Percentages below 5 percent are considered to be protective of human health. The corresponding input parameters and the distribution probability plot from the model are included with the table.

Dioxins/Furans. The procedure for calculating the 2,3,7,8-TCDD TE was described in *Section 6.1.1.* To evaluate the risk associated with dioxin-like compounds, an EPC was calculated by using the sample-specific 2,3,7,8-TCDD TEs. To obtain an EPC that represented an RME, non-detected values were treated as one-half the SQL and B-qualified data were eliminated from the calculations. The toxicity slope factors for 2,3,7,8-TCDD (USEPA, 1997a) were applied in the risk assessment calculations.

6.3.3 Adjustment for Dermal Absorption

Toxicity criteria have not been developed by USEPA specifically for the dermal absorption route of exposure; instead, oral health effects criteria are adjusted to assess this pathway. In order to have a meaningful comparison between the dermal absorption dose estimates, which represent internal (or absorbed) doses, and oral toxicity criteria, which typically represent potential (or administered) doses, toxicity criteria are modified to represent absorbed doses. The method for modifying toxicity criteria involves determination of an absolute oral absorption factor for each chemical and use of this value to increase the chemical's CSF or to decrease the chemical's RfD, as shown in the following equations:

(CSF) / (Absolute oral absorption factor) = Adjusted Dermal CSF
(RfD) x (Absolute oral absorption factor) = Adjusted Dermal RfD

The absolute oral absorption factors that are applied should reflect the specific conditions under which the toxicological study was conducted (e.g., method of administration such as gavage, water or diet, and vehicle of administration such as solvent or solution). The absolute oral absorption factors and adjusted toxicity criteria for the COPCs used when evaluating dermal absorption are also presented in **Appendix E-1, Tables E-11 and E-12.** The adjusted CSFs and RfDs presented in these tables were used to evaluate potential risks associated with dermal absorption exposures.

6.4 Human Health Risk Characterization

In this section, the potential human health cancer risks and noncancer hazards associated with selected human exposure pathways are calculated and detailed results are provided in **Appendix E-1, Tables E-19 through E-28.** To quantitatively assess risks at SWMU 39, the average daily doses (LADDs and ADDs) calculated in the exposure section are combined with the health effects criteria presented in the toxicity section. USEPA has developed guidance for assessing the potential risks to individuals from exposure to carcinogenic and noncarcinogenic chemicals, and uses separate methodologies for estimating the risks from these two different classes of compounds.

For exposures to potential carcinogens, the individual upper-bound excess lifetime cancer risk was calculated by multiplying the estimated LADD by the upper-bound CSF. Upper-bound is a term used by USEPA to describe CSFs, meaning that actual risks are unlikely to be higher than the risks predicted using the upper-bound CSFs. Using this approach, a risk level of $1x10^{-6}$, for

example, represents an upper-bound increase in the lifetime probability of 1 in 1,000,000 that an individual could develop cancer as a result of exposure.

The approach of calculating carcinogenic risks by multiplying the LADD by the CSF assumes that the increased risk of cancer resulting from exposure to a constituent is linearly proportional to the amount of chemical intake averaged over a lifetime. According to USEPA (1989a) risk assessment guidance, this approach is appropriate when the estimated carcinogenic risks calculated are less than 10^{-2} (i.e., one excess cancer case per 100 people exposed). If the estimated risks are above 10^{-2}, the assumption of linearity is not valid. In such cases, the carcinogenic risks should be calculated using the following equation, per USEPA risk assessment guidance (USEPA, 1989a):

$$\text{Risk} = 1 - e^{(-\text{LADD} * \text{CSF})}$$

It is important to note that although the upper-bound cancer risk estimates provide plausible estimates of the upper limits of risk, the actual risk could be considerably lower.

In order to assess the upper-bound individual excess lifetime cancer risks associated with simultaneous exposure to COPCs, the risks derived from the individual chemicals were summed within each exposure pathway. This approach is consistent with the USEPA's guidelines for evaluating the toxic effects of chemical mixtures (USEPA, 1986b, 1989a).

Potential adverse health effects for noncarcinogens were calculated by means of an HI technique as recommended by USEPA (1989a). The ratio of the ADD to the reference dose (ADD:RfD) was derived for each chemical. Values of these ratios, called HQs, which are greater than 1 are indicative of the potential for adverse health effects. The effects from simultaneous exposures to COPCs were computed by summing the individual ratios (HQs) within each exposure pathway. This sum, known as the HI, serves the same function for the mixture as the HQ does for the individual compound. In general, HIs that are less than 1 are not likely to be associated with health risks and are, therefore, less likely to be of regulatory concern than HIs greater than 1. If an HI is greater than 1, the COPCs are subdivided into categories based on target organ affected by exposure (e.g., liver, kidney) in accordance with USEPA (1989a) guidance. HIs are then recalculated for these categories to better identify whether noncarcinogenic effects to specific target organs or endpoints might occur.

The upper-bound excess lifetime cancer risks derived in this report can be compared to USEPA's target risk range for health protectiveness at Superfund sites of $1x10^{-6}$ to $1x10^{-4}$ (USEPA, 1990). In addition, USEPA's Office of Solid Waste and Emergency Response (USEPA, 1991b) has issued a directive clarifying the role of HHRA in the Superfund process. The directive states that, where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than $1x10^{-4}$, and the noncarcinogenic HI is less than 1, action generally is not warranted unless there could be adverse environmental effects (see *Section 7.0* for a discussion of potential ecological hazards).

6.4.1 Risk Estimates for Maintenance Workers under Current Land-Use Conditions at SWMU 39

A summary of the upper-bound excess lifetime cancer risks and HIs associated with maintenance worker exposures to surface soil at SWMU 39 under current land-use conditions are provided in **Appendix E-1, Table E-29**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are

identified in the text below. Since maintenance workers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-29** and discussed below.

Surface Soil. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in surface soil by a maintenance worker ($9.4x10^{-7}$) was less than the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in surface soil by a maintenance worker (HI = 0.12) was less than 1.

Lead was also evaluated as a COPC in surface soil at SWMU 39. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Per USEPA guidance (USEPA, 2002b, 2003d), site-specific lead exposures were evaluated for worker exposures using the Adult Lead Model. This calculation was based on the site-specific arithmetic mean concentration of lead detected in surface soil (1,520 mg/kg). Because there are no site-specific groundwater data available for SWMU 39, it was assumed that water would be obtained from alternate water supply and the maximum concentration would be no greater than the action level for groundwater (15 µg/L; USEPA, 1996e). The corresponding input parameters are provided in **Appendix E-1, Table E-15a**. The results of the model are presented in **Appendix E-1, Table E-15b**. The input value of 1,520 mg/kg in soil results in 8.6 percent of receptors above a geometric mean blood lead level of 3.8 µg/dl. This value is above the blood lead goal of no more than 5 percent of children (fetuses of exposed women) exceeding 10 µg/dl blood lead, which is considered to be protective of human health by USEPA (1994b).

Cumulative Risk and Hazard. The potential cumulative risk for maintenance workers exposed to surface soil at SWMU 39 under current land-use conditions was $9.4x10^{-7}$, which was less than the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for maintenance workers (HI = 0.12) was less than 1.

Because there is no toxicity value to lead, an HQ was not calculated for lead. Therefore, no HQ was available for inclusion in the cumulative hazard index calculation. The results of the Adult Lead Model are described in the previous section. These results indicate that lead concentrations at SWMU 39 are above the criterion for blood lead levels in exposed populations.

6.4.2 Risk Estimates for Maintenance Workers under Future Land-Use Conditions at SWMU 39

A summary of the upper-bound excess lifetime cancer risks and HIs associated with maintenance worker exposures to surface soil and total soil at SWMU 39 under future land-use conditions are provided in **Appendix E-1, Table E-30**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since maintenance workers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-30** and discussed below.

Surface Soil. The total upper-bound excess lifetime cancer risks and HIs associated with COPCs in surface soil are assumed to be the same as those under current land-use conditions.

Total Soil. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in total soil was $8.1x10^{-7}$, which was less than the target risk range of $1x10^{-6}$ to $1x10^{-4}$.

The HI associated with exposures to noncarcinogenic COPCs in total soil by a maintenance worker (HI = 0.11) was less than 1.

Lead was also evaluated as a COPC in total soil at SWMU 39. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Per USEPA guidance (USEPA, 2002b, 2003d), site-specific lead exposures were evaluated for worker exposures using the Adult Lead Model. This calculation was based on the site-specific arithmetic mean concentration of lead detected in total soil (1,060 mg/kg). Because there are no site-specific groundwater data available for SWMU 39, it was assumed that water would be obtained from alternate water supply and the maximum concentration would be no greater than the action level for groundwater (15 µg/L; USEPA, 1996e). The corresponding input parameters are provided in **Appendix E-1, Table E-16a**. The results of the model are presented in **Appendix E-1, Table E-16b**. The input value of 1,060 mg/kg in soil results in 5.4 percent of receptors above a geometric mean blood lead level of 3.1 µg/dl. This value is above the blood lead goal of no more than 5 percent of children (fetuses of exposed women) exceeding 10 µg/dl blood lead, which is considered to be protective of human health by USEPA (1994b).

Cumulative Risk and Hazard. Since surface soil represents the more highly contaminated portion of soil, cumulative risk and hazard estimates are conservatively based on this soil data grouping. The potential cumulative risk for maintenance workers exposed to surface soil at SWMU 39 under future land-use conditions was 9.4×10^{-7}, which was less than the USEPA's target risk range of 1×10^{-6} to 1×10^{-4} for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for maintenance workers (HI = 0.12) was less than 1.

Because there is no toxicity value to lead, an HQ was not calculated for lead. Therefore, no HQ was available for inclusion in the cumulative HI calculation. The results of the Adult Lead Model are described in the previous section. These results indicate that lead concentrations at SWMU 39 are above the criterion for blood lead levels in exposed populations.

6.4.3 Risk Estimates for Excavation Worker under Future Land-Use Conditions at SWMU 39

A summary of the upper-bound excess lifetime cancer risks and HIs associated with excavation worker exposures to total soil at SWMU 39 under future land-use conditions is provided in **Appendix E-1, Table E-31**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above 1×10^{-6} or HIs above 1 are identified in the text below. Since excavation workers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-31** and discussed below.

Total Soil. The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in total soil was 4.8×10^{-7}, which was less than the target risk range of 1×10^{-6} to 1×10^{-4}. The HIs associated with exposures to noncarcinogenic COPCs in total soil by an excavation worker for the ingestion and dermal pathways combined (HI = 1.3) exceeded 1. No individual chemical HI was equal to or exceeded 1. The HI for inhalation (HI = 0.020) was less than 1.

Lead was also evaluated as a COPC in total soil at SWMU 39. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Per USEPA guidance (USEPA, 2002b, 2003d), site-specific lead exposures were evaluated for worker exposures using the Adult Lead Model. This calculation was based on the site-specific arithmetic mean

concentration of lead detected in total soil (1,060 mg/kg). Because there are no site-specific groundwater data available for SWMU 39, it was assumed that water would be obtained from alternate water supply and the maximum concentration would be no greater than the action level for groundwater (15 µg/L; USEPA, 1996e). The corresponding input parameters are provided in **Appendix E-1, Table E-17a**. The results of the model are presented in **Appendix E-1, Table E-17b**. The input value of 1,060 mg/kg in soil results in 16.1 percent of receptors above a geometric mean blood lead level of 5.1 µg/dl. This value is above the blood lead goal of no more than 5 percent of children (fetuses of exposed women) exceeding 10 µg/dl blood lead, which is considered to be protective of human health by USEPA (1994b).

Cumulative Risk and Hazard. The potential cumulative risk for excavation workers exposed to total soil at SWMU 39 under future land-use conditions was 4.8×10^{-7}, which was below the USEPA's target risk range of 1×10^{-6} to 1×10^{-4} for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for excavation workers was equal to 1.3. No individual chemical HI was equal to or exceeded 1.

Because there is no toxicity value for lead, an HQ was not calculated for lead. Therefore, no HQ was available for inclusion in the cumulative HI calculation. The results of the Adult Lead Model are described in the previous section. These results indicate that lead concentrations at SWMU 39 are above the criterion for blood lead levels in exposed populations.

6.4.4 Risk Estimates for Adult Residents under Future Land-Use Conditions at SWMU 39

A summary of the upper-bound excess lifetime cancer risks and HIs associated with adult resident exposures to total soil at SWMU 39 under future land-use conditions is provided in **Appendix E-1, Table E-32**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above 1×10^{-6} or HIs above 1 are identified in the text below. Since residents may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-32** and discussed below.

Total Soil. The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in total soil were estimated to be 5.6×10^{-6} for incidental ingestion. The primary contributors were dioxins/furans and arsenic. This value was within the target risk range of 1×10^{-6} to 1×10^{-4}. The risk estimates for dermal absorption (6.7×10^{-7}) and inhalation (5.5×10^{-10}) were below the target risk range of 1×10^{-6} to 1×10^{-4}. The HI associated with exposures to noncarcinogenic COPCs in total soil by an adult resident (HI = 0.60) was less than 1.

Lead was also evaluated as a COPC in total soil at SWMU 39. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Per USEPA guidance (USEPA, 1992e; 1994b,c; 2002c; 2004f), site-specific lead exposures were evaluated for residential exposures using the IEUBK model. This calculation was based on the site-specific arithmetic mean concentration of lead detected in total soil (1,060 mg/kg). Because there are no site-specific groundwater data available for SWMU 39, it was assumed that water would be obtained from alternate water supply and the maximum concentration would be no greater than the action level for groundwater (15 µg/L; 1996e). The results of the model are presented in **Appendix E-1, Table E-18**. The corresponding input parameters and distribution probability plot are also provided with the table. The predicted geometric mean blood lead level for the young child was 10.44 µg/dl, with 53.7 percent of the population potentially experiencing

concentrations above 10 µg/dl, below which adverse manifestations are not expected. These results indicate that if the site were to be developed for residential use in the future, the percent of the exposed population with a blood lead level exceeding 10 µg/dl (1.0 percent) would be above the 5 percent level of exceedance considered to be protective of human health by USEPA.

Cumulative Risk and Hazard. The potential cumulative risk for adult residents exposed to total soil at SWMU 39 under future land-use conditions was $6.3x10^{-6}$, which is within the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for adult residents was equal to 0.60.

Because there is no toxicity value for lead, an HQ was not calculated for lead. Therefore, no HQ was available for inclusion in the cumulative hazard calculation. However, the results of the IEUBK model are described in the previous section. These results indicate that lead concentrations at SWMU 39 are above the criterion for blood lead levels in exposed populations.

6.4.5 Risk Estimates for Child Resident under Future Land-Use Conditions at SWMU 39

A summary of the upper-bound excess lifetime cancer risks and HIs associated with child resident exposures to total soil at SWMU 39 under future land-use conditions is provided in **Appendix E-1, Table E-33**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since residents may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-33** and discussed below.

Total Soil. The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in total soil were estimated to be $1.1x10^{-5}$ for incidental ingestion. The primary contributors were dioxins/furans and arsenic. This value was within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The risk estimates for dermal absorption (8.8×10^{-7}) and inhalation (6.2×10^{-10}) were below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HIs associated with exposures to noncarcinogenic COPCs in total soil by a child resident exceeded 1 for the ingestion pathway (HI = 3.8), primarily due to iron. The HI for vanadium was 1.7 for ingestion and dermal absorption combined. The HI for inhalation (HI = 0.0065) was less than 1.

As described in *Section 6.1.2.2*, a margin of exposure evaluation was performed because the HI for iron (1.5) exceeded a value of 0.5. The calculated intake of iron was 0.44 mg/kg-day via the route of ingestion. This value was compared to amounts that are associated with an RDA of 10 mg/day (0.36 to 1.11 mg/kg-day) for children from 6 months to 10 years of age (USEPA, 1996d). The intake calculated for total soil at SWMU 39 is within the allowable range.

Lead was also evaluated as a COPC in total soil at SWMU 39. Because there is no toxicity value for lead, an HQ for noncarcinogenic effects was not calculated for lead. Per USEPA guidance (USEPA, 1992e; 1994b,c; 2002c; 2004f), site-specific lead exposures were evaluated for residential exposures using the IEUBK model. This calculation was based on the site-specific arithmetic mean concentration of lead detected in total soil (1,060 mg/kg). Because there are no site-specific groundwater data available for SWMU 39, it was assumed that water would be obtained from alternate water supply and the maximum concentration would be no greater than the action level for groundwater (15 µg/L; USEPA, 1996e). The results of the model are presented in **Appendix E-1, Table E-18**. The corresponding input parameters and distribution probability plot are also provided with the table. The predicted geometric mean blood lead level

for the young child was 10.44 µg/dl, with 53.7 percent of the population potentially experiencing concentrations above 10 µg/dl, below which adverse manifestations are not expected. These results indicate that if the site were to be developed for residential use in the future, the percent of the exposed population with a blood lead level exceeding 10 µg/dl (1.0 percent) would be above the 5 percent level of exceedance considered to be protective of human health by USEPA.

Cumulative Risk and Hazard. The potential cumulative risk for child residents exposed to total soil at SWMU 39 under future land-use conditions was 1.1×10^{-5}, which is within the USEPA's target risk range of 1×10^{-6} to 1×10^{-4} for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for child residents was equal to 5.0, primarily due to iron and vanadium. When recalculated by target organ, the following target organs exceeded 1: blood (2.1), liver (2.1), GI irritation (1.5), and kidney (1.7).

Because there is no toxicity value for lead, an HQ was not calculated for lead. Therefore, no HQ was available for inclusion in the cumulative hazard calculation. However, the results of the IEUBK model are described in the previous section. These results indicate that lead concentrations at SWMU 39 are above the criterion for blood lead levels in exposed populations.

6.4.6 Summary of Predominant COPCs at SWMU 39

This section summarizes the predominant COPCs associated with potential risks and hazards at SWMU 39. For the purposes of the HHRA, predominant COPCs are defined as chemicals contributing to exposure route total cancer risks (i.e., based on the sum of every route evaluated) greater than or equal to 1×10^{-6} or exposure route total HIs greater than or equal to one. The predominant COPCs are summarized by receptor, media, and exposure route, in **Appendix E-1, Tables E-34 through E-38**. The predominant COPCs are discussed according to exposure medium in the text below.

Surface Soil. As shown in **Appendix E-1, Tables E-34 and E-35**, there are no predominant COPCs representing cancer risk for current and future exposures to surface soil at SWMU 39. The total cancer risk estimates for surface soil exposures were below the USEPA target risk range for health protectiveness. There are no predominant COPCs representing non-carcinogenic hazard. The HIs for current and future exposures to surface soil were less than 1.

Total Soil. As shown in **Appendix E-1, Tables E-35 through E-38**, the predominant COPCs representing cancer risk for total soil are arsenic and dioxins/furans. The total cancer risk estimates for total soil exposures for maintenance workers and excavation workers were below the USEPA target risk range for health protectiveness. The total cancer risk estimates for total soil exposures for adult and child residents were within the USEPA target risk range. The predominant COPCs representing non-carcinogenic hazard for total soil are iron and vanadium. Based on a "margin-of-exposure" evaluation, however, the intake of iron was within the allowable range. The HIs for total soil were less than 1 for the maintenance worker and adult resident, and greater than 1 for the excavation worker and child resident.

6.5 Uncertainties in the HHRA

Risk assessments involve the use of assumptions, judgments, and incomplete data to varying degrees that contribute to the uncertainty of the final estimates of risk. Uncertainties result both from the use of assumptions or models in lieu of actual data and from the error inherent in the estimation of risk-related parameters, and may cause risk to be overestimated or underestimated. Based on the uncertainties described below, this risk assessment should not be construed as presenting an absolute estimate of risk to persons potentially exposed to chemicals at SWMU 39.

Consideration of the uncertainty attached to various aspects of the risk assessment process allows one to better interpret the risk assessment results and understand the potential adverse effects on human health. In general, the primary sources of uncertainty are associated with environmental sampling and analysis, selection of chemicals for evaluation, toxicological data, and exposure assessment. The effects of these uncertainties on the risk estimates are discussed below.

Environmental Sampling and Analysis. Uncertainty in environmental chemical analysis can stem from several sources including errors inherent in the sampling or analytical procedures. Analytical accuracy errors or sampling errors can result in rejection of data, which decreases the available data for use in the HHRA, or in the qualification of data, which increases the uncertainty in the detected chemical concentrations. There is uncertainty associated with chemicals reported in samples at concentrations below the reported detection limit, but still included in data analysis, and with those chemicals qualified with the letter J, indicating that the concentrations are estimated. Another issue involves the amount of blank-related (i.e., B-qualified) data in the data set. These data were eliminated from the HHRA. The effects of using data with these uncertainties may over- or underestimate risks.

The data set for each medium represented a compilation of several subsets. These subsets consisted of samples that were collected at various times under different investigations and analyzed by different laboratories. Combining these data involves some uncertainty in the risk assessment. The degree of potential overestimation or underestimation is not known. However, several measures were taken to minimize this uncertainty, which included using validated data, ensuring that chemical names in the file were comparable, and reviewing data qualifiers.

Selection of Chemicals for Evaluation. A comparison of maximum detected chemical concentrations to USEPA Region III RBCs was conducted for each medium. Chemicals whose maximum concentrations were below their respective RBCs were not carried through the assessment. It is unlikely that this risk-based screening would have excluded chemicals that would be of concern, based on the conservative exposure assumptions and conservatively derived toxicity criteria that are the basis of the RBCs. Although following this methodology does not provide a quantitative risk estimate for every chemical, it focuses the assessment on the chemicals accounting for the greatest risks (i.e., chemicals whose maximum concentrations exceed their respective RBCs), and the overall cumulative risk estimates would not be expected to be significantly greater if not the same.

Toxicological Data. The assessment of risks relied on USEPA-derived dose-response criteria. These health effects criteria are conservative and are designed to be protective of sensitive subpopulations. The health criteria used to evaluate long-term exposures, such as RfDs or CSFs, are based on concepts and assumptions that bias an evaluation in the direction of overestimation of health risk. As USEPA notes in its Guidelines for Carcinogenic Risk Assessment (USEPA, 1986a): "There are major uncertainties in extrapolating both from animals to humans and from high to low doses. There are important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility. Human populations are variable with respect to genetic constitution, diet, occupational and home environment, activity patterns and other cultural factors."

These uncertainties are compensated for by using upper-bound 95% UCLs for CSFs for carcinogens, and safety factors for RfDs for noncarcinogens. The assumptions used here provide a rough but plausible estimate of the upper limit of risk; in other words, it is not likely that the true risk would be much more than the estimated risk, but it could very well be considerably

lower, even approaching zero. More refined modeling in the area of dose-response calculation (e.g., using maximum likelihood dose-response values rather than the 95% UCL) would be expected to substantially lower the final risk.

Lead was not included in the quantitative risk estimates since a dose-response toxicity value is not available for this chemical. Lead was selected as a COPC in surface and total soil at SWMU 39. Adult exposures to lead were evaluated by using a model developed by USEPA's Technical Review Workgroup for Lead to calculate blood lead concentrations for non-residential adults (USEPA, 2003d, 2004e). Residential exposures to lead were evaluated using the IEUBK model (USEPA, 1994c, 2002c, 2004f). Because the non-carcinogenic effects from lead are evaluated separately, these effects are not represented in the cumulative HI.

The Adult Lead Model was used to evaluate exposures of workers to lead in surface soil and total soil (USEPA, 2003d), as discussed in *Section 6.3.2*. Because the Adult Lead Model is a probabilistic model, the default parameters are based on central tendency values. For example, the incidental ingestion rate for soil that is assumed for the model is 50 mg/day, whereas an incidental ingestion rate of 100 mg/day was used for the maintenance worker. Another area of uncertainty, however, is the exposure frequency. The exposure frequency for the Adult Lead Model is 219 days/year, while the exposure frequency for the maintenance worker is 50 days/year. According to the guidance for the Adult Lead Model (USEPA, 2003d), infrequent exposures (i.e., less than 1 day per week) over a minimum duration of 90 days would be expected to produce oscillations in blood lead concentrations associated with the absorption and subsequent clearance of lead from the blood between each exposure event. The exposure parameters for the excavation worker also differed from the parameters used in the Adult Lead Model. The incidental ingestion rate for the excavation worker was 330 mg/day. However, the suggested default value for exposure to an excavation worker via incidental ingestion is 100 mg/day (USEPA, 2004e).

For dermal absorption exposure pathways, the absence of dermal toxicity criteria necessitated the use of oral toxicity data. In order to calculate risk estimates for the dermal absorption pathway, absorbed dermal absorption doses were combined with oral toxicity values. As described in *Section 6.3*, oral toxicity values, which are typically expressed in terms of potential (or administered) doses, should be adjusted when assessing dermal absorption doses, which are expressed as internal (or absorbed) doses. In this assessment, absolute oral absorption factors that reflect the toxicity study conditions were used to modify the oral toxicity criteria. For chemicals for which sufficient information is lacking (i.e., dioxins, aluminum, copper, iron, and thallium), a default oral absorption factor of 1.0 was used, as recommended by USEPA. The risk estimates for the dermal absorption pathways may be over- or underestimated depending on how closely the values used in the HHRA reflect the difference between the oral and dermal routes.

For chemicals without IRIS toxicity criteria, provisional toxicity criteria (i.e., PPRTVs) were used if available (**Appendix E-1, Tables E-11 through E-14**). The PPRTVs present a source of uncertainty, since USEPA has evaluated the compound, but consensus has not been established on the toxicity criteria. For this assessment, use of provisional toxicity criteria was preferable to not evaluating the chemical in order to limit data gaps. However, because the toxicity criteria have not been formally accepted by USEPA, there is uncertainty with these values and, therefore, with the risks calculated using these toxicity criteria. Another source of uncertainty is values obtained from HEAST. These values have not been updated since 1997.

For some chemicals (e.g., lead), there are no toxicity criteria available (**Appendix E-1, Tables E-11 through E-14**). Although lack of published toxicity data could result in an underestimation of risk, this uncertainty is likely to be balanced by the conservative nature of the verified toxicity values that were available for use.

Exposure Assessment. The primary areas of uncertainty affecting exposure parameter estimation involve the assumptions regarding exposure pathways, the estimation of EPCs, and the parameters used to estimate chemical doses. The uncertainties associated with these various sources are discussed below.

An underlying assumption in the HHRA is that individuals at the site would engage in certain activities that would result in exposures via each selected pathway. For example, it was assumed that receptors would engage in regular activities under current and future land-use conditions that would result in exposures to COPCs. This assumption is conservative, in that it is more likely that the activity patterns assumed to occur in this analysis would likely occur occasionally.

With respect to calculating EPCs, one assumption was that the concentrations of chemicals in the media evaluated would remain constant over time. Depending on the properties of the chemical and the media in which it was detected, this assumption could over- or underestimate risks to a low or high degree, depending on the degree of chemical degradation or transport to other media, although for the site in question, it is likely an overestimation, as further degradation is likely.

When calculating EPCs from sampling data, one-half of the reported quantitation limit was used for non-detect samples in the calculation of the 95% UCL on the mean. An approach dealing with non-detected chemical concentrations is associated with some uncertainty, because chemicals that were not detected at the specified sample quantitation limit may be absent from the medium or may be present at a concentration below the sample quantitation limit. The uncertainty of the EPC will increase as the number of non-detects in a data set increases, and the uncertainty could result in either the over- or underestimation of EPCs.

The 95% UCL was used preferably as the EPC for each medium if at least 5 samples were available for a data grouping. If the 95% UCL exceeded the maximum detected value or if fewer than 5 samples were available for a data grouping, the maximum was conservatively used as a default for the EPC. Using a value that is based on one sampling location (i.e., the maximum) is associated with some uncertainty, and adds a great deal of conservatism to the assessment.

The EPCs for lead in surface soil and total soil were based on arithmetic mean concentrations because the Adult Lead Model and the IEUBK Model are probabilistic models. The results of these models in *Section 6.4* represent average lead concentrations across SWMU 39. As shown by the distribution of lead concentrations in *Section 4.2*, however, the highest concentrations of lead were found in the ponds. The inclusion of these samples in the average concentrations for the site tends to skew the results of the Adult Lead Model and IEUBK Model for SWMU 39 as a whole. To address this uncertainty, average (i.e., arithmetic mean) lead concentrations were calculated for surface soil and total soil samples collected from inside the ponds (**Table 6-6**). Similarly, average lead concentrations were calculated for surface soil and total soil samples collected from outside the ponds (**Table 6-6**).

To compare model results for average lead concentrations inside and outside the ponds, the Adult Lead Model and IEUBK Model were re-run using the average lead concentrations from these data sets. For the industrial receptors, results from the Adult Lead Model are presented in **Table 6-7** and **Appendix E-1, Tables E-39a through E-44b**. Average lead concentrations for

the samples and for samples collected inside the ponds resulted in values above USEPA's blood lead goal of no more than 5% of children (fetuses of exposed women) exceeding the 10 µg/dl blood lead, which is considered to be protective of human health (USEPA, 1994b). Average lead concentrations for samples collected outside the ponds resulted in values below USEPA's blood lead goal.

Table 6-6
Samples Collected from Inside Versus Outside the Ponds

SAMPLES COLLECTED INSIDE PONDS		
SURFACE SOIL		
39SB05A	39SB1A	39SB3A
39SB05B	39SB1B	39SB3B
39SB06A	39SB2B	39SB4B
39SB06B		
SUBSURFACE SOIL		
39SB05C	39SB2D	39SB4D
39SB06C	39SB3D	39SB4F
39SB1D		
SAMPLES COLLECTED OUTSIDE PONDS		
SURFACE SOIL		
39SS07	39SS1	39SS10
39SS08	39SS2	39SS11
39SS09	39SS3	39SS12
SUBSURFACE SOIL		
39MW7A	39MW8A	

For the residential receptors, results from the IEUBK Model are presented in **Table 6-8 and Appendix E-1, Tables E-45 and E-46**. Average lead concentrations for the samples and for samples collected inside the ponds resulted in values above USEPA's blood lead goal of no more than 5% of children exceeding the 10 µg/dl blood lead, which is considered to be protective of human health (USEPA, 1994b). Average lead concentrations for samples collected outside the ponds resulted in values below USEPA's blood lead goal.

The parameter values used to describe the extent, frequency, and duration of exposure are associated with some uncertainty. Actual risks for certain individuals within an exposed population may vary from those predicted depending upon their actual intake rates (e.g., soil ingestion rates), nutritional status, or body weights. The exposure assumptions were selected to produce an upper-bound estimate of exposure in accordance with USEPA guidelines regarding evaluation of potential exposures at Superfund sites (e.g., exposures were assumed to occur for 25 years for workers). In addition, many USEPA (1991a) default exposure parameters are highly conservative and are based on risk management interpretations of limited data. An example is soil ingestion rates. Although current USEPA guidance recommends default soil ingestion rates of 100 mg/day for individuals over 6 years of age, other studies, such as Calabrese et al. (1990), have shown that the USEPA default soil ingestion rate of 100 mg/day is likely to greatly overestimate adult exposures and risks. In addition, chemicals in soil were assumed to be 100% bioavailable; this assumes that ingested chemicals present in a soil matrix are completely absorbed through the gastrointestinal tract, which is unlikely due to their affinity to the soil

Table 6-7
Comparison of Results from Adult Lead Model Samples Collected Inside versus Outside Ponds

Receptor/Medium	Arithmetic Mean Lead Concentration (mg/kg)	Geometric Mean Blood Lead Level (µg/dl)	Percent (%) Population Above Geometric Mean
SITE SAMPLES			
Maintenance Worker (Surface Soil)	1,520	3.8	**8.6**
Maintenance Worker (Total Soil)	1,060	3.1	**5.4**
Excavation Worker (Total Soil)	1,060	5.1	**16.1**
SAMPLES COLLECTED INSIDE PONDS			
Maintenance Worker (Surface Soil)	2,840	5.7	**19.8**
Maintenance Worker (Total Soil)	1,723	4.1	**10.2**
Excavation Worker (Total Soil)	1,723	7.3	**29.5**
SAMPLES COLLECTED OUTSIDE PONDS			
Maintenance Worker (Surface Soil)	43	1.7	0.8
Maintenance Worker (Total Soil)	37	1.7	0.8
Excavation Worker (Total Soil)	37	1.7	0.9

Footnote:

Values in **bold** represent an exceedance above the blood lead goal of no more than 5 percent of children (fetuses of exposed women) exceeding 10 µg/dl blood lead, which is considered to be protective of human health (USEPA, 1994b).

Table 6-8
Comparison of Results from IEUBK Model Samples
Collected Inside versus Outside Ponds

Receptor/Medium	Arithmetic Mean Lead Concentration (mg/kg)	Geometric Mean Blood Lead Level (µg/dl)	Percent (%) Population Above Geometric Mean
SITE SAMPLES			
Residents (Total Soil)	1,060	10.44	**53.7**
SAMPLES COLLECTED INSIDE PONDS			
Residents (Total Soil)	1,723	14.24	**77.4**
SAMPLES COLLECTED OUTSIDE PONDS			
Residents (Total Soil)	37	2.77	0.32

Footnote:

Values in **bold** represent an exceedance above the blood lead level goal of no more than 5 percent of children exceeding 10 µg/dl blood lead, which is considered to be protective of human health (USEPA, 1994b).

particles. Therefore, based on the conservative exposure assumptions used in the HHRA, exposures and estimated potential risks are likely to be overestimated for the ingestion of soil pathways.

Evaluation of the dermal absorption exposure pathway is affected by uncertainties in exposure parameters specific to dermal contact. For example, there is uncertainty associated with the exposed skin surface areas used, since the choice of exposed body parts could slightly over- or underestimate risks. More significant uncertainties are associated with the selection and use of dermal absorption factors. There were no specific dermal absorption factors for aluminum, chromium, iron, thallium, or vanadium. According to the Agency for Toxic Substances Disease Registry (ATSDR), no reliable quantitative studies were located regarding absorption in humans or animals for the dermal exposure to aluminum, thallium, and vanadium (ATSDR, 1992a,b; 1999). Although chromium III and chromium VI can penetrate the skin to some extent, studies were based on direct contact with chromium compounds (ATSDR, 2000) rather than chromium in soil. For this HHRA, the dermal absorption factors were based on USEPA Region III's technical guidance, *Assessing Dermal Exposure from Soil* (USEPA, 1995b). and *Updated Dermal Exposure Assessment Guidance* (USEPA, 2003a). The latter of these documents clarifies USEPA Region III's implementation of USEPA's interim draft document, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E: Supplemental Guidance for Dermal Risk Assessment* (USEPA, 2004b). When comparing the USEPA Region III dermal

absorption factors to values in the USEPA's RAGS, Part E, the values for the majority of the COPCs differed (**Table 6-9**). For example, the default dermal absorption factor for inorganics is 1 percent (USEPA, 1995b, 2003a). However, USEPA's *RAGS, Part E* (USEPA 2004b), states that the speciation of the compound is critical to the dermal absorption of inorganics and there are too little data to extrapolate a reasonable default value. Very limited information is available on dermal absorption of chemicals from contacted soil under realistic environmental conditions. In fact, there are no actual human epidemiological data to support the hypothesis that absorption of soil-bound compounds under realistic exposure conditions is a complete route of exposure. Therefore, the impact of using the dermal absorption factors to evaluate dermal absorption exposures is not known.

Table 6-9
Dermal Absorption Factors

COPC	USEPA Region III Dermal Absorption Factor[a]	USEPA RAGS Part E Dermal Absorption Factor[b]
TCDD	0.03	0.03[c]
Aluminum	0.01	d
Arsenic	0.032	0.03
Chromium	0.01	d
Copper	0.01	d
Iron	0.01	d
Lead	0.01	d
Manganese	0.01	d
Thallium	0.01	d
Vanadium	0.01	d

a) USEPA, 1995b: Assessing Dermal Exposure from Soil. Hazardous Waste Management Division. Office of Superfund Programs. Region III, Philadelphia, PA.

b) USEPA, 2004b: Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final.

c) The dermal absorption factor is 0.001 if soil organic content >10%.

d) No default value is given.

As discussed in Section 6.2.3, the PEF is used to calculate the particulate inhalation ADDs and LADDs. One of the inputs for calculating the PEF is the Q/C value, which represents both local climatic conditions and the size of the contaminated area. The sampling and analysis program for SWMU 39 was designed to characterize the 2.6-acre site. The Q/C values from the *Soil Screening Level* (SSL) guidance (USEPA, 1996a) are presented by source area, city, and climatic zone. Thus, the 2.6-acre area was considered to be the source area for purposes of the PEF calculation. Based on a 2-acre site, a Q/C value of 41.83 was selected to represent the SWMU 39 study area. A PEF of 6.06×10^8 m^3/kg was calculated using the Q/C value for a 2-acre site.

Because the source area (i.e., SWMU 39) is larger than the 0.5 acres that is used to represent a residential lot and there are no plans for residential development, the sampling program was not designed to address 0.5-acre subareas or to define exposures areas for residential lots (as described in Section 4.1.4 of the SSL guidance). To address this uncertainty, it was assumed that the sampling performed in the 2.6-acre area at the SWMU 39 is representative of concentrations

in any one subarea of the site and the Q/C term associated with a 0.5 acre area was used to calculate the PEF. Based on a 0.5-acre site, a Q/C value of 53.89 was selected and a PEF of 7.81×10^8 m^3/kg was calculated using this value. A comparison was then made of inhalation risks and hazards estimated based on the PEF calculated for a 2.6-acre site versus those estimated based on the PEF calculated for a 0.5-acre site. Results are presented in the table below. The results indicate that inhalation risk and hazard estimates are lower when using a PEF calculated based on a 0.5-acre subarea versus estimates using a PEF calculated for a larger area.

Receptor	PEF based on 2 acres (QC = 41.83; PEF = 6.06×10^8 m^3/kg)		PEF based on 0.5 acres (QC = 53.89; PEF = 7.81×10^8 m^3/kg)	
	Cancer Risk	Non-Cancer Hazard	Cancer Risk	Non-Cancer Hazard
Adult Resident	5.5E-10	1.1E-03	4.3E-10	8.9E-04
Child Resident	6.2E-10	6.5E-03	4.8E-10	5.0E-03

6.6 HHRA Summary

This HHRA was performed to evaluate the potential human health effects associated with chemical contamination from past operations at SWMU 39. For the purposes of the HHRA, surface soil and total soil were evaluated.

The HHRA was performed for both current and future land-use conditions. Under current land-use conditions, maintenance worker exposures to surface soil were evaluated. Although exposures to trespassers were considered, it is unlikely that a trespasser would have access to SWMU 39 due to security at the Installation. However, the maintenance worker scenario would be similar to the limited exposure that a trespasser could experience at the site and would be protective of the trespasser.

Under future conditions, maintenance worker exposures to surface soil and maintenance worker and excavation worker exposures to total soil were evaluated. Exposures to surface soil by a maintenance worker were assumed to be the same under future land-use conditions as those under current land-use conditions. In addition, adult resident and child resident exposures to total soil were evaluated under future conditions.

Upper-bound excess lifetime cancer risks and non-cancer HIs were estimated for the exposure pathways and data groupings described above. Estimations of non-cancer HIs and excess lifetime cancer risks and non-cancer HIs for maintenance worker, excavation worker, resident adult, and resident child exposures evaluated in the HHRA are presented in **Appendix E-1, Tables E-19 through E-28**. Summaries of upper-bound excess lifetime cancer risks and non-cancer HIs for exposures evaluated in the HHRA are presented in **Appendix E-1, Tables E-29 through E-33**; the predominant exposure pathways and COPCs are shown in **Appendix E-1, Tables E-34 through E-38**. These results are summarized for each receptor group.

Maintenance Worker. For the current and future maintenance worker exposures to surface soil at SWMU 39, the risk characterization results showed total cancer risk associated with surface soil (9.4×10^{-7}) was below the target risk range. The total HI (HI = 0.12) was less than 1. However, site concentrations of lead in surface soil were above the health protective criterion for lead.

For the future maintenance worker exposures at SWMU 39, the risk characterization results showed total cancer risk associated with total soil (8.1×10^{-7}) was below the target risk range.

The total HI (HI = 0.11) were below 1. However, site concentrations of lead in total soil were above the health protective criterion for lead.

Excavation Worker. For the future excavation worker, the risk characterization results showed total cancer risk associated with total soil ($4.8x10^{-7}$) was below the target risk range. The total HI (HI = 1.3) was slightly above 1. No individual chemical HI was equal to 1. Site concentrations of lead in total soil were above the health protective criterion for lead.

Adult Resident. For the future adult resident, the risk characterization results showed total cancer risks associated with total soil ($6.3x10^{-6}$) were within the target risk range. The total HI (HI = 0.60) was below 1. For the residential scenario, site concentrations were above the health protective criterion for lead.

Child Resident. For the future child resident, the risk characterization results showed total cancer risk associated with total soil ($1.1x10^{-5}$) was within the target risk range. The total HI (HI = 5.0) was greater than 1, primarily due to iron and vanadium. The margin-of-exposure evaluation indicated that the intake of iron was within the allowable range. For the residential scenario, site concentrations were above the health protective criterion for lead.

7.0 ECOLOGICAL RISK ASSESSMENT

An SLERA was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at SWMU 39, the Incinerator Wastewater Ponds. The results of the SLERA contribute to the overall characterization of the site and the scientific/management decision point (SMDP) reached from the SLERA includes one of the following:

- There is adequate information to conclude that ecological risks are negligible and therefore there is no need for further action at the site on the basis of ecological risk;
- The information is not adequate to make a decision at this point and further refinement of data is needed to augment the ecological risk screening; or,
- The information collected and presented indicates that a more thorough assessment is warranted.

The SLERA was performed following the *RFAAP Final Master Work Plan* (URS, 2003), the *RFAAP Site Screening Process* (USEPA, 2001c), the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al., 1996), and Steps 1, 2 and 3a of the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997c). Steps 1, 2 and 3a were completed as part of the SLERA. The addition of Step 3a focuses the outcome of the SLERA, streamlines the review process, and allows one assessment to function as the initial forum for ecological risk management decision making at the site.

The primary objective of the SLERA is to assess whether there is enough information to state that there is the potential for unacceptable risks to ecological receptors as a result of potential hazardous substance releases. This objective is met by characterizing the ecological communities in the vicinity of SWMU 39, assessing the particular hazardous substances being released, identifying pathways for receptor exposure, and estimating the magnitude and likelihood of potential risk to identified receptors. The SLERA addresses the potential for adverse effects to vegetation, the soil invertebrate community, wildlife, endangered and threatened species, and wetlands or other sensitive habitats that may be associated with SWMU 39.

Concentrations of chemicals were measured in relevant environmental media including soil. Groundwater that may have been collected in association with SWMU 39 is being assessed under MWP Work Plan Addendum 009, "Horseshoe Area Groundwater Study" (IT, 2002b), in addition, groundwater does not discharge to the surface in the vicinity of SWMU 39, and there is no potential exposure for ecological receptors to groundwater at this site. Although area-wide groundwater does ultimately discharge to the New River as mentioned previously, groundwater is being assessed as a separate study. Using available concentration data, a SLERA was performed by following Steps 1 and 2 of USEPA (1997c). Step 1 includes a screening-level problem formulation and ecological effects evaluation, and Step 2 includes a screening level preliminary exposure estimate and risk calculation. The SLERA is organized as follows: Site Characterization (*Section 7.1*); Identification of Chemicals of Potential Ecological Concern (COPECs) and Concentration Statistics (*Section 7.2*); Identification of Exposure Pathways and Potential Receptors for Analysis (*Section 7.3*); Identification of Assessment and Measurement

Endpoints (*Section 7.4*); Exposure Estimation (*Section 7.5*); Effects Assessment (*Section 7.6*); Risk Characterization (*Section 7.7*); Uncertainty Analysis (*Section 7.8*); and, Results and Conclusions (*Section 7.9*).

7.1 Site Characterization

This site characterization section includes a general discussion of SWMU 39 itself, vegetative communities, a species inventory, and a discussion on threatened and endangered species.

SWMU 39 is located in the north-central section of the Horseshoe Area, adjacent to the Hazardous Waste Incinerators (SWMU 14). Operation of the ISP (HWMU 39; used for the collection of incinerator scrubber wastewaters) began in 1979 and continued until May 1992. The ISP was RCRA clean closed in 1997. Two earthen settling ponds (SWMU 39) were excavated approximately six to eight feet into the natural grade. The ponds were designed to receive scrubber and precooler quench water from incinerator exhaust. The settling ponds were evaporation ponds, and neither has an inlet or an outlet.

A fence surrounds the ponds, and the enclosed area is approximately 450-ft. by 300-ft. at the widest points. The total area of the SWMU is approximately 2.6 acres, which encloses the soil samples collected from the site. Mowed grass is the predominant vegetation around the ponds and immediately outside the fenced area. Mature pine trees are located beyond the grassy area outside the fence along the southwest, south, and northeast edges of the site. Young trees and saplings are sporadically distributed throughout the site, including a few in the bottoms and at the edges of the ponds. Both ponds are dry, although they may temporarily hold standing water after rain events. The soil surrounding the settling ponds and just outside the fence is also included in this investigation.

7.1.1 General Installation Background

The Virginia Department of Game and Inland Fisheries (1999) conducted the most recent Installation-wide biological survey at RFAAP. Major objectives of this survey were to sample flora and fauna, identify and delineate the major habitat community types, and provide management recommendations for both community types and threatened, endangered or species of concern. Eight community types were identified at RFAAP:

- bottomland forest;
- calcareous forest;
- cliffs;
- grasslands;
- oak forest;
- pine plantation;
- successional forest; and,
- water.

Endangered plants or animals were not observed at SWMU 39 during the Installation-wide biological survey of 1999. Five state-listed rare plants were observed at RFAAP during this survey: *Clematis coattails, Cystoptris tennesseensis, Hasteola suaveolens, Sagittaria rigida,* and *Eleocharis intermedia.* State threatened animals located at RFAAP include the invertebrate *Speyeria idalia* and the birds *Ammodramus henslowii* (Henslow's sparrow) and *Lanius ludovicianus* (loggerhead shrike).

An earlier comprehensive inventory of the mammals, birds, reptiles, aquatic invertebrates, trees, and plants found on the Installation, and of fish inhabiting the New River where it flows through the Installation, was conducted in 1976 during the RFAAP Installation Assessment (USATHAMA, 1976). Information from that assessment was summarized in previous documents (Dames & Moore, 1992). The summarized information was updated for the RFI through personal communication with RFAAP biologists and is presented in the following paragraphs (from URS, 2003).

Many of the reptiles, mammals, and birds listed in the assessment (USATHAMA, 1976) are believed to breed on the Installation. However, indications are that some species, including ruffed grouse and upland plovers, have decreased in number or have disappeared from RFAAP. Foxes, which were once trapped to prevent rabies outbreaks (the last trapping program for foxes was conducted in 1966), were reintroduced to RFAAP as a control for groundhogs. Deer are common at RFAAP and bow hunting has been allowed at the facility since 1991. Migratory waterfowl are found throughout the spring and winter near the New River because the Installation is on the Atlantic Flyway. Federally protected black vultures are present at RFAAP during certain times of the year. Between 1,500 and 3,000 of these migratory birds nest in thickets on the facility (Washington Post, 1995). Public fishing occurs in the New River where it flows through RFAAP.

The Virginia Department of Game and Inland Fisheries identified the following terrestrial flora and fauna as endangered or threatened for Pulaski and Montgomery Counties:

- Plant species - six endangered, three threatened;
- Insect species - one endangered, four threatened;
- Bird species - three endangered; and,
- The locally endangered mountain lion.

In addition, a fish, salamander, four additional bird species, and the river otter are identified as species of concern in the two counties in which RFAAP is located.

According to the RFAAP Installation Assessment (USATHAMA, 1976), timber harvesting occurred at RFAAP in the past. The most recent harvest was conducted in 1987. Tree species at RFAAP include the shortleaf pine, loblolly pine, eastern white pine, yellow poplar, and black walnut. There are 2,537 acres of managed woodland on site (personal communication with T. Thompson, RFAAP Conservation Specialist 1995, as cited in URS, 2003). In 1964, 922 acres of the Horseshoe Area were reforested. No reforestation has occurred in the MMA.

RFAAP is located at the boundary of the central Appalachian Ridges and Valleys Ecoregion and the central Appalachian Ecoregion (Omernik, 1986). These two Ecoregions are characterized in **Table 7-1**.

The area included in SWMU 39 is relatively flat with a slight rise to approximately 1,720 feet msl along the southern edge of the site. There are very few buildings in the area, and the area is accessed by unpaved roads. Surface water runoff is to the north, toward the New River, which is approximately 1,200 feet away. There are no storm drains, manholes, or catch basins in the area.

Table 7-1
Ecoregions of RFAAP

Ecoregion	Land Surface Form	Potential Natural Vegetation	Land Use
Central Appalachian Ridges and Valleys	Open low hills to open low mountains	Appalachian oak in undisturbed areas	Mosaic of cropland and pasture with some woodland and forest
Central Appalachian	Open low to high hills, open mountains	Mixed mesophytic forest[1], Appalachian oak, northern hardwoods[2]	Forest and woodland mostly ungrazed

[1]maple, buckeye, beech, tuliptree, oak, linden
[2]maple, birch, beech, hemlock

Based on previous site visits and site reconnaissance performed by an ecologist in June 2002, a photographic record was prepared (**Appendix F-1**). Prior to the reconnaissance, relevant information was obtained, including topographic maps, township, county, or other appropriate maps. This information was used to identify the location of potential ecological units such as streams, creeks, ponds, grasslands, forest, and wetlands on or near the site. Additionally, the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, which identifies the locations of threatened and endangered species at RFAAP, was reviewed. The location of known or potential contaminant sources affecting the site and the probable gradient of the pathway by which contaminants may be released to the surrounding environment were identified. The reconnaissance was used to evaluate more subtle clues of potential effects from contaminant releases.

7.1.2 Surface Water

If present, surface water would drain north. However, there is no surface water or aquatic habitat at the site. The ponds may be ephemerally influenced by rain events. Natural surface runoff is expected to flow northward, following topography, and infiltrate into the ground.

7.1.3 Wetlands

According to the information presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, and confirmed during the site reconnaissance, there are no designated wetlands at SWMU 39. There are also no wetlands close enough to the site that could potentially be impacted or receive surface water drainage from the site.

7.1.4 Vegetative Communities

Vegetative communities at the site, as presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, were verified using the photographs in **Appendix F-1**. As shown in **Appendix F-1, Photos F-1 through F-9**, the area surrounding the ponds is primarily maintained grass, and little to no vegetation is growing in the pond basins. Mature pine trees are located at the edge of the site, and there are a few sporadic saplings and young trees growing on site and in the pond basins.

These two habitat types (grass and pine trees) can be expected to support different wildlife species assemblages; however, given the close proximity of the habitats to each other, many species would be expected to spend some amount of time within each community type for

foraging, resting, and loafing activities, depending on the season. The pond areas themselves would not be expected to provide suitable habitat for most species of wildlife.

Based on information from the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, and confirmed during the site reconnaissance, the following community description is presented for typical grassland communities at RFAAP.

The grassland communities at RFAAP are an aggregation of several community types that are so intermingled that delineation is impractical. Grassland may conveniently be subdivided into old field, meadow, and cultivated field. The term old field is used here to denote areas that were formerly open and subsequently abandoned, but are still open. In most cases, these areas were formerly pasture or hayfield. Trees or shrubs may be present individually or in small groups, but a canopy is lacking. At SWMU 39, there are a few saplings and young trees onsite but no large, mature trees. There is mature evergreen habitat just beyond the edges of the site. Old fields, in most cases, are dominated by native, warm-season species with a wide variety of other grasses, sedges, and herbs mixed in. The two dominants are little bluestem (*Schizachyrium scoparium*) and broomsedge (*Andropogon virginicus*) with others such as *Tridens flavus, Panicum oligosanthes, Panicum anceps, Eragrostis spectabilis, Setaria glauca, Sorghastrum nutans,* and *Paspalum* being frequent. Much of the old field community is mowed (on an infrequent basis) to help keep woody plants maintained.

Meadows are areas that are mowed regularly and, in most cases, have been planted in forage grasses for haying. These are typically non-native, cool-season species such as *Festuca elatior, Poa pratensis, Phleum pratense, Agrostis gigantea, Bromus inermis, Dactylis glomerata,* and *Arrhenatherum elatius*. These species may also be mixed with native species characteristic of old fields.

Cultivated fields are areas that have been plowed and seeded with various cover crops. These areas have a major ruderal component that persists after abandonment. Principal weed species are *Cirsium arvense, Carduus acanthoides, Carduus nutans, Erechtites hieracifolia, Hypochaeris radicata, Verbascum thapsus, Hieracium pilosella,* and *Datura stramonium.*

Grassland communities at RFAAP comprise 4,379 acres, or about 63 percent of the 6,901-acre total [Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey].

During the site reconnaissance, the study area was examined for vegetative stress, including looking for plants displaying stunted growth, poor foliage growth, tissue discoloration, and a loss of leaf coverage. There is little vegetation growing in the pond basins at SWMU 39, and in the northern basin a dead tree was observed (**Appendix F-1, Photo F-8**). Whether the tree died due to chemical stressors or other unrelated causes is not certain. Other evidence of vegetative stress due to chemicals may include the absence of plants growing in the pond basins.

There is an indication of low pH soil at the site, as sample 39SB05A had a pH of 4.0. As this one single soil sample was analyzed for pH, it is unknown if surface soil at the site have pH concentrations as low as 4.0. As soil pH decreases below 5.5, the availability of aluminum and manganese increases, and may reach a point of toxicity to plants. In addition, soil microorganisms associated with nitrification require a certain soil pH range to function efficiently (e.g., 5.5 to 6.5). Soil with a pH of 4.0 would be considered to have "extreme acidity" related to plant nutrients and aluminum (Pennsylvania State University Cooperative Extension,

1995). It should be noted that the addition of lime would increase soil pH and reduce the availability of aluminum and manganese. The average lead concentration in surface soil of 1,520 mg/kg is considerably above the phytotoxicity benchmark of 50 mg/kg (*Section 7.7.1*), and thus lead concentrations may be responsible for the limited plant growth observed at the site.

7.1.5 Species Inventory

As presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, six different taxa and several species were recorded during the survey. **Table 7-2** presents the numbers of species recorded at RFAAP associated with the grassland community type.

Table 7-2
Species Inventory within RFAAP's Grassland Community Type

Taxa	Number of Species	Typical Examples
Plants	24	little bluestem, broomsedge, panic grass, orchard grass, foxtail, timothy, thistle, fireweed, hawkweed
Invertebrates	~250 in 17 taxonomic orders	millipedes, beetles, flies, springtails, seed bugs, bees, ants, moths, butterflies, dragonflies, mantis, caddisflies, isopods, pill bugs, amphipods
Reptiles and amphibians	24	salamanders, toads, frogs, turtles, snakes
Fish	12	sunfish, minnows, trout (not expected at the site)
Birds	83	robin, swift, dove, sparrow, warbler, wren, hawk
Mammals	13	red fox, white-tailed deer, shrew, meadow vole

7.1.6 Threatened, Rare and Endangered Species Information

Threatened, rare, or endangered species found within the grassland community type at RFAAP include those presented in **Table 7-3** [Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey]. Given the grassland community type at the site, it is possible these species could also occur at the site, however, as mentioned in *Section 7.1.1*, no threatened, rare, or endangered species have been documented at SWMU 39.

Table 7-3
Threatened, Rare, and Endangered Species in RFAAP's Grassland Community

Common Name	Scientific Name	Federal Status	State Status
Midland sedge	*Carex mescochorea*	not available	Watchlist
Shaggy false gromwell	*Onosmodium hispidissimum*	not available	Watchlist
Regal fritillary butterfly	*Speyeria idalia*	not available	State threatened
Henslow's sparrow	*Ammodramus henslowii*	not available	State threatened
Loggerhead shrike	*Lanius ludovicianus*	not available	State threatened

Although a unique community type (the calcareous fen) exists within the RFAAP grassland community type, it is not found at or near SWMU 39.

7.2 Identification of COPECs and Concentration Statistics

A list of surface soil samples used in the SLERA is presented in **Table 7-4**. From the chemical results of samples on this list, a subset of the detected chemicals have data of good quality and are potentially a result of site-related sources. It should be noted that pond composite samples collected by Dames & Moore in 1992 were not used in this SLERA. These samples were not used because they were composites and potentially underestimated constituent concentrations. It should be further noted that, while the thallium results reported in the 1992 VI are believed to be false laboratory positives (see *Section 2.3.1.2* for details), neither laboratory nor validation flags were assigned to the results. Therefore, analysis of the thallium results in the ERA was performed without bias. Examples of screening criteria that have been used include the following: analytical detection limits (**Tables 7-5 and 7-6**); and comparison with risk-based ecotoxicity screening values [Biological Technical Assistance Group (BTAG) Screening Levels for direct contact exposure (**Table 7-5**) and other screening levels appropriate for food chain exposure (**Table 7-6**) based on information presented in **Table 7-7**]. The COPEC selection process is described in more detail in the following subsections. A discussion of non-detected constituent concentrations compared with ecotoxicity screening values is presented in the Uncertainty Analysis section *(Section 7.8)*.

Table 7-4
Surface Soil Samples Used in the SWMU 39 SLERA

39SB05A	39SB4B
39SB05B	39SS07
39SB06A	39SS08
39SB06B	39SS09
39SB1A	39SS1
39SB1AD (duplicate)	39SS10
39SB1B	39SS11
39SB2B	39SS12
39SB3A	39SS2
39SB3B	39SS3

7.2.1 Data Organization

The data for each chemical have been sorted by medium. To assess potential ecological impacts, soil from 0-2 ft bgs have been considered. The 0-2 ft depth interval was selected for three primary reasons: (1) to maintain consistency with other RFAAP ecological risk assessment documents that used 0-2 ft, or a similar depth interval (e.g., Ecological Risk Assessment Approach, IT, 1998; Screening Ecological Risk Assessment, IT, 1999); (2) to address the most important ecological soil depth exposure interval, as soil depths below two feet would be infrequently contacted; and (3) to focus on the soil depth interval expected to have the highest COPEC concentrations, as discharges at SWMU 39 were surficial. Although some burrowing wildlife (e.g., the red fox) may actually burrow to depths greater than two feet, their prey items would be primarily associated with surface soil, and incidental contact by the fox with deeper soil is expected to be insignificant compared to exposures associated with soil in the 0-2 ft depth range.

Table 7-5

Occurrence, Distribution and Selection of Chemicals of Potential Ecological Concern for Surface Soil at SWMU 39 for Direct Contact Exposure

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Ecological Screening Toxicity Value (3)	COPEC Flag (Y/N)	Rationale for Selection or Deletion (4)
Surface Soil	NA	2,3,7,8-TCDD TE (RME)	8.31E-07	2.07E-05	mg/kg	39SB05A	5/5	N/A	2.07E-05	N/A	1.00E-02	No	BSL
(0 - 2 ft.)	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.37E-06 J	5.44E-05	mg/kg	39SB05A	3/3	N/A	5.44E-05	N/A	NVA	No	TEQ
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.02E-05	1.04E-04	mg/kg	39SB05A	5/5	N/A	1.04E-04	N/A	NVA	No	TEQ
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1.76E-07	4.30E-06	mg/kg	39SB05A	3/5	1.71E-07 - 2.00E-07	4.30E-06	N/A	NVA	No	TEQ
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	3.85E-07 J	3.52E-05 J	mg/kg	39SB05A	4/5	1.29E-07 - 1.29E-07	3.52E-05	N/A	NVA	No	TEQ
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	2.93E-07	5.47E-06	mg/kg	39SB05A	3/5	2.63E-07 - 3.29E-07	5.47E-06	N/A	NVA	No	TEQ
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	1.19E-07	1.19E-05	mg/kg	39SB05A	3/5	1.26E-07 - 1.30E-07	1.19E-05	N/A	NVA	No	TEQ
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	3.90E-07	8.19E-06	mg/kg	39SB05A	3/5	2.06E-07 - 2.58E-07	8.19E-06	N/A	NVA	No	TEQ
	72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	2.00E-07	7.65E-07	mg/kg	39SB05A	2/5	3.30E-08 - 1.54E-07	7.65E-07	N/A	NVA	No	TEQ
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	6.74E-07	1.49E-05	mg/kg	39SB05A	4/5	2.00E-07 - 2.00E-07	1.49E-05	N/A	NVA	No	TEQ
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	1.93E-07	4.78E-06	mg/kg	39SB05A	3/5	1.11E-07 - 1.24E-07	4.78E-06	N/A	NVA	No	TEQ
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1.20E-07	3.03E-06	mg/kg	39SB05A	3/5	1.70E-07 - 1.70E-07	3.03E-06	N/A	NVA	No	TEQ
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	1.31E-07	1.98E-05	mg/kg	39SB05A	4/5	1.47E-07 - 1.47E-07	1.98E-05	N/A	NVA	No	TEQ
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	5.35E-07 J	1.03E-05	mg/kg	39SB05A	3/5	1.16E-07 - 1.30E-07	1.03E-05	N/A	NVA	No	TEQ
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	3.93E-07	3.53E-06 J	mg/kg	39SB05A	3/5	1.08E-07 - 1.22E-07	3.53E-06	N/A	NVA	No	TEQ
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.72E-07 J	3.54E-07	mg/kg	39SB05A	2/5	3.30E-08 - 1.27E-07	3.54E-07	N/A	NVA	No	TEQ
	3268-87-9	Octachlorodibenzodioxin	2.69E-04 J	7.75E-03	mg/kg	39SB06B	5/5	N/A	7.75E-03	N/A	NVA	No	TEQ
	39001-02-0	Octachlorodibenzofuran	9.32E-07	3.08E-05 J	mg/kg	39SB05A	5/5	N/A	3.08E-05	N/A	NVA	No	TEQ
	38998-75-3	Total Heptachlorodibenzofuran	5.31E-07	8.44E-05	mg/kg	39SB05A	5/5	N/A	8.44E-05	N/A	NVA	No	TEQ
	37871-00-4	Total Heptachlorodibenzo-p-dioxin	1.80E-05	2.02E-04	mg/kg	39SB05A	5/5	N/A	2.02E-04	N/A	NVA	No	TEQ
	55684-94-1	Total Hexachlorodibenzofuran	2.59E-07	1.27E-04	mg/kg	39SB05A	4/5	1.26E-07 - 1.26E-07	1.27E-04	N/A	NVA	No	TEQ
	34465-46-8	Total Hexachlorodibenzo-p-dioxin	1.60E-06	1.21E-04	mg/kg	39SB05A	5/5	N/A	1.21E-04	N/A	NVA	No	TEQ
	30402-15-4	Total Pentachlorodibenzofuran	4.83E-07	7.29E-05	mg/kg	39SB05A	4/5	1.11E-07 - 1.11E-07	7.29E-05	N/A	NVA	No	TEQ
	36088-22-9	Total Pentachlorodibenzo-p-dioxin	3.11E-07	3.58E-05	mg/kg	39SB05A	3/5	1.70E-07 - 1.70E-07	3.58E-05	N/A	NVA	No	TEQ
	30402-14-3	Total Tetrachlorodibenzofuran	9.28E-07	5.73E-05	mg/kg	39SB05A	3/5	1.08E-07 - 1.22E-07	5.73E-05	N/A	NVA	No	TEQ
	41903-57-5	Total Tetrachlorodibenzo-p-dioxin	6.71E-07	1.77E-05	mg/kg	39SB05A	3/5	1.26E-07 - 1.27E-07	1.77E-05	N/A	NVA	No	TEQ
	121-14-2	2,4-Dinitrotoluene	2.33E-01	2.33E-01	mg/kg	39SB06A	1/14	1.40E-01 - 4.50E-01	2.33E-01	N/A	2.30E-01	Yes	ASL
	55-63-0	Nitroglycerin	1.80E-01 J	1.98E+01	mg/kg	39SB06A	2/5	3.31E-01 - 3.68E-01	1.98E+01	N/A	NVA	Yes	TX
	7429-90-5	Aluminum	1.08E+04	3.74E+04	mg/kg	39SB3B	19/19	N/A	3.74E+04	N/A	1.00E+00	Yes	ASL
	7440-36-0	Antimony	9.50E-01 J	1.40E+00 J	mg/kg	39SB1A	5/15	5.53E-01 - 7.14E+00	1.40E+00	N/A	4.80E-01	Yes	ASL
	7440-38-2	Arsenic	4.30E-01 J	7.26E+00	mg/kg	39SS08	19/19	N/A	7.26E+00	N/A	3.28E+02	No	BSL
	7440-39-3	Barium	9.48E+01	2.16E+02 L	mg/kg	39SB4B	19/19	N/A	2.16E+02	N/A	4.40E+02	No	BSL
	7440-41-7	Beryllium	6.28E-01	1.40E+00	mg/kg	39SB3B	17/18	5.00E-01 - 5.00E-01	1.40E+00	N/A	2.00E-02	Yes	ASL
	7440-43-9	Cadmium	8.00E-02 J	7.11E-01 J	mg/kg	39SS08	6/19	1.17E-01 - 7.00E-01	7.11E-01	N/A	2.50E+00	No	BSL
	7440-70-2	Calcium	2.63E+02	3.85E+04	mg/kg	39SS1	19/19	N/A	3.85E+04	N/A	NVA	No	NUT
	7440-47-3	Chromium	1.44E+01	9.51E+01	mg/kg	39SB06A	19/19	N/A	9.51E+01	N/A	7.50E-03	Yes	ASL

Table 7-5
Occurrence, Distribution and Selection of Chemicals of Potential Ecological Concern for Surface Soil at SWMU 39 for Direct Contact Exposure

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Ecological Screening Toxicity Value (3)	COPEC Flag (Y/N)	Rationale for Selection or Deletion (4)
	7440-48-4	Cobalt	7.50E+00 L	2.90E+01	mg/kg	39SS10	19/19	N/A	2.90E+01	N/A	1.00E+02	No	BSL
	7440-50-8	Copper	1.42E+01	3.75E+02	mg/kg	39SB06A	19/19	N/A	3.75E+02	N/A	1.50E+01	Yes	ASL
	7439-89-6	Iron	1.63E+04 J	5.28E+04	mg/kg	39SB3B	19/19	N/A	5.28E+04	N/A	1.20E+01	Yes	ASL
	7439-92-1	Lead	1.77E+01	1.65E+04	mg/kg	39SB06A	18/19	1.05E+01 - 1.05E+01	1.65E+04	N/A	1.00E-02	Yes	ASL
	7439-95-4	Magnesium	1.27E+03	1.90E+04	mg/kg	39SS1	19/19	N/A	1.90E+04	N/A	4.40E+03	No	NUT
	7439-96-5	Manganese	9.69E+01 J	1.38E+03 J	mg/kg	39SS10	19/19	N/A	1.38E+03	N/A	3.30E+02	Yes	ASL
	7439-97-6	Mercury (Inorganic)	2.90E-02 J	1.02E-01 L	mg/kg	39SB06A	10/19	5.00E-02 - 1.40E-01	1.02E-01	N/A	5.80E-02	Yes	ASL
	7440-02-0	Nickel	1.43E+01	3.81E+01	mg/kg	39SS08	19/19	N/A	3.81E+01	N/A	2.00E+00	Yes	ASL
	7440-09-7	Potassium	1.40E+03	3.71E+03	mg/kg	39SB2B	19/19	N/A	3.71E+03	N/A	NVA	No	NUT
	7782-49-2	Selenium	5.78E-01 L	1.20E+00 L	mg/kg	39SB4B	2/19	2.50E-01 - 1.23E+00	1.20E+00	N/A	1.80E+00	No	BSL
	7440-22-4	Silver	9.72E-01	1.35E+00	mg/kg	39SS1	2/11	2.50E-01 - 1.23E+00	1.35E+00	N/A	9.80E-06	Yes	ASL
	7440-23-5	Sodium	3.15E+01	2.88E+02 J	mg/kg	39SB3A	16/16	N/A	2.88E+02	N/A	NVA	No	NUT
	7440-28-0	Thallium	1.30E-01 J	2.27E+01	mg/kg	39SS1	13/19	7.40E-01 - 6.62E+00	2.27E+01	N/A	1.00E-03	Yes	ASL
	7440-62-2	Vanadium	2.19E+01	9.27E+01 K	mg/kg	39SB3B	19/19	N/A	9.27E+01	N/A	5.00E-01	Yes	ASL
	7440-66-6	Zinc	5.24E+01	3.01E+02 J	mg/kg	39SS12	19/19	N/A	3.01E+02	N/A	1.00E+01	Yes	ASL
	7440-44-0	Total Organic Carbon	4.56E+03	4.56E+03	mg/kg	39SB05A	1/1	N/A	4.56E+03	N/A	NVA	No	PHYS
	72-54-8	4,4'-DDD	3.10E-04 J	3.10E-04 J	mg/kg	39SS07	1/6	7.78E-04 - 2.70E-01	3.10E-04	N/A	1.00E-01	No	BSL
	5103-71-9	alpha-Chlordane	1.35E-03	1.35E-03	mg/kg	39SB06A	1/6	7.36E-04 - 3.30E-01	1.35E-03	N/A	1.00E-01	No	BSL
	72-20-8	Endrin	3.79E-03	3.79E-03	mg/kg	39SB06A	1/6	7.36E-04 - 4.50E-01	3.79E-03	N/A	1.00E-01	No	BSL
	7421-93-4	Endrin aldehyde	6.81E-04 J	6.81E-04 J	mg/kg	39SB05A	1/6	7.36E-04 - 5.30E-01	6.81E-04	N/A	NVA	Yes	TX
	53494-70-5	Endrin ketone	2.82E-03	2.82E-03	mg/kg	39SB06A	1/6	7.36E-04 - 5.30E-01	2.82E-03	N/A	NVA	Yes	TX
	5103-74-2	gamma-Chlordane	1.41E-03	1.41E-03	mg/kg	39SB06A	1/6	7.36E-04 - 3.30E-01	1.41E-03	N/A	1.00E-01	No	BSL
	72-43-5	Methoxychlor	2.35E-03	2.35E-03	mg/kg	39SS07	1/6	7.78E-04 - 3.30E-01	2.35E-03	N/A	1.00E-01	No	BSL
	84-66-2	Diethyl phthalate	5.90E-02	5.90E-02 J	mg/kg	39SB1A	1/9	2.40E-01 - 4.50E-01	5.90E-02	N/A	NVA	Yes	ASL
	84-74-2	Di-n-butyl phthalate	5.23E-01	5.23E-01	mg/kg	39SB1A	1/9	6.10E-02 - 4.50E-01	5.23E-01	N/A	NVA	Yes	ASL

(1) Maximum concentration used for screening.
(2) Background values are not used in the screening.
(3) Screening toxicity values from BTAG (1995).
(4) Rationale Codes
Selection Reason: Toxicity Information May Be Available (TX)
Above Screening Levels (ASL)

Deletion Reason: Below Screening Level (BSL)
Nutrient (NUT)
Physical/Chemical (PHYS)
While some individual chlorinated dioxin and furan constituents may exceed their toxicity values, dioxins and furans will be analyzed by the toxicity equivalent provided by the TCDD-TE (TEQ)
Tentatively Identified Compounds not used in risk evaluation (TIC)
For 2,3,7,8-TCDD-TE, two values were calculated, the MAX and the RME (see text for further discussion). RME value selected for screening (TEQ-RME).

Definitions: N/A = Not Applicable or Not Available
SQL = Sample Quantitation Limit
COPEC = Chemical of Potential Ecological Concern
NVA = No Value Available

Qualifiers: L = Reported value may be biased low
K = Reported value may be biased high
J = Estimated Value

Table 7-6

Occurrence, Distribution and Selection of Chemicals of Potential Ecological Concern for Surface Soil at SWMU 39 for Food Chain Exposure

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Ecological Screening Toxicity Value (3)	COPEC Flag (Y/N)	Rationale for Selection or Deletion (4)
Surface Soil	NA	2,3,7,8-TCDD TE (RME)	8.31E-07	2.07E-05	mg/kg	39SB05A	5/5	N/A	2.07E-05	N/A	3.150E-06	Yes	ASL
(0 - 2 ft.)	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.37E-06 J	5.44E-05	mg/kg	39SB05A	3/3	N/A	5.44E-05	N/A	3.860E-05	No	TEQ
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.02E-05	1.04E-04	mg/kg	39SB05A	5/5	N/A	1.04E-04	N/A	1.990E-07	No	TEQ
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1.76E-07	4.30E-06	mg/kg	39SB05A	3/5	1.71E-07 - 2.00E-07	4.30E-06	N/A	3.860E-05	No	TEQ
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	3.85E-07 J	3.52E-05 J	mg/kg	39SB05A	4/5	1.29E-07 - 1.29E-07	3.52E-05	N/A	3.860E-05	No	TEQ
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	2.93E-07	5.47E-06	mg/kg	39SB05A	3/5	2.63E-07 - 3.29E-07	5.47E-06	N/A	1.990E-07	No	TEQ
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	1.19E-07	1.19E-05	mg/kg	39SB05A	3/5	1.26E-07 - 1.30E-07	1.19E-05	N/A	3.860E-05	No	TEQ
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	3.90E-07	8.19E-06	mg/kg	39SB05A	3/5	2.06E-07 - 2.58E-07	8.19E-06	N/A	1.990E-07	No	TEQ
	72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	2.00E-07	7.65E-07	mg/kg	39SB05A	2/5	3.30E-08 - 1.54E-07	7.65E-07	N/A	3.860E-05	No	TEQ
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	6.74E-07	1.49E-05	mg/kg	39SB05A	4/5	2.00E-07 - 2.00E-07	1.49E-05	N/A	1.990E-07	No	TEQ
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	1.93E-07	4.78E-06	mg/kg	39SB05A	3/5	1.11E-07 - 1.24E-07	4.78E-06	N/A	3.860E-05	No	TEQ
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1.20E-07	3.03E-06	mg/kg	39SB05A	3/5	1.70E-07 - 1.70E-07	3.03E-06	N/A	1.990E-07	No	TEQ
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	1.31E-07	1.98E-05	mg/kg	39SB05A	4/5	1.47E-07 - 1.47E-07	1.98E-05	N/A	3.860E-05	No	TEQ
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	5.35E-07 J	1.03E-05	mg/kg	39SB05A	3/5	1.16E-07 - 1.30E-07	1.03E-05	N/A	3.860E-05	No	TEQ
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	3.93E-07	3.53E-06 J	mg/kg	39SB05A	3/5	1.08E-07 - 1.22E-07	3.53E-06	N/A	NVA	No	TEQ
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.72E-07 J	3.54E-07	mg/kg	39SB05A	2/5	3.30E-08 - 1.27E-07	3.54E-07	N/A	NVA	No	TEQ
	3268-87-9	Octachlorodibenzodioxin	2.69E-04 J	7.75E-03	mg/kg	39SB06B	5/5	N/A	7.75E-03	N/A	1.990E-07	No	TEQ
	39001-02-0	Octachlorodibenzofuran	9.32E-07	3.08E-05 J	mg/kg	39SB05A	5/5	N/A	3.08E-05	N/A	3.860E-05	No	TEQ
	38998-75-3	Total Heptachlorodibenzofuran	5.31E-07	8.44E-05	mg/kg	39SB05A	5/5	N/A	8.44E-05	N/A	3.860E-05	No	TEQ
	37871-00-4	Total Heptachlorodibenzo-p-dioxin	1.80E-05	2.02E-04	mg/kg	39SB05A	5/5	N/A	2.02E-04	N/A	1.990E-07	No	TEQ
	55684-94-1	Total Hexachlorodibenzofuran	2.59E-07	1.27E-04	mg/kg	39SB05A	4/5	1.26E-07 - 1.26E-07	1.27E-04	N/A	3.860E-05	No	TEQ
	34465-46-8	Total Hexachlorodibenzo-p-dioxin	1.60E-06	1.21E-04	mg/kg	39SB05A	5/5	N/A	1.21E-04	N/A	1.990E-07	No	TEQ
	30402-15-4	Total Pentachlorodibenzofuran	4.83E-07	7.29E-05	mg/kg	39SB05A	4/5	1.11E-07 - 1.11E-07	7.29E-05	N/A	3.860E-05	No	TEQ
	36088-22-9	Total Pentachlorodibenzo-p-dioxin	3.11E-07	3.58E-05	mg/kg	39SB05A	3/5	1.70E-07 - 1.70E-07	3.58E-05	N/A	1.990E-07	No	TEQ
	30402-14-3	Total Tetrachlorodibenzofuran	9.28E-07	5.73E-05	mg/kg	39SB05A	3/5	1.08E-07 - 1.22E-07	5.73E-05	N/A	3.860E-05	No	TEQ
	41903-57-5	Total Tetrachlorodibenzo-p-dioxin	6.71E-07	1.77E-05	mg/kg	39SB05A	3/5	1.26E-07 - 1.27E-07	1.77E-05	N/A	1.990E-07	No	TEQ
	121-14-2	2,4-Dinitrotoluene	2.33E-01	2.33E-01	mg/kg	39SB06A	1/14	1.40E-01 - 4.50E-01	2.33E-01	N/A	1.280E+00	No	BSL
	55-63-0	Nitroglycerin	1.80E-01 J	1.98E+01	mg/kg	39SB06A	2/5	3.31E-01 - 3.68E-01	1.98E+01	N/A	1.500E+02	No	BSL
	7429-90-5	Aluminum	1.08E+04	3.74E+04	mg/kg	39SB3B	19/19	N/A	3.74E+04	N/A	5.000E+00	No	NIBC
	7440-36-0	Antimony	9.50E-01 J	1.40E+00 J	mg/kg	39SB1A	5/15	5.53E-01 - 7.14E+00	1.40E+00	N/A	5.000E+00	No	BSL
	7440-38-2	Arsenic	4.30E-01 J	7.26E+00	mg/kg	39SS08	19/19	N/A	7.26E+00	N/A	9.900E+00	No	BSL
	7440-39-3	Barium	9.48E+01	2.16E+02 L	mg/kg	39SB4B	19/19	N/A	2.16E+02	N/A	2.830E+02	No	BSL
	7440-41-7	Beryllium	6.28E-01	1.40E+00	mg/kg	39SB3B	17/18	5.00E-01 - 5.00E-01	1.40E+00	N/A	1.000E+01	No	BSL
	7440-43-9	Cadmium	8.00E-02 J	7.11E-01 J	mg/kg	39SS08	6/19	1.17E-01 - 7.00E-01	7.11E-01	N/A	4.000E+00	No	BSL
	7440-70-2	Calcium	2.63E+02	3.85E+04	mg/kg	39SS1	19/19	N/A	3.85E+04	N/A	NVA	No	NUT
	7440-47-3	Chromium	1.44E+01	9.51E+01	mg/kg	39SB06A	19/19	N/A	9.51E+01	N/A	4.000E-01	Yes	ASL

Table 7-6
Occurrence, Distribution and Selection of Chemicals of Potential Ecological Concern for Surface Soil at SWMU 39 for Food Chain Exposure

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Ecological Screening Toxicity Value (3)	COPEC Flag (Y/N)	Rationale for Selection or Deletion (4)
	7440-48-4	Cobalt	7.50E+00 L	2.90E+01	mg/kg	39SS10	19/19	N/A	2.90E+01	N/A	2.000E+01	Yes	ASL
	7440-50-8	Copper	1.42E+01	3.75E+02	mg/kg	39SB06A	19/19	N/A	3.75E+02	N/A	6.000E+01	Yes	ASL
	7439-89-6	Iron	1.63E+04 J	5.28E+04	mg/kg	39SB3B	19/19	N/A	5.28E+04	N/A	NVA	Yes	ASL
	7439-92-1	Lead	1.77E+01	1.65E+04	mg/kg	39SB06A	18/19	1.05E+01 - 1.05E+01	1.65E+04	N/A	4.050E+01	Yes	ASL
	7439-95-4	Magnesium	1.27E+03	1.90E+04	mg/kg	39SS1	19/19	N/A	1.90E+04	N/A	NVA	No	NUT
	7439-96-5	Manganese	9.69E+01 J	1.38E+03 J	mg/kg	39SS10	19/19	N/A	1.38E+03	N/A	5.000E+01	No	NIBC
	7439-97-6	Mercury (Inorganic)	2.90E-02 J	1.02E-01 L	mg/kg	39SB06A	10/19	5.00E-02 - 1.40E-01	1.02E-01	N/A	5.100E-04	Yes	ASL
	7440-02-0	Nickel	1.43E+01	3.81E+01	mg/kg	39SS08	19/19	N/A	3.81E+01	N/A	3.000E+01	Yes	ASL
	7440-09-7	Potassium	1.40E+03	3.71E+03	mg/kg	39SB2B	19/19	N/A	3.71E+03	N/A	NVA	No	NUT
	7782-49-2	Selenium	5.78E-01 L	1.20E+00 L	mg/kg	39SB4B	2/19	2.50E-01 - 1.23E+00	1.20E+00	N/A	2.100E-01	Yes	ASL
	7440-22-4	Silver	9.72E-01	1.35E+00	mg/kg	39SS1	2/11	2.50E-01 - 1.23E+00	1.35E+00	N/A	2.000E+00	No	BSL
	7440-23-5	Sodium	3.15E+01	2.88E+02 J	mg/kg	39SB3A	16/16	N/A	2.88E+02	N/A	NVA	No	NUT
	7440-28-0	Thallium	1.30E-01 J	2.27E+01	mg/kg	39SS1	13/19	7.40E-01 - 6.62E+00	2.27E+01	N/A	1.000E+00	Yes	ASL
	7440-62-2	Vanadium	2.19E+01	9.27E+01 K	mg/kg	39SB3B	19/19	N/A	9.27E+01	N/A	2.000E+00	No	NIBC
	7440-66-6	Zinc	5.24E+01	3.01E+02 J	mg/kg	39SS12	19/19	N/A	3.01E+02	N/A	8.500E+00	Yes	ASL
	7440-44-0	Total Organic Carbon	4.56E+03	4.56E+03	mg/kg	39SB05A	1/1	N/A	4.56E+03	N/A	NVA	No	PHYS
	72-54-8	4,4'-DDD	3.10E-04 J	3.10E-04 J	mg/kg	39SS07	1/6	7.78E-04 - 2.70E-01	3.10E-04	N/A	7.582E-01	No	BSL
	5103-71-9	alpha-Chlordane	1.35E-03	1.35E-03	mg/kg	39SB06A	1/6	7.36E-04 - 3.30E-01	1.35E-03	N/A	2.240E-01	No	BSL
	72-20-8	Endrin	3.79E-03	3.79E-03	mg/kg	39SB06A	1/6	7.36E-04 - 4.50E-01	3.79E-03	N/A	1.010E-02	No	BSL
	7421-93-4	Endrin aldehyde	6.81E-04 J	6.81E-04 J	mg/kg	39SB05A	1/6	7.36E-04 - 5.30E-01	6.81E-04	N/A	1.050E-02	No	BSL
	53494-70-5	Endrin ketone	2.82E-03	2.82E-03	mg/kg	39SB06A	1/6	7.36E-04 - 5.30E-01	2.82E-03	N/A	NVA	Yes	TX
	5103-74-2	gamma-Chlordane	1.41E-03	1.41E-03	mg/kg	39SB06A	1/6	7.36E-04 - 3.30E-01	1.41E-03	N/A	2.240E-01	No	BSL
	72-43-5	Methoxychlor	2.35E-03	2.35E-03	mg/kg	39SS07	1/6	7.78E-04 - 3.30E-01	2.35E-03	N/A	1.988E-02	No	BSL
	84-66-2	Diethyl phthalate	5.90E-02	5.90E-02 J	mg/kg	39SB1A	1/9	2.40E-01 - 4.50E-01	5.90E-02	N/A	1.000E+02	No	BSL
	84-74-2	Di-n-butyl phthalate	5.23E-01	5.23E-01	mg/kg	39SB1A	1/9	6.10E-02 - 4.50E-01	5.23E-01	N/A	2.000E+02	No	BSL

(1) Maximum concentration used for screening.

(2) Background values derived from site-specific statistical analysis. See text for supporting information.

(3) Screening toxicity values from USEPA SSLs (2000); Efroymson et al., PRGs (1997); and USEPA Region V EDQLs (1999); and other sources. See text for derivation.

(4) Rationale Codes

Selection Reason:

Toxicity Information May Be Available (TX)
Above Screening Levels (ASL)

Deletion Reason:

Background Levels (BKG)
Below Screening Level (BSL)
Nutrient (NUT)
Soil pH > 5.5 (pH)
Physical/Chemical (PHYS)
Not Important Bioaccumulative Constituent (NIBC)
While some individual chlorinated dioxin and furan constituents may exceed their toxicity values, dioxins and furans will be analyzed by the toxicity equivalent provided by the TCDD-TE (TEQ)
Tentatively Identified Compounds not used in risk evaluation (TIC)
For 2,3,7,8-TCDD-TE, two values were calculated, the MAX and the RME (see text for further discussion). RME value selected for screening (TEQ-RME).

Definitions:
N/A = Not Applicable or Not Available
SQL = Sample Quantitation Limit
COPEC = Chemical of Potential Ecological Concern
NVA = No Value Available

Qualifiers:
L = Reported value may be biased low
K = Reported value may be biased high
J = Estimated Value

Table 7-7
Selection of Ecological Screening Toxicity Values for Food Chain Exposure at SWMU 39

Parameter *(only detected constituents listed)*	Ecological Soil Screening Levels[a] (mg/kg)	Ecological Preliminary Remediation Goals[b] (mg/kg)	Ecological Data Quality Levels[c] (mg/kg)	Selected Ecological Screening Toxicity Value[d] (mg/kg)
2,3,7,8-TCDD TE (RME)	NVA[e]	0.00000315	0.000000199	0.00000315
1,2,3,4,6,7,8-Heptachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	NVA	NVA	0.000000199	0.000000199
1,2,3,4,7,8,9-Heptachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
1,2,3,4,7,8-Hexachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	NVA	NVA	0.000000199	0.000000199
1,2,3,6,7,8-Hexachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	NVA	NVA	0.000000199	0.000000199
1,2,3,7,8,9-Hexachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	NVA	NVA	0.000000199	0.000000199
1,2,3,7,8-Pentachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	NVA	NVA	0.000000199	0.000000199
2,3,4,6,7,8-Hexachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
2,3,4,7,8-Pentachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
2,3,7,8-Tetrachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
2,3,7,8-Tetrachlorodibenzo-p-dioxin	NVA	NVA	0.000000199	0.000000199
Octachlorodibenzodioxin	NVA	NVA	0.000000199	0.000000199
Octachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
Total Heptachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
Total Heptachlorodibenzo-p-dioxin	NVA	NVA	0.000000199	0.000000199
Total Hexachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
Total Hexachlorodibenzo-p-dioxin	NVA	NVA	0.000000199	0.000000199
Total Pentachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
Total Pentachlorodibenzo-p-dioxin	NVA	NVA	0.000000199	0.000000199
Total Tetrachlorodibenzofuran	NVA	NVA	0.0000386	0.0000386
Total Tetrachlorodibenzo-p-dioxin	NVA	NVA	0.000000199	0.000000199
2,4-Dinitrotoluene	NVA	NVA	1.28	1.28
Nitroglycerin	NVA	NVA	NVA	150[f]
Aluminum	NVA	NVA	NVA	NVA
Antimony	$21_{(mammal)}$	$5_{(plant)}$	0.1423	5
Arsenic	$37_{(plant)}$	$9.9_{(mammal, plant)}$	5.7	9.9
Barium	NVA	283	1.04	283
Beryllium	NVA	10	1.06	10
Cadmium	$29_{(plant)}$	$4_{(plant, bird)}$	0.00222	4
Calcium	NVA	NVA	NVA	Nutrient
Chromium	$5_{(plant)}$	$0.4_{(earthworm)}$	0.4	0.4
Cobalt	$32_{(bird)}$	$20_{(plant)}$	0.14033	20
Copper	$61_{(earthworm)}$	$60_{(earthworm)}$	0.3132	60
Iron	NVA	NVA	NVA	NVA
Lead	NVA	40.5	0.05373	40.5
Magnesium	NVA	NVA	NVA	Nutrient
Manganese	NVA	NVA	NVA	NVA
Mercury (Inorganic)	NVA	0.00051	0.1	0.00051
Nickel	NVA	30	13.6	30
Potassium	NVA	NVA	NVA	Nutrient

Table 7-7
Selection of Ecological Screening Toxicity Values for Food Chain Exposure at SWMU 39

Parameter *(only detected constituents listed)*	Ecological Soil Screening Levels[a] (mg/kg)	Ecological Preliminary Remediation Goals[b] (mg/kg)	Ecological Data Quality Levels[c] (mg/kg)	Selected Ecological Screening Toxicity Value[d] (mg/kg)
Selenium	NVA	0.21	0.02765	0.21
Silver	NVA	2	4.04	2
Sodium	NVA	NVA	NVA	Nutrient
Thallium	NVA	1	0.05692	1
Vanadium	NVA	2	1.59	2
Zinc	$120_{(earthworm)}$	$8.5_{(bird)}$	6.62	8.5
Total Organic Carbon	NVA	NVA	NVA	NVA
4,4'-DDD	NVA	NVA	0.75815	0.75815
alpha-Chlordane	NVA	NVA	0.224	0.224
Endrin	NVA	NVA	0.0101	0.0101
Endrin aldehyde	NVA	NVA	0.0105	0.0105
Endrin ketone	NVA	NVA	NVA	NVA
gamma-Chlordane	NVA	NVA	0.224	0.224
Methoxychlor	NVA	NVA	0.01988	0.01988
Diethyl phthalate	NVA	$100_{(plant)}$	24.8	100
Di-n-butyl phthalate	NVA	$200_{(plant)}$	0.14979	200

a Ecological Soil Screening Level Guidance, USEPA, July 2000, Draft.

b Preliminary Remediation Goals for Ecological Endpoints, R. A. Efroymson et al., August 1997.

c Ecological Data Quality Levels, USEPA Region V, October 1999.

d The following hierarchy was utilized to select the final Ecological Screening Toxicity Values for this assessment:

1. The lower value of either the Ecological Soil Screening Level Guidance or the Preliminary Remediation Goals for Ecological Endpoints.
2. Ecological Data Quality Levels, USEPA Region V

e NVA = No Value Available

f Value is from Los Alamos National Laboratory, 2002, Environmental Restoration Project, Environmental Screening Levels, Release 1.5, September.

Chemicals that were not detected at least once in a medium have not been included in the risk assessment, but are presented in **Appendix F-2, Table F-18**. Available background data exist for soil, as summarized in the Site Screening Process (USEPA, 2001c), and these data are used in the Risk Characterization (*Section 7.7.3*) to evaluate COPECs considered to be background related *(Section 7.2.4)*.

The analytical data may have qualifiers from the analytical laboratory quality control or from the data validation process that reflect the level of confidence in the data. Some of the more common qualifiers and their meanings are from USEPA (1989a). Besides taking into account the ecological depth of interest, the methodology for data summary was identical for the SLERA and the human health risk assessments.

Because of the uncertainty associated with characterizing contamination in environmental media, the 95% UCL of the mean has been estimated for chemicals selected as COPECs. The calculation of EPCs follows the same procedure used for the HHRA (*Section 6.2.2*).

7.2.2 Descriptive Statistical Calculations

Because of the uncertainty associated with characterizing contamination in environmental media, the 95% UCL of the mean has been estimated for chemicals selected as COPECs (**Table 7-8**). The calculation of EPCs follows the same procedure used for the HHRA (*Section 6.2.2*).

7.2.3 Frequency of Detection

Chemicals that are detected infrequently may be artifacts in the data that may not reflect site-related activity or disposal practices. These chemicals, however, have been included in the risk evaluation and a low frequency of detection was not used to deselect COPECs.

7.2.4 Natural Site Constituents (Background and Essential Nutrients)

Chemical concentrations are compared to facility-wide background concentrations as an indication of whether a chemical is present from site-related activity or as natural background (as discussed in *Section 2.3.1.4*). This comparison, performed as part of the Risk Characterization (*Section 7.7.3*), is generally valid for inorganic chemicals, but not for organic chemicals, because inorganic chemicals are naturally occurring and most organic chemicals are not. The 95% UTL (**Table 2-1**) was used as one of the background comparison statistics.

Chemicals with MDCs less than the background UTL and shown not to be statistically different based on appropriate population statistics are eliminated from further consideration. If the MDC exceeds the UTL, or the populations are shown to be statistically different, the chemical is retained as a COPEC. In general, UTLs were calculated as discussed in *Section 2.3.1.4*, and population statistics were performed as discussed in *Section 6.1.2.3*.

As recommended in both the Site Screening Process (USEPA, 2001c) and the Final Master Work Plan (URS, 2003) the essential nutrients calcium, magnesium, potassium and sodium were eliminated as COPECs. The elimination of essential nutrients was the same for the SLERA and the HHRA *(Section 6.1.2.2)*.

7.2.5 Comparison to Risk-Based Screening Ecotoxicity Values

A comparison was performed between MDCs of chemicals in sampled media and risk-based ecotoxicity screening values for ecological endpoints. Chemicals that exceeded the screening values, or for which no screening values are available, were retained as COPECs. The following

Table 7-8
Exposure Point Concentration Summary for Ecological Receptors for Surface Soil at SWMU 39

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Surface Soil (0 - 2 ft.)	2,3,7,8-TCDD TE (RME)	mg/kg	5.71E-06	N/A	2.07E-05	2.07E-05	mg/kg	Max	Test(3)
	2,4-Dinitrotoluene	mg/kg	1.52E-01	2.02E-01 (NP)	2.33E-01	2.02E-01	mg/kg	95%UCL-Bst	Test(1)
	Diethylphthalate	mg/kg	1.64E-01	2.01E-01 (N)	5.90E-02	5.90E-02	mg/kg	Max	Test(5)
	Di-n-butyl phthalate	mg/kg	1.86E-01	2.81E-01 (N)	5.23E-01	2.81E-01	mg/kg	95%UCL-N	Test(4)
	Endrin	mg/kg	1.13E-01	7.11E+07 (T)	3.79E-03	3.79E-03	mg/kg	Max	Test(5)
	Endrin aldehyde	mg/kg	1.33E-01	2.58E-01 (NP)	6.81E-04	6.81E-04	mg/kg	Max	Test(5)
	Endrin ketone	mg/kg	1.33E-01	3.66E+08 (T)	2.82E-03	2.82E-03	mg/kg	Max	Test(5)
	Nitroglycerin	mg/kg	4.10E+00	N/A	1.98E+01	1.98E+01	mg/kg	Max	Test(3)
	Aluminum	mg/kg	2.22E+04	2.58E+04 (T)	3.74E+04	2.58E+04	mg/kg	95%UCL-T	Test(2)
	Antimony	mg/kg	1.24E+00	1.89E+00 (NP)	1.40E+00	1.40E+00	mg/kg	Max	Test(5)
	Beryllium	mg/kg	9.40E-01	1.05E+00 (N)	1.40E+00	1.05E+00	mg/kg	95%UCL-N	Test(4)
	Chromium	mg/kg	3.83E+01	4.68E+01 (T)	9.51E+01	4.68E+01	mg/kg	95%UCL-T	Test(2)
	Cobalt	mg/kg	1.55E+01	1.82E+01 (T)	2.90E+01	1.82E+01	mg/kg	95%UCL-T	Test(2)
	Copper	mg/kg	8.14E+01	1.18E+02 (NP)	3.75E+02	1.18E+02	mg/kg	95%UCL-Bst	Test(1)
	Iron	mg/kg	3.09E+04	3.52E+04 (T)	5.28E+04	3.52E+04	mg/kg	95%UCL-T	Test(2)
	Lead	mg/kg	1.52E+03	1.28E+04 (T)	1.65E+04	1.28E+04	mg/kg	95%UCL-T	Test(2)
	Manganese	mg/kg	5.19E+02	8.12E+02 (T)	1.38E+03	8.12E+02	mg/kg	95%UCL-T	Test(2)
	Mercury	mg/kg	4.97E-02	6.22E-02 (T)	1.02E-01	6.22E-02	mg/kg	95%UCL-T	Test(2)
	Nickel	mg/kg	2.12E+01	2.40E+01 (T)	3.81E+01	2.40E+01	mg/kg	95%UCL-T	Test(2)
	Selenium	mg/kg	4.74E-01	6.20E-01 (NP)	1.20E+00	6.20E-01	mg/kg	95%UCL-Bst	Test(1)
	Silver	mg/kg	4.17E-01	5.97E-01 (NP)	1.35E+00	5.97E-01	mg/kg	95%UCL-Bst	Test(1)
	Thallium	mg/kg	2.55E+00	4.28E+00 (NP)	2.27E+01	4.28E+00	mg/kg	95%UCL-Bst	Test(1)
	Vanadium	mg/kg	5.57E+01	6.32E+01 (N)	9.27E+01	6.32E+01	mg/kg	95%UCL-N	Test(4)
	Zinc	mg/kg	9.53E+01	1.11E+02 (NP)	3.01E+02	1.11E+02	mg/kg	95%UCL-Bst	Test(1)

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N), 95% UCL based on bootstrap statistic (95% UCL-Bst).

N/A - Not Applicable; Not Available

Distributions: Normal (N); Lognormal/Transformed (T); Undefined/Nonparametric (NP).

Test(1) The data were determined to be neither normally or lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50); Bootstrap Statistic used.

Test(2) The data were determined to be lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50).

Test(3) The 95% UCL was not calculated due to limited number of samples (n<=5); therefore, the maximum detect was used as the EPC.

Test(4) The data were determined to be normally distributed using Shapiro-Wilks Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50).

Test(5) The 95% UCL exceeds the maximum detected concentration; therefore, the maximum detect was used as the EPC.

screening values, or screening value hierarchy (as noted) were used to select soil COPECs for direct contact exposure and food chain exposure:

For Direct Contact Exposure

(1) the lower of the flora and fauna *BTAG Screening Values* (USEPA, 1995d)

For Food Chain Exposure

(1) the lower of *Ecological Soil Screening Levels* (USEPA, 2000c) and *Preliminary Remediation Goals for Ecological Endpoints* (Efroymson et al., 1997); and,

(2) *Ecological Data Quality Levels* (USEPA, 1999b).

The results of the direct contact and food chain exposure COPEC screenings are presented in **Tables 7-5 and 7-6**. COPECs were selected for further consideration in the SLERA if the MDC exceeded the available screening value. If no screening value was available, the constituent was carried forward for consideration in the SLERA, unless it is an essential nutrient, or site-specific information exists to eliminate it from further consideration (see following discussion). Note: **Table 7-7** presents a compilation of the screening toxicity values for soil food chain exposure, and shows the final values that are used in the screening assessment to select COPECs for the food chain pathway. Although **Table 7-7** shows some screening values are based on earthworms or plants, this is because the screening values for these receptors were lower than those based on upper trophic level receptors. Ecological soil screening levels (SSLs) from USEPA and preliminary remediation goals (PRGs) from Efroymson both consider bioaccumulation for avian and mammalian wildlife receptors. The conservative pre-screen approach used for the SLERA is to select the lowest screening value from these two references, even if they are based on direct-contact exposure for earthworms or plants. It should be noted that SSLs consider bioaccumulation for the meadow vole, short-tailed shrew, long-tailed weasel, mourning dove, American woodcock, and red-tailed hawk; and PRGs consider bioaccumulation for short-tailed shrew, white-footed mouse, red fox, white-tailed deer, American woodcock, and red-tailed hawk. Ecological data quality levels (EDQLs) from USEPA Region 5 were also used, and these levels consider bioaccumulation for the meadow vole and masked shrew.

USEPA (2000c) recommends that aluminum should be identified as a COPEC for those sites with soil with a pH less than 5.5. The technical basis for this rationale is that soluble and toxic forms of aluminum are present in soil under soil pH values of less than 5.5. Of the 20 surface soil samples from SWMU 39, pH was measured at one location, and the pH was 4. However, aluminum is not considered by USEPA to be a significant bioaccumulator (USEPA, 2000c); therefore, aluminum was not selected as a COPEC for food chain exposure.

Dioxin-like compounds were treated according to procedures provided by USEPA and WHO (USEPA, 1989b, 1994a; WHO, 1998). Dioxin-like compounds (PCDDs and PCDFs) are present in the environmental media as complex mixtures. PCDDs and PCDFs consist of a family of approximately 75 and 135 congeners, respectively. To simplify the task of screening PCDDs/PCDFs for evaluation in this risk assessment, these compounds were evaluated with respect to a single member of this class of compounds. The concentration of each congener was evaluated on the basis of its concentration relative to that of 2,3,7,8-TCDD, which has been shown to be the most potent congener of the class of PCDDs/PCDFs. This procedure is described in the HHRA *(Section 6.1.1)*.

As there were just five surface soil samples analyzed for dioxins and furans, the 95% UCL statistic was not calculated, and the maximum TCDD TE (2.07E-5 mg/kg for sample 39SB05A) was used as the EPC for this SLERA. Even if one-half of the detection limit is used for non-detect congeners and B-qualified data are eliminated from consideration, the EPC for sample 39SB05A is still 2.07E-5 mg/kg, as non-detect results and B-qualified data are not an issue for this sample.

7.2.6 Summary of COPEC Selection

Tables 7-5 and 7-6 have been prepared for detected constituents in surface soil, with the following information:

- CAS number;
- Chemical name;
- Range of detected concentrations, and associated qualifiers;
- Concentration units;
- Location of maximum detected concentration;
- Frequency of detection;
- Range of detection limits;
- Concentration used for screening (i.e., maximum);
- Risk-based screening criterion, if available (BTAG screening values for direct contact exposure and values from **Table 7-7** for food chain exposure);
- COPEC selection conclusion: YES or NO; and,
- Rationale for selection or rejection of the COPEC.

Footnotes in the tables provide the rationale for selecting or rejecting a chemical as a COPEC. An evaluation of the constituents that were eliminated from further consideration was performed to assess whether constituents should be reinstated as COPECs due to other considerations. An example of an exception includes chemicals known to have been disposed on-site historically. Based on this evaluation, no additional COPECs are recommended.

Twenty COPECs (14 inorganic and six organic COPECs) have been selected for surface soil for direct contact exposure (**Table 7-5**). Chemicals not eliminated using the screening procedures previously presented are considered final direct contact COPECs and have been quantitatively evaluated in this SLERA for direct contact.

Twelve COPECs (10 inorganic and two organic COPECs) have been selected for surface soil for food chain exposure (**Table 7-6**). Chemicals not eliminated using the screening procedures previously presented are considered final food chain exposure COPECs and have been quantitatively evaluated in this SLERA. It should be noted that some COPECs were not selected if they are considered to be Not Important Bioaccumulative Constituents (NIBC), per Table 4.2 in *Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment – Status and Needs* (USEPA, 2000d).

Table 7-8 presents EPCs for these COPECs, based on the statistical procedures discussed in *Section 7.2.2*. Arithmetic mean concentrations are also presented for informational purposes.

7.3 Identification of Exposure Pathways and Potential Receptors for Analysis

Terrestrial wildlife at SWMU 39 may be exposed to COPECs by several pathways, including: (1) the ingestion of impacted soil or food while foraging: (2) dermal absorption of chemicals

from soil; and, (3) inhalation of chemicals that have been wind-eroded from soil or have volatilized from soil. Among these potential exposure pathways, the greatest potential for exposure to chemicals is likely to result from the ingestion of chemicals in food. The incidental ingestion of impacted soil (while foraging) is a less important exposure route. The ingestion of food and soil, however, are viable exposure pathways and were considered in this SLERA. As surface water and sediment are not associated with SWMU 39, exposures to these media were not included, nor are aquatic receptors identified for the site. Although **Appendix F-1, Photo F-5** shows some standing water at the site, the area of this standing water is very small (approximately 0.1 acre or less) and isolated. Standing water following rain events is expected to last only a few days, given the porosity of the soil (*Section 2.2*). The site is not expected to exhibit conditions that would support temporary breeding areas for amphibians. Receptor-specific exposures via inhalation or dermal absorption were not selected for further evaluation because of a lack of appropriate exposure data and the expectation that these pathways would be insignificant in comparison to the other exposure pathways quantified. Off-gassing of VOCs from soil or particulate concentrations in air from wind erosion are expected to result in toxicologically insignificant COPEC concentrations in ambient air, given the expected mixing and dilution that would occur. Dermal absorption is expected to be a minor exposure pathway, as fur or feathers are expected to function as a barrier to COPEC transport across the skin.

The appropriate assessment receptors have been selected for evaluation during the SLERA. In order to focus the exposure characterization portion of the SLERA on species or components that are the most likely to be affected, given the toxicological and mobility characteristics of the COPECs, and on those COPECs that, if affected, are most likely to produce greater effects in the on-site ecosystem, the SLERA has focused the selection process on species, groups of species, or functional groups, rather than higher organization levels such as communities or ecosystems. Site biota were organized into major functional groups. For terrestrial communities, the major groups are plants and wildlife, including terrestrial invertebrates, mammals, and birds. Species presence was assessed during a literature review and during the site reconnaissance (*Section 7.1*) prior to identification of target receptor species.

Primary criteria for selecting appropriate assessment receptors included, but were not limited to, the following:

- The assessment receptor will have a relatively high likelihood of contacting chemicals via direct or indirect exposure;
- The assessment receptor will exhibit marked sensitivity to the COPECs given their mode of toxicity, propensity to bioaccumulate, etc.;
- The assessment receptor will be a key component of ecosystem structure or function (e.g., importance in the food web, ecological relevance); and,
- The assessment receptor may be listed as rare, threatened, or endangered (RTE) by a governmental organization; or the receptor will consist of critical habitat for RTE species. Based on the availability of species-specific data, an RTE surrogate species may be selected.

Additional criteria for selection of assessment receptors were used to identify species that offer the most favorable combination of characteristics for determining the implications of on-site contaminants. These criteria included: (1) limited home range; (2) role in local nonhuman food

chains; (3) potential high abundance and wide distribution; (4) sufficient toxicological information available in the literature for comparative and interpretive purposes; (5) sensitivity to COPECs; (6) relatively high likelihood of occurrence on-site following remediation (if required); (7) suitability for long-term monitoring; (8) importance to the stability of the ecological food chain or biotic community of concern; and, (9) relatively high likelihood that they will be present or that habitats present could support the species.

It is important that sufficient toxicological information is available in the literature on the receptor species, or that a closely related species may be selected. While the ecological communities have species with many desirable characteristics for use as receptor species, not every species has been used extensively for toxicological testing.

7.3.1 Terrestrial Receptors

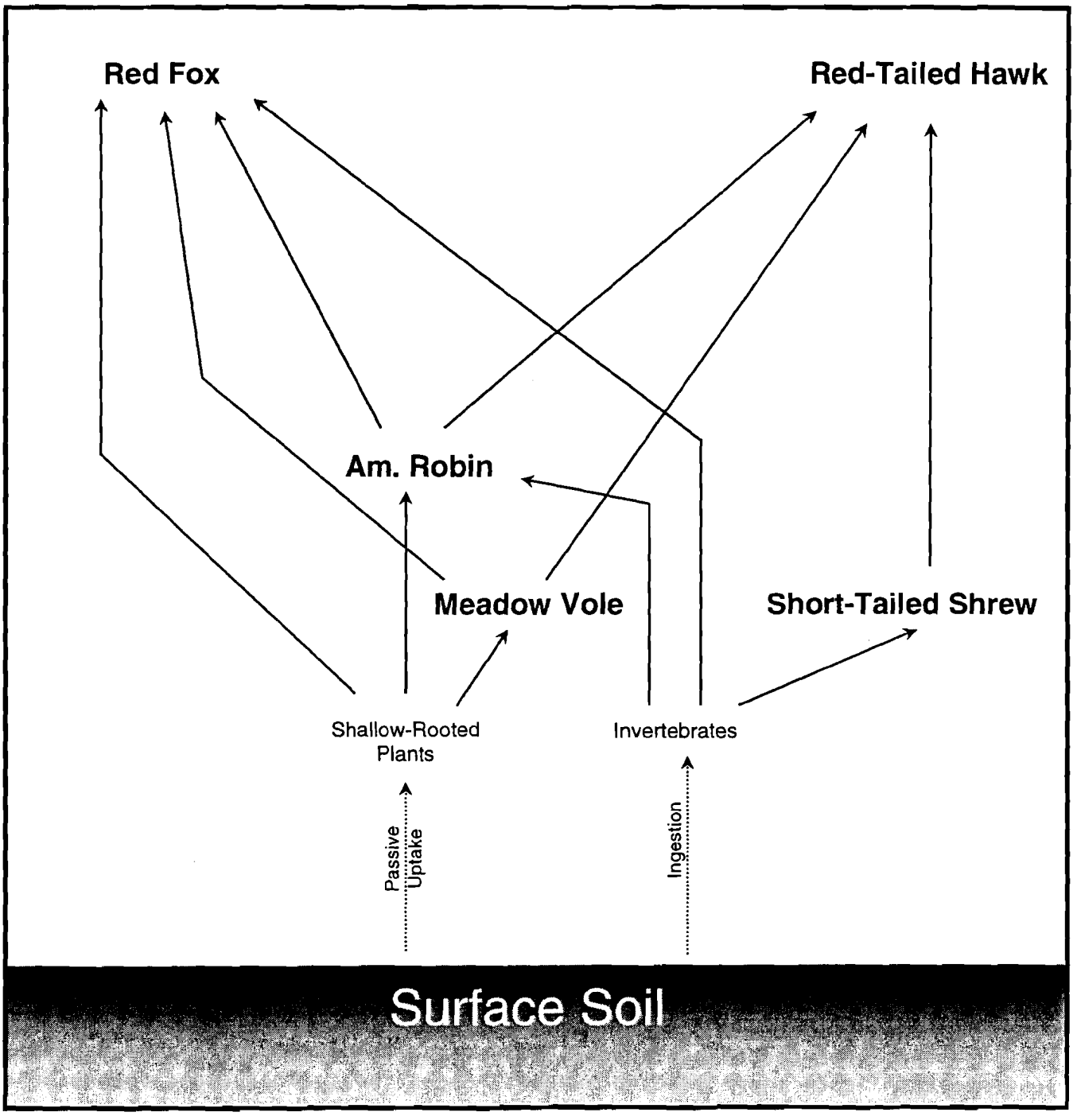
Five representative receptor species that are expected or possible in the area of SWMU 39 (*Section 7.1*) were selected as indicator species for the potential effects of COPECs. These indicator species represent two classes of vertebrate wildlife (mammals and birds) and a range of both body size and food habits, including herbivory, omnivory, and carnivory. Note: potential impacts to terrestrial plants were considered by documenting the presence or absence of vegetative stress at the site (*Section 7.1.4*). The five animal species selected include the meadow vole (*Microtus pennsylvanicus*) (small, herbivorous mammal), short-tailed shrew (*Blarina brevicauda*) (small, insectivorous mammal), American robin (*Turdus migratorius*) (small omnivorous bird), red-tailed hawk (*Buteo jamaicensis*) (large, carnivorous bird), and red fox (*Vulpes vulpes*) (medium, carnivorous mammal). Data used to model exposure for these species are summarized in **Appendix F-2, Table F-1**.

The meadow vole, shrew, and robin represent the prey base for the larger predators of the area (represented by the red-tailed hawk and the red fox). A terrestrial food web is presented in **Figure 7-1**. Many of these species have limited home ranges, particularly the meadow vole, shrew, and American robin, which make them particularly vulnerable to exposure from site constituents. The selected terrestrial receptor species have a potential high abundance and wide distribution at the site; also, sufficient toxicological information (with the exception of some bird species) is available in the literature for comparative and interpretive purposes. These species are considered important to the stability of the local ecological food chain and biotic community. Finally, the selected species have readily-available exposure data, as summarized in the Wildlife Exposure Factors Handbook (USEPA, 1993).

Larger mammal species were generally not selected as sensitive receptors due to their large home ranges; however, the far-ranging red-tailed hawk and red fox were retained due to their unique role as top predators in the food chain. Smaller birds, except for the robin, were generally not included because most are migratory. The potential risk to species with larger home ranges and migratory avian species are generally included within the predicted risks to the selected terrestrial indicator receptors. Receptor profiles for these five selected species are presented in the following five sections.

Meadow Vole. The meadow vole inhabits grassy areas (upland and wetland) and obtains a significant portion of its herbivorous diet from the site. The vole resides in every area of the United States and Canada where there is good grass cover, ranges in size from about 9 to 13 centimeters in length, and weighs between 17 and 52 grams (USEPA, 1993). It is likely to have a relatively high rate of incidental soil ingestion given that it is sometimes coprophagous

Figure 7-1
Simplified Terrestrial Food Web
Conceptual Site Exposure Model (CSEM)



(consumes its own feces for secondary nutrient adsorption) and builds runways and burrows in the soil. The meadow vole has a limited foraging range, increasing its potential to be exposed (directly or indirectly) to COPECs in on-site surface soil. The vole has an average home range of 0.09 acres, with summer ranges larger than winter ranges. The vole does not hibernate and is active year-round. Population densities can range up to several hundred per hectare (USEPA, 1993).

Short-Tailed Shrew. The short-tailed shrew is an insectivore that feeds largely on soil invertebrates. It would be potentially exposed to COPECs through prey items and have a relatively high rate of incidental ingestion of soil while foraging on earthworms. This short-tailed shrew is the largest shrew found in North America. It is solid gray above and below, with a short tail, and weighs between 15 and 29 grams (Whitaker, 1995). Total length of this shrew is 76 to 102 millimeters (Burt and Grossenheider, 1980). The range of this shrew extends from southeastern Canada and the northeastern U.S. to Nebraska, Missouri, Kentucky, and in the mountains to Alabama (Whitaker, 1995). Preferable habitat for the shrew includes forests, grasslands, marshes, and brushy areas. It will make a nest of dry leaves, grass, and hair beneath logs, stumps, rocks, or debris (Burt and Grossenheider, 1980). This mammal has a voracious appetite, and will consume earthworms, other terrestrial invertebrates, and sometimes young mice (Whitaker, 1995). Mean population densities range from 5.7, in the winter, to 28 per acre in the summer (USEPA, 1993). Their home range varies from 0.5 to 1 acre (Burt and Grossenheider, 1980) and an average value of 0.96 acres has been used in this SLERA (**Appendix F-2, Table F-1**). Longevity is typically around 20 months (USEPA, 1993), with 5 to 8 young born to each of 2 to 3 litters (Burt and Grossenheider, 1980).

American Robin. The American robin is an omnivore that feeds on both plants (primarily fruit) and terrestrial invertebrates including earthworms. The robin occurs throughout most of the continental United States and Canada during the breeding season and winters in the southern half of the United States and Mexico and Central America. They live in a variety of habitats, including woodlands, wetlands, suburbs and parks. Robins are likely to forage throughout RFAAP and are present year-round. Most robins build nests of mud and vegetation on the ground or in the crotches of trees or shrubs. Robins forage primarily on the ground and in low vegetation by probing and gleaning. They are approximately 25 centimeters in size, have a body weight range of 63 to 103 grams, and an average home range of 1.2 acres (USEPA, 1993). The average longevity of a robin that survives to its first January is from 1.3 to 1.4 years (USEPA, 1993).

Red-Tailed Hawk. The red-tailed hawk is a common predator in the mixed landscapes typifying RFAAP. The wooded habitats and riverside trees within RFAAP are considered ideal foraging and nesting habitats for these raptors. This hawk is one of the most common and widespread members of the genus *Buteo* in the continental United States and Canada (Brown and Amadon, 1968). Red-tailed hawks live in a variety of habitats, such as farmlands, woodlands, mountains, and deserts, as long as there is open country interspersed with woods, bluffs, or streamside trees. They are primarily carnivorous, feeding on small rodents, as well as fish. Other prey items include amphibians, reptiles, crayfish, and other birds (Adamcik et al., 1979; Ehrlich et al., 1988). Home range has been reported as small as 66.8 acres, with a population density of 0.16 pairs per acre (Janes, 1984), although USEPA (1993) reports an average territory size of 2,081 acres. Breeding population density is one nest per 0.009 acre or one individual per 0.004 acre. Body weight for male red-tails is 1,028.6 to 1,142.9 grams, and for females 1,371.4

to 1,600 grams (Brown and Amadon, 1968), although USEPA (1993) reports an average body weight of 1,134 grams. More northerly populations are migratory, while the more southerly are year-round residents. They typically mate for life or until one of the pair dies, with pairs clinging to territories year after year (Austing, 1964).

Red Fox. The red fox is a carnivorous predator that occurs in a wide range of habitats typical of RFAAP. Red fox use many types of habitat, including cropland, rolling farmland, brush, pastures, hardwood stands, and coniferous forests. They are present throughout the United States and Canada, and are the most widely distributed carnivore in the world. These foxes have a length of 56 to 63 centimeters, with a 35 to 41 centimeter tail and an average weight of 4,530 grams. They do not undergo hibernation, and most often occupy abandoned burrows or dens of other species.

One fox family per 100 to 1,000 hectares is typical, and the average home range is 892 hectares (2,204 acres) (USEPA, 1993). Red fox incur high mortality rates as a result of shooting, trapping, disease, and accidents. Fecundity is higher in areas of high mortality and low population density.

A pictorial representation of potential exposure has been prepared and is presented as **Figure 7-1**. This food web pictorial clarifies the conceptual site exposure model (CSEM). The CSEM traces the contaminant pathways through both abiotic components and biotic food web components of the environment. The CSEM presents potentially complete exposure pathways. The CSEM has been used as a tool for judging the appropriateness and usefulness of the selected measurement endpoints in evaluating the assessment endpoints, and for identifying sources of uncertainty in the exposure characterization.

7.4 Identification of Assessment and Measurement Endpoints

The protection of ecological resources, such as habitats and species of plants and animals, is a principal motivation for conducting the SLERA. Key aspects of ecological protection are presented as policy goals. These are general goals established by legislation or agency policy that are based on societal concern for the protection of certain environmental resources. For example, environmental protection is mandated by a variety of legislation and government agency policies (e.g., CERCLA, National Environmental Policy Act). Other legislation includes the Endangered Species Act 16 U.S.C. 1531-1544 (1993, as amended) and the Migratory Bird Treaty Act 16 U.S.C. 703-711 (1993, as amended). To assess whether these protection goals are met at the site, assessment and measurement endpoints have been formulated to define the specific ecological values to be protected and to define the degree to which each may be protected.

Unlike the human health risk assessment process, which focuses on individual receptors, the SLERA focuses on populations or groups of interbreeding nonhuman, nondomesticated receptors. In the SLERA process, the risks to individuals are generally assessed if they are protected under the Endangered Species Act.

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. Suggested criteria that may be considered in selecting assessment endpoints suitable for a specific ecological risk assessment are:

1. ecological relevance;

2. susceptibility to the contaminant(s);
3. accessibility to prediction and/or measurement; and,
4. definable in clear, operational terms (Suter, 1993).

Selected assessment endpoints should reflect environmental values that are protected by law, are critical resources, or have relevance to ecological functions that may be impaired. Both the entity and attribute are identified for each assessment endpoint.

Assessment endpoints are inferred from effects to one or more measurement endpoints. The measurement endpoint is a measurable response to a stressor that is related to the valued attribute of the chosen assessment endpoint. It serves as a surrogate attribute of the ecological entity of interest (or of a closely related ecological entity) that can be used to draw a predictive conclusion about the potential for effects to the assessment endpoint. Information gained during the site reconnaissance was used to assist in the selection of assessment and measurement endpoints. These endpoints, formal expressions of the environmental values to be protected (Suter, 1993), have been used to focus the goals of the SLERA.

Measurement endpoints for this SLERA are based on toxicity values from the available literature. When possible, receptors and endpoints have been concurrently selected by identifying those that are known to be adversely affected by chemicals at the site based on published literature. COPECs for those receptors and endpoints have been identified by drawing on the scientific literature to obtain information regarding potential toxic effects of site chemicals to site species. This process ensures that a conservative approach is taken in selecting endpoints and evaluating receptors that are likely to be adversely affected by the potentially most toxic chemicals at SWMU 39.

7.4.1 Assessment Endpoints

ERAGS (USEPA, 1997c) states: "For the screening-level ecological risk assessment, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments. Adverse effects on populations can be inferred from measures related to impaired reproduction, growth, and survival. Adverse effects on communities can be inferred from changes in community structure or function. Adverse effects on habitats can be inferred from changes in composition and characteristics that reduce the habitats' ability to support plant and animal populations and communities."

The assessment endpoints for SWMU 39 are stated as the protection of long-term survival and reproductive capabilities for populations of herbivorous, insectivorous, and carnivorous mammals, and omnivorous and carnivorous birds. The corresponding H_0 for each of the assessment endpoints is stated as: the presence of site contaminants within soil, vegetation, and prey will have no adverse effect on the survival or reproductive capabilities of populations of herbivorous, insectivorous, and carnivorous mammals, and omnivorous and carnivorous birds.

Assessment receptor species were selected based on the likelihood of finding the species at SWMU 39. Historical information, the site reconnaissance, and the availability of toxicological data were used to select terrestrial receptor species. These receptor species are depicted in the food web model (**Figure 7-1**). Food web models are simplified versions of the possible movement of present or potentially present contaminants through the food chain. Due to lack of

data for every possible species, key species have been selected to represent broad classes, or guilds.

The food web CSEM was developed to illustrate how the selected terrestrial species are ecologically linked within food webs. One species was used to represent each of the major trophic levels and habitats. The decision was made not to complicate the food web models with detailed species selection at the base of the food web (i.e. specific terrestrial invertebrates). Thus, generic terrestrial invertebrates were used to represent the bottom of the food chain. For terrestrial invertebrates and plants, partitioning coefficients and simple empirical uptake models were employed to estimate COPEC concentrations within tissues *(Section 7.5)*. These tissue concentrations were then used as input values for exposure to higher trophic level receptors through the dietary route of exposure. Brief life-history descriptions for the selected receptor species are provided in *Section 7.3.1*.

Trophic levels may be exposed to COPECs, either by direct exposure to contaminated abiotic media or through ingestion of lower trophic level food items. Primary producers (plants) absorb COPECs (as well as nutrients) from soil and/or water. In terrestrial species bioconcentration occurs in plants and invertebrates, and higher food chain receptors bioaccumulate COPECs through the ingestion of food items.

7.4.2 Measurement Endpoints

Measurement endpoints are frequently numerical expressions of observations (e.g. toxicity test results or community diversity indices) that can be compared statistically to detect adverse responses to a site contaminant. Examples of typical measurement endpoints include mortality, growth or reproduction in toxicity tests; individual abundance; species diversity; and the presence or absence of indicator data in field surveys of existing impacts (USEPA, 1997c).

For assessments, measurable responses to stressors may include LOAELs, NOAELs, LC50s (lethal concentration to 50 percent of the test population), LD50s (lethal dose to 50 percent of the test population), collectively termed toxicity endpoint values (see *Section 7.5* for further explanation). The most appropriate measurement endpoint(s) were chosen based on exposure pathways as well as the ecotoxicity of the contaminant.

As two of the selected receptor species (the American robin and the short-tailed shrew) feed on terrestrial invertebrates, a reduction in the abundance of these invertebrates could result in an adverse impact due to food shortages. Therefore, the direct contact toxicity of COPECs to soil invertebrates was selected as a measurement endpoint for protection of long-term survival and reproductive capabilities for populations of insectivorous mammals and omnivorous birds.

7.5 Exposure Estimation

This section includes a discussion of how COPEC exposures were quantified, including intake (*Section 7.5.1*) and bioaccumulation (*Section 7.5.2*).

An estimate of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the site was developed, considering both current and reasonably plausible future use scenarios. Exposure characterization is critical in further evaluating the risk of compounds identified as COPECs during the selection process (*Section 7.2*). The exposure assessment was conducted by linking the magnitude (concentration) and distribution (locations) of the constituents detected in the media sampled during the investigation, evaluating pathways by which chemicals may be transported through the

environment, and identifying the points at which organisms found in the study area may contact contaminants.

An exposure analysis was performed, which combines the spatial and temporal distribution of the ecological receptors with those of the COPEC to evaluate exposure. The exposure analysis focuses on the chemical amounts that are assumed to be bioavailable, and the means by which the ecological receptors are exposed (e.g., exposure pathways). The focus of the analysis is dependent on the assessment receptors being evaluated as well as the assessment and measurement endpoints.

Ecological routes of exposure for biota may be direct (bioconcentration) or through the food web via the consumption of contaminated organisms (bioaccumulation). Food web exposure can occur when terrestrial (or aquatic) fauna consume contaminated biota. Examples of food web exposure include animals at higher trophic levels consuming plants or animals that bioaccumulate contaminants. Direct exposure routes include dermal contact, absorption, inhalation, and ingestion. Examples of direct exposure include animals incidentally ingesting contaminated soil (or sediment); animals ingesting surface water; plants absorbing contaminants by uptake from contaminated soil (or sediment); and the dermal contact of aquatic organisms with contaminated surface water or sediment. As discussed previously, no surface water or sediment was present within the drainage ditches, and exposure to these media are not considered. In addition, as discussed in *Section 7.3*, dermal contact and inhalation exposures are considered insignificant compared to other quantified routes of exposure.

Contamination of biota could result from exposure to one or more COPECs. Bioavailability is an important contaminant characteristic that influences the degree of chemical-receptor interaction. Bioavailable compounds are those that a receptor can take in from the environment. Bioavailability of a chemical is a function of several physical and chemical factors such as grain size and organic carbon content. Environmental conditions such as soil moisture, soil pH, and cation exchange capacities significantly influence whether potential soil contaminants remain chemically bound in the soil matrix or whether they can be chemically mobilized (in a bioavailable form) and released for plant absorption. Generally, neutral to alkaline soil (soil pH of 6.5 or greater) restrict the absorption of toxic metals, making pathway completion to plants difficult. As discussed in *Section 7.2*, the pH in surface soil at SWMU 39 is 4 (based on one sample). For purposes of this SLERA, bioavailability is conservatively assumed to be 100 percent.

Exposure pathways consist of four primary components: source and mechanism of contaminant release, transport medium, potential receptors, and exposure route. A chemical may also be transferred between several intermediate media before reaching the potential receptor. These components have been addressed within this SLERA. If these components are not complete, then contaminants in those media do not constitute an environmental risk at that specific site. The major fate and transport properties associated with typical site contaminants directly affect a contaminant's behavior in each of the exposure pathway components.

For terrestrial faunal receptors, calculation of exposure rates relies upon determination of an organism's exposure to COPECs found in surface soil, and on transfer factors used for food-chain exposure. Exposure rates for terrestrial wildlife receptors in this SLERA are based exclusively upon ingestion of contaminants from these media and from consumption of other organisms.

7.5.1 Intake

The first step in estimating exposure rates for terrestrial wildlife involves the calculation of food ingestion (and drinking water intake) rates for site receptors. USEPA (1993) includes a variety of exposure information for a number of avian and mammalian species. Information regarding feeding (and watering) rates, and dietary composition are available for many species, or may be estimated using allometric equations (Nagy, 1987). Data have also been gathered on incidental ingestion of soil, and are incorporated for the receptor species. This information is summarized in **Appendix F-2, Table F-1**. For this SLERA, conservative Tier 1 exposures are based on maximum dietary intake, maximum incidental soil intake, minimum body weight, 100 percent site exposure [i.e., area use factor (AUF) set equal to unity], and the use of COPEC MDCs as EPCs. Less conservative Tier 2 exposures are based on average dietary and incidental soil intake, average body weight, calculated AUF based on site area and home range of the receptor species, and COPEC EPCs set equal to 95% UCLs.

Algorithms have been evaluated for calculating exposure for terrestrial vertebrates that account for exposure via ingestion of contaminated water, incidental ingestion of contaminated soil, ingestion of plants grown in contaminated soil, and prey items. Singular algorithms have been developed for soil to plant uptake and for animal bioaccumulation (transfer factors).

The basic equation for estimating dose through the dietary pathway is:

$$D_p = \sum_{k=1}^{m} (C_k \times F_k \times I_k) / W$$

where:

D_p = the potential average daily dose (mg/kg-day),
C_k = the average COPEC concentration in the k^{th} food type (mg/kg dry weight)
F_k = the fraction of the k^{th} food type that is contaminated
I_k = the ingestion rate of the k^{th} food type (kg dry weight/day)
W = the body weight of the receptor (kg wet weight).

Literature values for animal-specific sediment ingestion have been used if available. However, such values generally are not available in the literature.

7.5.2 Bioaccumulation and Bioconcentration Factors

For the current SLERA, bioaccumulation factors (BAFs) and bioconcentration factors (BCFs) for soil-to-plants, soil-to-earthworms, and soil-to-small mammals and birds are presented in **Appendix F-2, Tables F-2, F-3, and F-4**, respectively. BAFs and/or BCFs were not available for every COPEC, but were estimated as described in the footnotes to these tables. For each BAF/BCF pathway, both a Tier 1 and Tier 2 value is presented, as recommended in the Site Screening Process (USEPA, 2001c) and the RFAAP Final MWP (URS, 2003). The Tier 1 BAF/BCF is the maximum value found in the literature, to represent a worst-case exposure scenario, while the Tier 2 BAF/BCF represents a conservative, yet more realistic exposure value.

Soil-to-plant BAF/BCF values (**Appendix F-2, Table F-2**) are based on information from USEPA (2000c), Efroymson et al. (2001), Baes et al. (1984), and IAEA (1994). Tier 2 values are based on regression equations, if available, that produce a BAF/BCF value that scales in a non-linear fashion with soil COPEC concentration. If a regression equation is not available, or

not recommended for a particular COPEC, an upper-bound or median value is used. It should be noted that as the regression equation predicts COPEC concentrations in plants, the actual BAF/BCF value is estimated by dividing the estimated plant COPEC concentration by the soil COPEC concentration.

Soil-to-earthworm BAF/BCF values (**Appendix F-2, Table F-3**) are based on information from Sample et al. (1998a), Sample et al. (1999), USEPA (2000c), and Beyer (1990). Earthworms are used as a surrogate species to represent terrestrial invertebrates including insects. Tier 2 values are based on regression equations, if available, that produce a BAF/BCF value that scales in a non-linear fashion with soil COPEC concentration. If a regression equation is not available, or not recommended for a particular COPEC, an upper-bound or mean value is used. It should be noted that as the regression equation predicts COPEC concentrations in earthworms, the actual BAF/BCF value is estimated by dividing the earthworm COPEC concentration by the soil COPEC concentration.

For the organic COPECs at SWMU 39 (2,3,7,8-TCDD TE and endrin ketone) the following equation from USEPA (2000c) was used to estimate the BAF/BCF, along with the COPEC-specific K_{ow} and site-specific fraction of organic carbon information:

$$BAF/BCF = \frac{10^{(\log Kow - 0.6)}}{Foc \times 10^{(0.983 \times \log Kow + 0.00028)}}$$

where:

$\text{Log } K_{ow}$ = log octanol-water partition coefficient (see **Appendix F-2, Table F-3**),
F_{oc} = fraction of organic carbon (0.0046 for SWMU 39).

Soil-to-small mammal and small bird BAF/BCF values (**Appendix F-2, Table F-4**) are based on information from Sample et al. (1998b). Tier 2 values are based on available 90th percentile BAF/BCF values. Conservative values for endrin ketone were estimated to be 1 and 0.5 (for Tier 1 and Tier 2, respectively), and the values for 2,3,7,8-TCDD TE were estimated to be 2.2 (for both Tier 1 and 2) based on a review of data from Sample et al. (1998b).

The estimated chemical intakes for each exposed receptor group under each exposure pathway and scenario are presented in the risk characterization spreadsheets in **Appendix F-2, Tables F-8 through F-17**. These intake estimates are combined with the COPEC toxicity values, discussed in the following section, to characterize potential ecological risk. The uncertainties associated with the estimation of chemical intake are discussed in *Section 7.8*.

For direct contact exposure for soil invertebrates to COPECs in surface soil, measured COPEC concentrations were simply compared with direct contact benchmarks appropriate for the soil invertebrate community.

7.6 Ecological Effects Characterization

The ecological effects characterization includes the selection of literature benchmark values and the development of toxicity reference values (TRVs).

7.6.1 Selection of Literature Benchmark Values

Appropriate sources for literature benchmark values have been consulted, such as (1) Toxicological Benchmarks for Wildlife (Sample et al., 1996); Development of Toxicity

Reference Values for Conducting Ecological Risk Assessments at Naval Facilities in California (Engineering Field Activity, West, 1998); Review of the Navy - USEPA Region IX BTAG Toxicity Reference Values for Wildlife (CH2M-Hill, 2000); and, (2) LD50 values from data bases such as the Registry of Toxic Effects Concentrations (RTEC) (extrapolated to chronic NOAEL or LOAEL values using recommended Tri-Service [Wentsel et al., 1996] uncertainty factors). The level of effort has been limited to documents that summarize the available ecotoxicological information and does not consist of a review of the primary toxicological literature (i.e., details of toxicity test conditions were not reviewed to assess validity of the tests performed).

7.6.2 Development of Toxicity Reference Values

TRVs were selected from available data for the SWMU 39 study area. These TRVs focus on the growth, survival, and reproduction of species and/or populations. Empirical data are available for the specific receptor-endpoint combinations in some instances. However, for some COPECs, data on surrogate species and/or on endpoints other than the NOAEL and LOAEL had to be used. The NOAEL is a dose of each COPEC that will produce no known adverse effects in the test species. The NOAEL was judged to be an appropriate toxicological endpoint for the Tier 1 approach since it would provide the greatest degree of protection to the receptor species; however, both NOAELs and LOAELs are used for informational purposes in the Tier. Both the NOAEL and the LOAEL were also used in the Tier 2 approach; however, the LOAEL is recommended as a point of comparison for decision-making for risk management purposes. In general, LOAELs for growth, reproduction and/or developmental endpoints are thought to be protective at the population level of biological organization. In addition, in instances where data are unavailable for a site-associated COPEC, toxicological information for surrogate chemicals had to be used. Safety factors are used to adjust for these differences and extrapolate risks to the site's receptors at the NOAEL and/or LOAEL endpoint. This process is described in the following paragraphs.

Toxicity information pertinent to identified receptors has been gathered for those analytes identified as COPECs. Because the measurement endpoint ranges from the NOAEL to the LOAEL, preference was given to chronic studies noting concentrations at which no adverse effects were observed and ones for which the lowest concentrations associated with adverse effects were observed. As previously noted, where data are unavailable for the exposure of a receptor to a COPEC, data for a surrogate chemical have been gathered for use in the SLERA.

Using the relevant toxicity information, TRVs have been calculated for each of the COPECs. TRVs represent NOAELs and LOAELs with safety factors incorporated for toxicity information derived from studies other than no-effects or lowest-effects studies.

TRVs have been calculated from LD_{50} values, when required, using safety factors specified in Ford et al. (1992) and reported in Wentsel et al. (1996) and summarized in the footnotes to **Appendix F-2, Tables F-5 and F-6** for NOAEL and LOAEL TRVs, respectively. Interclass toxicity extrapolations were not performed as physiological differences between classes are too great to be addressed with the use of simplistic safety factors. Separate uncertainty factors are used to account for extrapolation to the no effects or lowest-effects endpoints, for study duration, and for extrapolation across taxonomic groups (e.g., species, genus, family, order), as shown in **Appendix F-2, Table F-7** for the receptors used in this SLERA. Although additional safety

factors may be employed for endangered species, no endangered species were selected as representative receptors and these additional safety factors were not required.

These factors were used together to derive a final adjusted TRV, as shown in the risk characterization spreadsheets referenced in *Section 7.7*. Toxicity reference threshold value uncertainties are discussed in *Section 7.8*.

Exposure TRVs provide a reference point for the comparison of toxicological effects upon exposure to a contaminant. To complete this comparison, receptor exposures to site contaminants are calculated (*Section 7.5*).

To assess direct contact exposure for terrestrial invertebrates, the following three sources were evaluated and used as appropriate:

- BTAG screening values for fauna (USEPA, 1995d);
- Screening toxicity values for earthworms from Oak Ridge National Laboratory (ORNL) (1997); and,
- Screening toxicity values for earthworms from Los Alamos National Laboratory (LANL) (2002).

7.7 Risk Characterization

The risk characterization phase integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is a determination of the likelihood, severity, and characteristics of adverse effects to environmental stressors present at a site. Qualitative and semiquantitative approaches have been taken to estimate the likelihood of adverse effects occurring as a result of exposure of the selected site receptors to COPECs.

For this assessment, TRVs and exposure rates have been calculated and are used to generate HQs (Wentsel et al., 1996), by dividing the receptor exposure rate for each contaminant by the calculated TRV. Environmental effects quotients (EEQs) or HQs are a means of estimating the potential for adverse effects to organisms at a contaminated site, and for assessing the potential that toxicological effects will occur among site receptors.

7.7.1 Terrestrial Plant Impact Assessment

To assess the potential impact of COPEC concentrations in surface soil on terrestrial plant species, visual observations were recorded during the site reconnaissance *(Section 7.1.4)*. Plants were not quantitatively evaluated in this SLERA as the RFAAP Final MWP (URS, 2003) states: "Owing to the invasive and successive nature of plant communities, plants as receptors do not typically warrant a detailed examination of effects." In addition, because of an inadequate plant toxicity database, and because of the disturbed nature of the site, risks to plants are not quantitatively evaluated; however, plants (and invertebrates) are included in the SLERA as media through which the wildlife receptors may be exposed indirectly to COPECs in the soil by means of the food chain.

Vegetation growth is limited in the pond basins, and a dead tree that had been growing near the edge of the north pond was observed (**Appendix F-1, Photo F-8**). The ponds have been inactive for approximately 10 years, and there is little evidence of revegetation. It is possible that chemicals in the soil inhibit the establishment and growth of vegetation in the pond basins. The

average lead concentration in surface soil is 1,520 mg/kg (**Table 7-8**), which is considerably above the phytotoxicity benchmark of 50 mg/kg (Efroymson et al., 1997).

7.7.2 Predictive Risk Estimation for Terrestrial Wildlife

The risk associated with SWMU 39 has been estimated. The risk estimation has been performed through a series of quantitative HQ calculations that compare receptor-specific exposure values with TRVs. The EEQs (or HQs) are compared to HQ guidelines for assessing the risk posed from contaminants. It should be noted that HQs are not measures of risk, are not population-based statistics, and are not linearly-scaled statistics, and therefore an HQ above 1, even exceedingly so, does not guarantee that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Tannenbaum, 2001, 2003; Bartell, 1996).

The simple HQ ratios have been summed to provide conservative HI estimates for chemicals and exposure pathways for a given receptor. HQ summation is appropriate and scientifically defensible for a given receptor if HQs for those chemicals that have a similar mode of toxicological action. While individual contaminants may affect distinct target organs or systems within an organism, classes of chemicals may act in similar ways, thus being additive in effect. The summation of HQs into an HI was performed in this SLERA as a conservative approach. To assess whether or not individual COPEC HQs should be segregated based on dissimilar modes of toxicological action, individual COPEC effects were evaluated. However, as risk drivers resulted in HQs greater than approximately 10 to 1,000,000 (see following paragraphs), segregation of COPECs by mode of toxicological action was not necessary.

Tier 1 and Tier 2 individual COPEC EEQs and HIs (summed EEQs) for terrestrial receptors at SWMU 39 are presented in risk characterization tables (**Appendix F-2, Tables F-8 through F-17**) for the five selected receptor species. These summed EEQs are presented in **Table 7-9** (rounded to two significant figures), along with the hazard driver (the COPEC(s) contributing the majority of the total estimated EEQ) and the exposure pathway of concern (the pathway contributing the most to the total estimated EEQ).
As shown in **Table 7-9**, Tier 1 total EEQs were considerably greater than 100 for the five receptor species, using TRVs based on either NOAEL or LOAEL values. The American robin was predicted to be the most impacted, followed by the short-tailed shrew, the meadow vole, red fox, and red-tailed hawk. Lead was the COPEC contributing the most to the total EEQs for each of the receptors. Exposure pathways of most concern, based on the results of the food-chain modeling, were plant, earthworm, and small mammal ingestion.

More realistic Tier 2 total EEQs were also elevated, especially those based on NOAEL TRVs. The Tier 2 total EEQs were much lower than the Tier 1 total EEQs however, and both the NOAEL and LOAEL Tier 2 total EEQs for the red-tailed hawk and red fox were below one. Tier 2 total EEQs based on LOAEL values were 190 for the American robin, 870 for the short-tailed shrew, and 8.1 for the meadow vole (**Table 7-9**). Lead was identified as a hazard driver for each of the wildlife receptors, while copper, thallium, and TCDD TE were also identified as major contributors for some of the receptors. Exposure pathways of most concern, based on the results of the food-chain modeling, were earthworm and incidental soil ingestion.

The specific results of the Tier 2 risk estimation for the meadow vole, short-tailed shrew, and American robin are discussed below. The specific results for the red-tailed hawk and red fox are not discussed because the summed EEQs are below one (with the exception of iron, which does

Table 7-9
Wildlife EEQ Hazard Summary for Food Chain Exposure

Receptor	Tier 1[a]		Tier 2[b]	
	NOAEL-Based EEQ	LOAEL-Based EEQ	NOAEL-Based EEQ	LOAEL-Based EEQ
Meadow vole	56,000	7,000	57	8.1
Hazard Driver(s)[c]:	Pb (plant ingestion)		Pb, Cu, Tl (soil ingestion)	
Short-tailed shrew	930,000	93,000	8,500	870
Hazard Driver(s)[c]:	Pb (earthworm ingestion)		TCDD TE, Tl, Pb (earthworm, soil ingestion)	
American robin	1,000,000	100,000	1,600	190
Hazard Driver(s)[c]:	Pb (earthworm, plant ingestion)		Pb, Cr (earthworm, soil ingestion)	
Red-tailed hawk	6,300	640	0.53	0.055
Hazard Driver(s)[c]:	Pb (mammal ingestion)			
Red fox	26,000	2,700	0.32	0.036
Hazard Driver(s)[c]:	Pb (earthworm ingestion)			

[a] Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
[b] Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR less than or equal to 1.
[c] Hazard drivers are those chemicals contributing the most to the total estimated EEQ, and the primary route of exposure associated with this driver.

Notes:
EEQ = Ecological Effects Quotient.
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
FHR = Fraction home range
BW = body weight.
BAF/BCF = Bioaccumulation Factor/Bioconcentration Factor.
EPC = exposure point concentration.

not have a screening value). Therefore the COPECs represent no probable risk to these two receptors.

Meadow Vole. The total EEQs for both NOAEL and LOAEL TRVs exceeded one (57 and 8.1 respectively). Four COPECs had individual EEQs that exceeded NOAELs: copper (EEQ = 2.3), lead (EEQ = 39), selenium (EEQ = 1.4), and thallium (EEQ = 13). Three of these COPECs had individual EEQs that exceeded LOAELs: copper (EEQ = 1.8), lead (EEQ = 3.9), and thallium (EEQ = 1.3). The primary exposure pathways were the incidental ingestion of soil and ingestion of plants. The results of the Tier 2 risk evaluation for meadow voles are presented in **Appendix F-2, Table F-9**.

Short-tailed Shrew. The total EEQs for both NOAEL and LOAEL TRVs exceeded one (8,500 and 870 respectively). Of the twelve COPECs, eleven had individual EEQs that exceeded NOAELs; the chromium EEQ was less than one, and iron does not have a NOAEL (see **Appendix F-2, Table F-11** for individual EEQs). Eight COPECs had individual EEQs that exceeded LOAELs: TCDD TE (EEQ = 470), cobalt (EEQ = 3.8), copper (EEQ = 6.6), lead (EEQ = 120), nickel (EEQ = 4.6), selenium (EEQ = 6.9), thallium (EEQ = 250), and zinc (EEQ = 4.1).

The primary exposure pathways were the ingestion of earthworms and, for lead, the incidental ingestion of soil. The results of the Tier 2 risk evaluation for short-tailed shrew are presented in **Appendix F-2, Table F-11**.

American Robin. The total EEQs for both NOAEL and LOAEL TRVs exceeded one (1,600 and 190 respectively). Of the twelve COPECs, eleven had individual EEQs that exceeded NOAELs; the endrin ketone EEQ was less than one, and iron does not have a NOAEL (see **Appendix F-2, Table F-13** for individual EEQs). Nine COPECs had individual EEQs that exceeded LOAELs: 2,3,7,8-TCDD TE (EEQ = 15), chromium (EEQ = 43), cobalt (EEQ = 1.6), copper (EEQ = 1.1), lead (EEQ = 110), nickel (EEQ = 1.5), selenium (EEQ = 1.7), thallium (EEQ = 6.6), and zinc (EEQ = 5.5). The primary exposure pathways were the ingestion of earthworms and, for lead, the incidental ingestion of soil. The results of the Tier 2 risk evaluation for American robins are presented in **Appendix F-2, Table F-13**.

A potential reduction in wildlife food supply was evaluated using a direct contact toxicity evaluation for soil invertebrates (such as earthworms) exposed to COPECs in surface soil. The 20 COPECs identified from the direct contact exposure screen (**Table 7-5**) were evaluated for potential toxicity to the terrestrial soil invertebrate community. BTAG screening values for faunal toxicity were used, as well as earthworm toxicity benchmarks from ORNL and LANL (**Table 7-10**). The lowest relevant screening value was selected from the available screening values, as discussed in the footnotes to **Table 7-10**. Maximum detected concentrations were used to estimate a Tier 1 EEQ, and EPCs more appropriate for invertebrate populations (e.g., the 95% UCL concentration) were used to estimate a Tier 2 EEQ. Tier 1 EEQs ranged from 0.19 to 238, with chromium having the lone EEQ above 33. If chromium is assumed to be in the trivalent form, and not hexavalent, the chromium EEQ drops from 238 to 3.0 (**Table 7-10**). Tier 2 EEQs ranged 0.12 to 117, with chromium having the lone EEQ above 25. If chromium is assumed to be in the trivalent form, and not hexavalent, the chromium EEQ drops from 117 to 1.5 (**Table 7-10**). Based on the Tier 2 EEQ results, and assuming chromium is in the trivalent form (based on site-specific information), lead (HQ = 26), copper (HQ = 2.4), and chromium (HQ = 1.5) are the direct contact COPECs in soil that are estimated to have a potential adverse impact on the terrestrial invertebrate community, and therefore could potentially reduce the food supply for higher trophic level wildlife such as the American robin, and short-tailed shrew.

7.7.3 Background Metals Considerations

A background evaluation was conducted on the surface soil analytical results to assess whether inorganic COPEC drivers discussed in the previous section were potentially related to naturally occurring soil concentrations. Inorganic COPEC drivers for the food chain assessment are chromium, copper, lead, and thallium, while direct contact assessment COPEC drivers are chromium, copper, and lead. Inorganics with maximum detected concentrations (MDCs) less than the background UTL and shown not to be statistically different based on appropriate population statistical tests are considered background related. For SWMU 39, none of the inorganic COPEC drivers for surface soil could be attributed to background, because the MDCs for chromium, copper, lead and thallium exceeded their respective UTLs. Therefore, none of the inorganic COPEC drivers are potentially background-related.

Table 7-10
Direct Contact Toxicity Evaluation for Surface Soil at SWMU 39

Chemical (1)	Detection Frequency	Maximum Concentration	EPC	Units	BTAG Screening Toxicity Value (2)	Comment on BTAG Value	ORNL Screening Toxicity Value (3)	Comment on ORNL Value	LANL Screening Toxicity Value (4)	Lowest Relevant Screening Value (5)	Tier 1 EEQ (6)	Tier 2 EEQ (7)
Aluminum	19/19	3.74E+04	2.58E+04	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---
Antimony	5/15	1.40E+00	1.40E+00	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---
Beryllium	17/18	1.40E+00	1.05E+00	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---
Chromium	19/19	9.51E+01	4.68E+01	mg/kg	NVA	---	32	Cr III	1.4	32	3.0	1.5
Chromium	19/19	9.51E+01	4.68E+01	mg/kg	0.0075	For Bacteria	0.4	Cr VI	0.2	0.4	238	117
Copper	19/19	3.75E+02	1.18E+02	mg/kg	15	---	50	---	13	50	7.50	2.35
Iron	19/19	5.28E+04	3.52E+04	mg/kg	12	Rabbit LD-50	NVA	---	NVA	NVA	---	---
Lead	18/19	1.65E+04	1.28E+04	mg/kg	0.01	Quail Impact	500	---	2000	500	33.0	25.7
Manganese	19/19	1.38E+03	8.12E+02	mg/kg	330	No reference	NVA	---	NVA	NVA	---	---
Mercury (Inorganic)	10/19	1.02E-01	6.22E-02	mg/kg	0.058	No reference	0.1	For organic and inorganic forms	0.05	0.1	1.02	0.62
Nickel	19/19	3.81E+01	2.40E+01	mg/kg	NVA	---	200	---	100	200	0.19	0.120
Silver	2/11	1.35E+00	5.97E-01	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---
Thallium	13/19	2.27E+01	4.28E+00	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---
Vanadium	19/19	9.27E+01	6.32E+01	mg/kg	58	No reference	NVA	---	NVA	NVA	---	---
Zinc	19/19	3.01E+02	1.11E+02	mg/kg	NVA	---	200	---	350	200	1.51	0.55
2,4-Dinitrotoluene	1/14	2.33E-01	2.02E-01	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---
Nitroglycerin	2/5	1.98E+01	1.98E+01	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---
Endrin aldehyde	1/6	6.81E-04	6.81E-04	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---
Endin ketone	1/6	2.82E-03	2.82E-03	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---
Diethyl phthalate	1/9	5.90E-02	5.90E-02	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---
Di-n-butyl phthalate	1/9	5.23E-01	5.23E-01	mg/kg	NVA	---	NVA	---	NVA	NVA	---	---

NVA = No Value Available

EPC = Exposure Point Concentration.

(1) COPECs from Table 7-5.

(2) Screening toxicity values for fauna from BTAG (1995).

(3) Screening toxicity values for earthworms from ORNL (1997, ES/ER/TM-126/R2).

(4) Screening toxicity values for earthworms from Los Alamos National Laboratory (2002), Environmental Restoration Project, Environmental Screening Levels, Release 1.5, Sept.

(5) The lowest relevant screening value is the lowest value appropriate for the RFAAP site:

Non referenced values are omitted.

Bacteria and amoeba are deemed inappropriate receptor species.

Rabbit and quail are omitted, as wildlife impacts are evaluated in the food chain model section of the SLERA.

As LANL values were developed for a desert environment, they are only used if no other appropriate values are available.

(6) Tier 1 ecological effect quotient (EEQ) is estimated by dividing the maximum soil concentration by the lowest relevant direct contact screening value.

(7) Tier 2 EEQ is estimated by dividing the EPC by the lowest relevant direct contact screening value.

7.8 Uncertainty Analysis

The results of the SLERA are influenced to some degree by variability and uncertainty. Uncertainty within the risk analysis can be reduced by using species-specific and site-specific data (i.e., to better quantify contamination of media, vegetation, and prey through: direct field measurements, toxicity testing of site-specific media, and field studies using site-specific receptor species). Detailed media, prey, and receptor field studies are costly; thus, the preliminary analyses of risk have been conducted to limit the potential use of these resource-intensive techniques to those COPECs that continue to show a relatively high potential for ecological risk. Since assessment criteria were developed based on conservative assumptions, the result of the assessment errs on the side of conservatism. This has the effect of maximizing the likelihood of accepting a false positive (Type I error: the rejection of a true H_o) and simultaneously minimizing the likelihood of accepting a true negative (Type II error: the acceptance of a false H_o).

A number of factors contribute to the overall variability and uncertainty inherent in ecological risk assessments. Variability is due primarily to measurement error; laboratory media analyses and receptor study design are the major sources of this kind of error. Uncertainty, on the other hand, is associated primarily with deficiency or irrelevancy of effects, exposure, or habitat data to actual ecological conditions at the site. Species physiology, feeding patterns, and nesting behavior are poorly predictable; therefore, toxicity information derived from toxicity testing, field studies, or observation will have uncertainties associated with them. Laboratory studies conducted to obtain site-specific, measured information often suffer from poor relevance to the actual exposure and uptake conditions on site (i.e., bioavailability, exposure, assimilation, etc., are generally greater under laboratory conditions as compared to field conditions). Calculating an estimated value based on a large number of assumptions is often the alternative to the accurate (but costly) method of direct field or laboratory observation, measurement, or testing. Finally, habitat- or site-specific species may be misidentified if, for example, the observational assessment results are based on one brief site reconnaissance.

Of concern is the uncertainty associated with the EEQs based on thallium, one of the estimated hazard drivers for the site. The EEQ for thallium is quite elevated for two primary reasons: (1) an unrealistically low mammalian TRV; and, (2) an unrealistically high earthworm BAF from soil used in the food-chain model. The thallium TRVs used for mammals are from Sample et al. (1996) and are based on a subchronic rat study for one dose that was used to derive a LOAEL for reproductive (male testicular function) effects. Due to the limitations of the study, an uncertainty factor of 100 was used by Sample et al. (1996) to estimate a NOAEL from a LOAEL and to estimate a chronic TRV from a subchronic study. An alternative rat study is available from Downs et al. (1960), however, that evaluates chronic thallium exposure to weanlings, with measured effects including weight loss, histological changes in skin, increase in kidney weights, increases in mortality, and hair loss. Use of the Downs et al. (1960) study results in a low mammalian TRV of 0.48 mg/kg-day (as adopted by *Development of Toxicity Reference Values for Conducting Ecological Risk Assessments at Naval Facilities in California* (Engineering Field Activity, West, 1998). The Downs et al. (1960) TRV for thallium was not used in this SLERA because, by definition, SLERAs should use the lowest available TRV.

The BAF/BCF values used for thallium uptake by earthworms in the current assessment are 3.2 for the conservative Tier 1 approach and 1.2 for the more realistic Tier 2 approach. There values are based, respectively, on the geometric mean of maximum and 90th percentile BAF/BCF values

available for 18 inorganics from Sample et al. (1998) (**Appendix F-2, Table F-3**), as no literature BAF/BCF values are available for thallium itself. An alternative thallium BAF/BCF value may be estimated from data presented in the *Screening Level Ecological Risk Assessment Protocol* (USEPA, 1999c). This guidance presents alternative thallium BCF information, including a conservative default BCF of 0.22. The BCF of 0.22, however, is based on the assumption that thallium is as bioaccumulative as eight other inorganics (e.g., arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) for which empirical data are available. This is an overly conservative approach because thallium is not expected to be as bioaccumulative as these eight inorganics. Thallium is not listed as one of the Important Bioaccumulative Constituents, per Table 4.2 in *Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment – Status and Needs* (USEPA, 2000d), whereas these other eight inorganics are listed.

USEPA (1999b) presents soil-to-earthworm BCFs for the eight inorganics listed in the previous paragraph, however, the BCF for cadmium is unusually elevated (e.g., 0.96) compared with the other seven inorganics (e.g., 0.11, 0.01, 0.04, 0.03, 0.04, 0.02, and 0.56 for an arithmetic average of 0.12). Cadmium may thus be excluded from a list of reasonable surrogate inorganics for thallium because cadmium is listed as having a high potential for terrestrial bioaccumulation, whereas the other inorganics, including thallium, are listed as having a moderate potential for terrestrial bioaccumulation [Table 2-1 in *Data Requirements and Confidence Indicators for Ecological Benchmarks Supporting Exemption Criteria for the Hazardous Waste Identification Rule* (USEPA, 1999d)]. Therefore, using BCF data for inorganics from USEPA (1999b) and excluding cadmium, the average surrogate BCF for moderately bioaccumulative inorganics is 0.12, and this BCF may be conservatively used to estimate the soil-to-earthworm BAF for thallium.

The alternative BAF/BCF value for thallium of 0.12 is 27-fold and 10-fold lower than the Tier 1 and Tier 2 BAF/BCF values, respectively, used in the current assessment.

Use of these two alternative references for thallium (for TRVs and for BAF/BCF values) would result in modification of the Tier 2 thallium EEQs for mammals as follows:

- Change in LOAEL EEQ for thallium: 32 x 10 = 320-fold reduction; and,
- Change in NOAEL EEQ for thallium: 65 x 10 = 650-fold reduction.

This would reduce the short-tailed shrew Tier 2 NOAEL-based total EEQ from 8,500 to approximately 6,000, and would reduce the short-tailed shrew Tier 2 LOAEL-based total EEQ from 870 to approximately 620. Similar EEQ reductions would be expected for the meadow vole, resulting in revised total EEQs of 44 (NOAEL-based) and 6.8 (LOAEL-based). For the American robin the sole reduction in the EEQ would be from the use of the alternative BAF/BCF factor (as the robin's TRV is not based on a mammalian toxicity study). Thus, the Tier 2 total EEQs for the robin, based primarily on thallium, would be reduced to just less than 1,600 (NOAEL-based) and from190 to approximately 180 (LOAEL-based).

Many constituents were not detected in surface soil analytical samples. **Appendix F-2, Table F-18** evaluates the uncertainty associated with these constituents' detection limits by presenting a comparison of the maximum detection limit for each non-detect constituent with a conservative ecological toxicity screening value. Ecological screening values were compiled as discussed in *Section 7.2.4*, and final screening values are presented in **Appendix F-2, Table F-19**. For surface soil, 59 of the 145 non-detect constituents had maximum detection limits that exceeded

either one or both of the screening criteria. This finding is not unexpected, given the conservative and numerically low screening values.

The uncertainty analysis is presented in **Table 7-11** and lists some of the major assumptions made for the SLERA; the direction of bias caused by each assumption (i.e., if the uncertainty results in an overestimate or underestimate of risk); the likely magnitude of impact (quantitative [percent difference], or qualitative [high, medium, low, or unknown]); if possible, a description of recommendations for minimizing the identified uncertainties if the SLERA progresses to higher level assessment phases; and the ease of implementing the recommendation (USEPA, 1997c).

The uncertainty analysis identifies and, if possible, quantifies the uncertainty in the individual preliminary scoping assessment, problem formulation, exposure and effects assessment, and risk characterization phases of this SLERA. Based on this uncertainty analysis, the most important biases, that may result in an overestimation of risk, include the following:

- Assuming that COPECs are 100 percent bioavailable;
- Using some laboratory-derived or empirically-estimated partitioning and transfer factors to predict COPEC concentrations in plants, invertebrates, prey species. This is especially important for thallium in soil uptake by earthworms;
- Using toxicity data from laboratory studies not based on a chronic exposure period, and/or without a NOAEL endpoint, thereby requiring the use of large uncertainty factors. This is especially important for mammalian exposure to thallium;
- Inclusion of sample outliers in the estimation of EPCs for risk drivers; and,
- Use of the hazard quotient method to estimate risks to populations or communities.

7.9 SLERA Results and Conclusions

The data, results, and conclusions of the SLERA are described in this section. Conclusions are derived from the risk assessment and are based on the responses to the assessment hypotheses and assessment endpoints. The assessment results for food chain exposure are summarized in **Table 7-9**, and direct contact EEQ results for terrestrial invertebrates, which may serve as a food source for wildlife, are summarized in **Table 7-10**. The food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles for modeled contact with the hazard drivers (primarily lead, but also thallium, 2,3,7,8-TCDD TE, chromium, and copper) in surface soil. The direct contact assessment Tier 2 results suggest a potential reduction in wildlife food supply due primarily to lead, copper, and chromium concentrations in surface soil. Analysis of the site and background data indicates that none of the inorganic COPEC drivers are related to naturally occurring surface soil concentrations.

Based on uncertainties of toxicity, on the fact that no wildlife RTE species have been confirmed at the SWMU 39 study area, and the small size of the SWMU (2.6 acres), remedial measures solely to address ecological concerns may not be warranted at this time for soil. The SMDP reached for this SLERA, however, in conjunction with the findings of the HHRA, is that the information collected and presented indicates that a more thorough assessment is warranted, in this case in the form of a CMS. As human health risks and/or hazards are unacceptable, and chemical-specific human health preliminary remediation goals (PRGs) have been developed for the site (*Section 8.2*), these PRGs are evaluated to (1) decide if they are also protective of the

Table 7-11
Uncertainty Analysis

Component	Bias	Magnitude	Ways to Minimize Uncertainty	Additional Comments
Use of 95% UCL as source-term concentration	Overestimates Risk	Medium	Use central tendency	Easy to implement, but may not be acceptable to Agency.
Assumption that soil depth interval of 0-2 ft is representative of surface soil	Overestimates Risk	Low to Medium	Resample to obtain additional samples 0-0.5 ft. for surface soil characterization	Moderately costly to implement.
Use of representative receptor species for site ecological community	Underestimates Risk	Low	Select additional receptor species	Easy to implement, but unlikely to change conclusions.
Use of conservative foraging factors (i.e., 100%) for some species	Overestimates Risk	Medium	Use more site-specific foraging factors, i.e., less than 100%	May be difficult to obtain site-specific foraging factors.
Assumption that COPECs are 100% bioavailable	Overestimates Risk	Medium to High	Obtain medium- and COPEC-specific bioavailability factors	Would be very difficult and costly to obtain these bioavailability factors.
Discounting of dermal and inhalation exposure routes	Underestimates Risk	Low	Include dermal and inhalation routes of exposure	Would be difficult to quantify these routes of exposure.
Use of partitioning and transfer factors to estimate COPEC concentrations in plants, invertebrates, and prey items.	Overestimates Risk	Medium to High	Measure COPEC concentrations in site plants, invertebrates, and other prey species.	Would be costly to implement.
Use of safety factors to convert LOAEL and LD_{50} toxicity data to NOAELs	Overestimates Risk	Medium	Obtain COPEC-specific NOAEL data	Would be costly to implement, unless data available in the literature.
Use of uncertainty factor of 8 to extrapolate TRVs between most species within the same class	Overestimates Risk	Medium	1) Assume TRVs similar for species in the same genus, family, or order; or 2) obtain species-specific NOAEL data	1) May not be accepted by Agency. 2) Would be very difficult to obtain species-specific NOAEL data.
Use of surrogate constituents to estimate toxicity for those COPECs without available toxicity data	Overestimates Risk	Low to Medium	Obtain COPEC-specific toxicity data	Would be very costly to obtain COPEC-specific toxicity data, unless available in the literature.
Use of hazard quotient method to estimate risks to populations or communities may be biased	Overestimates Risk	High	Perform population or community studies	Would be very costly to perform.

environment; and/or (2) decide if they will reduce the estimated ecological hazards by a significant amount.

The assessment results may serve as the foci of discussions with risk managers and regulatory agencies concerning the potential need for additional assessment at SWMU 39 to reduce the uncertainty in the estimate of ecological risk, as discussed in *Section 7.8*, if the no action alternative is selected in the CMS. It is very important to note that many conservative assumptions and modeling approaches were used in the assessment, and actual hazards to wildlife may be orders of magnitude lower than predicted herein.

8.0 DEVELOPMENT OF CORRECTIVE MEASURES OBJECTIVES

This chapter identifies the corrective measures objectives (CMOs) for the contaminants of interest (COIs) identified by the risk assessments and provides remediation volume estimates based on the CMOs and analytical results. CMOs are cleanup objectives that are developed during the RFI/CMS to protect human health and the environment. They consist of medium-specific goals for protecting human health and the environment. CMOs provide the basis for the identification, detailed analysis, and selection of corrective measures alternatives.

8.1 Summary of Chemicals of Interest

The HHRA (*Section 6.0*) identified four COIs (arsenic, lead, vanadium, and dioxins/furans as TCDD TE) under both an industrial and residential future-use scenario. The SLERA (*Section 7.0*) identified four COIs (lead, copper, chromium, and dioxins/furans as TCDD TE), but concluded that remedial measures solely to address ecological concerns are not warranted for soil. However, the residual risk to ecological receptors was calculated to evaluate whether remediation for human health concerns would be protective of the environment or significantly reduce ecological risks. Based on the results of the human health (*Section 6.0*) and ecological (*Section 7.0* and *Section 8.2.1*) risk evaluations, remedial goals were developed for arsenic, lead, vanadium, and dioxins/furans.

8.2 Remedial Goals

Preliminary remedial goals (PRGs) were obtained from USEPA Office of Solid Waste and Emergency Response (OSWER) Directives, where available. For analytes for which published cleanup levels were not identified, PRGs were calculated such that risks to human health are within the USEPA's acceptable range ($1x10^{-4}$ to $1x10^{-6}$ for carcinogens and an HI of 1.0 for non-carcinogens). The published or calculated values were then compared with the background values (95% UTL) and the maximum of the two values was selected as the Remedial Goal (RG) for the analyte. The future land use identified for the SMWU 39 study area is industrial. However, for comparison purposes in this RFI/CMS, RGs for both residential and industrial exposure scenarios were developed.

USEPA has published recommended residential and industrial cleanup levels for lead (USEPA, 1998c, 2003d) and dioxins/furans (USEPA, 1998c) in soil. These guidance documents are presented in **Appendix G-1** and are summarized as follows:

- Lead:
  - Industrial: 800 mg/kg
  - Residential: 400 mg/kg

The background 95% UTL for lead at RFAAP is 26.8 mg/kg (IT, 2001). Therefore, the industrial RG for lead is 800 mg/kg and the residential RG for lead is 400 mg/kg.

- Dioxins/Furans as TCDD TE:
  - Industrial: 0.005-0.020 mg/kg
  - Residential: 0.001 mg/kg

Background is not applicable to organic compounds. Therefore, the industrial RG for dioxins/furans is 0.0125 mg/kg (average of the industrial range) and the residential RG for dioxins/furans is 0.001 mg/kg.

As USEPA cleanup levels were not identified for arsenic and vanadium, RGs for arsenic and vanadium in soil were calculated such that risks to human health are within the USEPA's acceptable range ($1x10^{-4}$ to $1x10^{-6}$ for carcinogens and an HI of 1.0 for non-carcinogens). **Table 8-1** summarizes the residential and industrial risk-based RGs for arsenic and vanadium in soil at SWMU 39.

Table 8-1
Identification of Remedial Goals for Arsenic and Vanadium in SMWU 39 Soil

Analyte	Medium	Receptor	Calculated RG (lesser of HI=1.0 or $1x10^{-5}$ risk)	Background (mg/kg)	Industrial RG (mg/kg)	Residential RG (mg/kg)
Industrial Scenarios						
Arsenic	Surface and Total Soil	Maintenance Worker	39.7	15.8	15.8	---
	Surface and Total Soil	Industrial Worker	8.75	15.8		
	Total Soil	Excavation Worker	65.8	15.8		
Vanadium	Surface and Total Soil	Maintenance Worker	1,440	108	144	---
	Surface and Total Soil	Industrial Worker	321	108		
	Total Soil	Excavation Worker	144	108		
Residential Scenarios						
Arsenic	Total Soil	Adult Resident	5.0	15.8	---	15.8
	Total Soil	Child Resident	2.8	15.8		
Vanadium	Total Soil	Adult Resident	288	108	---	108
	Total Soil	Child Resident	37.7	108		

Details on the methodology used to calculate the RGs for arsenic and vanadium are presented in **Appendix G-2**.

8.2.1 Residual Ecological Hazards

As mentioned in *Section 7.0*, ecological HQs estimated for metals and TCDD in soil in the SLERA were found to be elevated. These estimates are associated with a considerable degree of uncertainty and are, by themselves, not appropriately definitive to recommend ecologically-based RGs. However, the SLERA suggests that proposed remediation based on human health-based RGs for lead and TCDD, as well as other COPCs in soil, be evaluated to assess whether the proposed action is either protective of the environment or significantly reduces ecological EEQs. This section integrates the ecological EEQs and the human health RGs to provide a semi-quantitative assessment of the reduction in potential ecological hazard affected by human health risk-based remediation.

Table 8-2 presents estimated residual ecological hazards for chemicals found to be ecological "risk drivers" for at least one of the receptors evaluated for the respective environmental media.

Table 8-2
Ecological Implications of Human Health Soil RGs on Ecological Receptors

Chemical[a]	Residential Human Health RG (mg/kg)	Expected Residual Conc.[b] (mg/kg)	Critical Ecological LOAEL EEQ (and receptor)[c]		EPC for Critical[d] Ecological Receptor (mg/kg)	Scaled[e] Ecological LOAEL EEQ Using Expected Residual Conc.	Estimated % Reduction in Ecological Hazard[f]
Copper	-	22.5	2.35	earthworm	118	0.4	81%
Copper	-	22.5	6.6	shrew	118	1.3	81%
Chromium	-	31.3	43	robin	46.8	29	33%
Chromium	-	31.3	1.5	earthworm	46.8	1.0	33%
Lead	400	99.2	122	shrew	12,800	0.9	99%
Lead	400	99.2	25.7	earthworm	12,800	0.2	99%
TCDD TE	.001	8.65E-07	474	shrew	2.07E-05	20	96%

[a] Chemicals shown are those having the highest ecological EEQ values in the Screening Level Ecological Risk Assessment (SLERA) (*Section 7.0*). Human health COCs are bolded.

[b] Residual concentrations in surface soil were estimated by removing the soil samples from the ecological data base that are within the proposed excavation footprint and recalculating the exposure point concentration, based on the resultant nine soil samples, following the methodology used in the SLERA (i.e., use of the 95% UCL EPC). Dilution from clean backfill was not considered in estimating residual concentrations.

[c] Value and corresponding receptor shown are for the highest Tier 2 EEQ value among receptors evaluated in the SLERA. For earthworms, trivalent chromium EEQ presented.

[d] Value shown is from the SLERA (i.e., the 95% UCL EPC).

[e] Estimated using the following scaling relationship: Scaled EEQ = Residual Conc. x (pre-remediation EEQ/pre-remediation EPC).

[f] Estimated by subtracting the scaled ecological LOAEL EEQ from the critical ecological LOAEL EEQ, and dividing by the critical LOAEL EEQ

Notes:

COC = chemical of concern

EPC = exposure point concentration (original EPC used in SLERA for surface soil exposure)

SLERA = Screening Level Ecological Risk Assessment

EEQ = ecological effects quotient from SLERA.

LOAEL = lowest-observed-adverse-effect level

NA = not applicable

RG = remedial goal.

Estimated post-remediation residual concentrations are based on the EPC for the nine samples in areas not proposed for remediation; revised EEQ values were scaled as described in the footnotes to the table. Using the estimated residual concentrations and the scaled EEQ estimation approach, the following EEQs based on LOAEL Tier 2 values are obtained.

- SWMU 39 residual surface soil concentrations, using the residential land-use scenario for human health cleanup, result in predicted EEQ percent reductions that range from 33% (for chromium) to 99% (for lead). Scaled food-chain EEQs are approximately 1.3, 0.9, and 20 for copper, lead, and TCDD effects on shrews, respectively, and approximately 29 for chromium effects on robins (**Table 8-2**).

- For the shrew, the estimated residual concentrations of copper, lead, and TCDD in surface soil are expected to reduce this receptors' EEQ from 850 to 269, or by almost 70%. This percentage reduction is considered significant.
- Potential impacts to earthworms (that are representative of the soil invertebrate community at the site) are estimated to be acceptable, as the scaled EEQs range from 0.2 to 1.0.

While some of the food-chain hazard-driver COPECs are still estimated to have potential EEQs greater than 1.0, this finding is not considered significant for the following reasons:

- The estimated ecological hazards in **Table 8-2** incorporate additional safety factors, such as the use of an 8-fold modifying factor to account for species-to-species extrapolation.
- Although the chromium EEQ is estimated to be 29 for the robin, the BAF/BCF value used for chromium uptake by earthworms in the SLERA was 3.2 in the Tier 2 approach. An alternative chromium BAF/BCF value may be estimated from data presented in the *Screening Level Ecological Risk Assessment Protocol* (USEPA, 1999b). This guidance presents an alternative chromium BAF/BCF of 0.01. This alternative BAF/BCF value for chromium is 320-fold lower than the Tier 2 BAF/BCF value used in the SLERA. Use of this alternative BAF/BCF would reduce the American robin Tier 2 NOAEL-based residual chromium EEQ of 29 to less than 0.1.
- Confirmation sampling following remediation would more accurately define COPEC concentrations that would remain, and the inclusion of sampling clean backfill, in order to estimate COPEC concentrations throughout the area of exposure post-remediation, would likely result in much lower residual concentrations.
- HQs are not measures of the probability that a wildlife receptor will develop a toxicological endpoint of concern, such as mortality or reproductive impairment. Additionally, EEQs in excess of 1 do not necessarily indicate that even a single individual of a species will demonstrate the associated effect endpoint. Thus, EEQs less than one are not necessarily a requirement to demonstrate acceptable ecological impacts.
- Bioaccumulation of COPECs in the food chain was estimated using simple empirical models, and actual uptake is expected to be less than estimated.

In conclusion, the proposed human health RGs in **Table 8-1** for residential land use are expected to result in residual COPEC concentrations in surface soil that are protective of the environment. It is also important to note that these ponds were engineered treatment units, and not otherwise naturally-occurring features at SWMU 39. Technically, this alone is thought to be justification for no further action from an ecological risk perspective. However, it is equally noteworthy that the proposed action will both remove the source areas to human health RGs, and bring the pond areas to grade (i.e., over two feet of soil will be placed over residual concentrations of COPECs that may remain post-excavation). This cover is expected to provide an additional barrier and eliminate or reduce most ecological exposure pathways.

There is an indication of low pH soil at the site, as sample 39SB05A had a pH of 4.0. As this one single soil sample was analyzed for pH, it is unknown if surface soil at the site have pH concentrations as low as 4.0. Sample 39SB05A is located in the center of the northern settling pond, within the area proposed of corrective measures. It is anticipated that soil in the areas

outside of the settling ponds would have a pH closer to that found in throughout the remainder of RFAAP (i.e., 6.49). If samples collected following completion of corrective measures at the site indicate that the pH of the soil is less than 5.5, addition of lime to increase soil pH will be considered.

8.3 Site-Specific Corrective Measures Objectives

Impacted soil in the study area is currently not used or expected to be used in the future. However, site workers (maintenance worker and excavation worker) may come into contact with contaminated soil in the future. In addition, impacted soil in the study area is not migrating off-site to potential receptors. Therefore, a corrective action objective has been established to reduce the contaminant concentrations in the study area with waste in place. Specifically, the corrective action objective for this RFI/CMS is to reduce contaminant concentrations in soil to levels that are protective of industrial workers at the site. However, the Army has evaluated the residential exposure pathways to assess what the remedial effort would be to obtain clean close out; therefore, a discussion of whether the proposed alternatives protect residential receptors is presented in the evaluation of alternatives. Clean close out has cost advantages over waste in place close out by eliminating long term costs and allowing for beneficial reuse.

8.4 Area and Volume of Contamination

Based on the CMOs described in *Section 8.3*, the area and volume of contamination have been calculated. The results of the SWMU 39 soil investigations indicate that lead and dioxins/furans (as TCDD TE) are present in surface soil at concentrations exceeding the Industrial RG (see Figure 4-2). No COIs were detected above the Industrial RG at depths greater than 1 ft bgs. Although not defined during the field activities, the calculated area of contamination (24,912 ft^2), presented as Figure 8-1, most likely defines the limit of contamination. This area consists of a 10 ft by 10 area in the southern pond and the entire footprint of the northern pond. The depth of soil to be removed to reduce the contaminant concentrations to less than their respective Industrial RGs was assumed to be 2 ft bgs. Based on the assumed area and depth of contamination, the total estimated volume of contaminated soil is 1,845 yd^3.

The area and volume of contamination for clean close out (i.e., exceeding the Residential RG) was similarly calculated. However, there is one location in the northern pond (39SB05C at a depth of 3-5 ft bgs) where lead was detected at depth above the Residential RG, but below the Industrial RBC. Therefore, it was assumed that additional excavation at depth was required in the northern pond to reduce contaminant concentrations to residential RGs. For this area, it was assumed that the volume of contamination in this area could be defined as a trapezoid with 1:1 side slope to a depth of 6 ft bgs with a base area 10 ft by 10 ft. Therefore, the total area of soil contamination, also presented on **Figure 8-1**, is estimated as 25,212 ft^2. The estimated volume of soil exceeding the Residential RGs is 1,905 yd^3.

SITE ID	39SB1A	39SB1B	39SB1D
DEPTH (ft)	0–0.5	1–2	4–6
TAL Metals (mg/kg)			
Lead	**7070**	**537**	21.4

SAMPLE ID	39SB05A	39SB05B	39SB05C
DEPTH (ft. bgs)	0–0.5	1–3	3–5
TAL Metals (mg/kg)			
Lead	**4,530**	**138**	**800**
Dioxins/Furans (ng/kg)			
TCDD TE	20.67	0.79	2.57

SAMPLE ID	39SS09
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**83.0** J

SAMPLE ID	39SS07
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**30.2** J

SAMPLE ID	39SB06A	39SB06B	39SB06C
DEPTH (ft. bgs)	0–0.5	1–3	3–5
TAL Metals (mg/kg)			
Lead	**16,500**	26.4	22.6
Dioxins/Furans (ng/kg)			
TCDD TE	4.53	1.65	0.94

CONTAMINATION ABOVE RESIDENTIAL TO 6' bgs (EXCAVATE TRAPEZOID AREA WITH 10'x10' BASE AND 1:1 SIDE SLOPES)

SITE ID	39SL2
DEPTH (ft)	0–1
TAL Metals (mg/kg)	
Lead	**21000**

INCINERATOR

39MW2

39MW6

39SS08

39SS09

39MW7

39SS1

39SB1

39SL2

39SS2

39SB05

INCINERATOR

39MW3

39SS7

SETTLING POND

RCRA CLOSED SPRAY POND

INCINERATOR

39MW5

39SS3

AREA=24,812 ft²

RESIDENTIAL AREA=400 ft²

39SB2

39MW4

39SS10

39SB3

39SB06

SETTLING POND

39SB4

39SS12

39MW8

INDUSTRIAL AREA=100 ft²

39SS11

39SL3

39MW1

SITE ID	39SB3A	39SB3B	39SB3D
DEPTH (ft)	0–0.5	1–2	4–6
TAL Metals (mg/kg)			
Lead	**249**	**73.6**	11.9

SAMPLE ID	39SS12
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**85.0** J

SAMPLE ID	39SS11
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**36.6** J

SAMPLE ID	39SS10
DEPTH (ft. bgs)	0–0.5
TAL Metals (mg/kg)	
Lead	**99.2**

SITE ID	39SL3
DEPTH (ft)	0–1
TAL Metals (mg/kg)	
Lead	**33.4**

N

LEGEND:

- 1992 VI SOIL SAMPLE (DAMES & MOORE)
- 1992 VI WASTE COMPOSITE SAMPLE (DAMES & MOORE)
- 1994 VI MONITORING WELL (DAMES & MOORE)
- 1997 RFI MONITORING WELL (ALLIANT TECHSYSTEMS)
- AREA EXCEEDING RESIDENTIAL REMEDIAL GOALS
- 1998 RFI MONITORING WELL (BORING) (ICF KAISER)
- 1998 RFI SOIL BORING (ICF KAISER)
- FENCE AROUND SITE BOUNDARY
- 2002 RFI SOIL BORING LOCATION (SHAW)
- 2002 RFI SURFACE SOIL LOCATION (SHAW)
- AREA EXCEEDING INDUSTRIAL REMEDIAL GOALS

Sample Summary

Previous Investigation	Contractor	TAL Metals			VOCs		SVOCs			PAHs		Explosives			Pest		PCBs		Herb		Dioxins/Furans		Total
		SS	SB	SD	SS	SB	SS	SB	SD	SS	SB	SS	SB	SD	SS	SB	SS	SB	SS	SB	SS	SB	
1992 VI	D&M	3	--	3C	--	--	3	--	3C	--	--	3	--	3C	--	--	--	--	--	--	--	--	18
1997 Closure of Spray Pond	ATK	8	16	--	--	--	8	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	48
1998 RFI	ICF Kaiser	2	14	--	--	--	2	14	--	2	14	--	--	--	--	--	--	--	--	--	--	--	56
2002 RFI	Shaw	8	4	--	3	4	--	--	--	--	--	3	4	--	3	--	3	4	3	--	3	4	46

NOTE:

J = ESTIMATED CONCENTRATION

DARK BORDER = VALUE EXCEEDS THE RESIDENTIAL SCREENING LEVEL (USEPA; APRIL, 2004)

SHADING = VALUE EXCEEDS THE INDUSTRIAL SCREENING LEVEL (USEPA; APRIL, 2004)

BOLD = VALUE EXCEEDS THE BACKGROUND CRITERION (IT, 2001)

VALUES DETECTED BELOW BACKGROUND ARE NOT SHOWN

0 100 FEET

SCALE

FILE: FIG8-1.dwg PLOT: 9-29-04

RADFORD AAP

FIGURE 8-1

SWMU 39
AREA OF CONTAMINATION

PREPARED BY: SHAW

CHECKED BY: GM

DATE: REVISED SEPTEMBER 2004

TASK NO: 83987008200000

SHAW DWG NO:

FIG 8-1

05011\296-1/1

9.0 CORRECTIVE MEASURES DEVELOPMENT

Technologies were screened during the CMS development on the basis of three criteria: effectiveness, implementability, and cost. Due to the site-specific conditions at SMWU 39, no technologies involving treatment were evaluated in detail. The first limitation to utilizing treatment technologies is that technologies capable of treating metals and dioxins/furans in an effective, implementable, cost-effective manner were not identified. For example, solidification/stabilization can be performed, but the binding agents capable of addressing the COIs created a monolithic block, which, when covered with fill to grade, would create a bathtub effect. Performing on-site stabilization with off-site disposal is not warranted nor is it cost-effective. Phytoremediation is an appropriate technology for addressing metals in soil, but does not address the dioxins/furans. In addition, access to the site requires shutting down the adjacent active incinerators. Therefore, technologies that require extensive on-site management/testing are not implementable.

The following four corrective measure alternatives were developed for SWMU 39 that are capable of meeting the CMOs described in *Section 8.0* and are effective, implementable, and cost-effective:

- Alternative One: No Further Action;
- Alternative Two: Institutional Controls (Land Use Controls, Groundwater Monitoring);
- Alternative Three: Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Land Use Controls, Groundwater Monitoring); and,
- Alternative Four: Excavation of Soil for Clean Close Out and Off-site Disposal.

A detailed description of these four alternatives is presented in this section.

9.1 Alternative One – No Further Action

The no further action alternative will be used as a baseline against which to measure the performance of other alternatives.

9.2 Alternative Two – Institutional Controls (Land Use Controls, Groundwater Monitoring)

The Institutional Controls alternative would include implementation of institutional restrictions and periodic reviews. The following components would be included under the Institutional Controls alternative: land-use restrictions, access restrictions, monitoring plan, monitoring well installation, groundwater monitoring, and periodic reviews. In addition, during the 2002 investigation, there was an indication of low pH soil at the site, as sample 39SB05A had a pH of 4.0. As this one single soil sample was analyzed for pH, it is unknown if surface soil at the site have pH concentrations as low as 4.0. Sample 39SB05A is located in the center of the northern settling pond. It is proposed that addition of lime to raise the pH to 5.5 or greater be considered if confirmatory samples indicate that soil within the ponds verify this result.

The components of the Institutional Controls alternative used for costing purposes are detailed below. The costs for this alternative are presented as **Table 9-1**.

Table 9-1
Cost for Alternative Two: Institutional Controls (Land Use Controls, Groundwater Monitoring)

ITEM	UNITS	UNIT COST	NUMBER	TOTAL	
CAPITAL COSTS					
Reporting/Workplans					
Long-term Sampling Plan	Report	$6,000.00	1	$6,000.00	Engineer's Estimate
Subtotal				**$6,000.00**	
Land Use Controls					
Deed Restrictions	Lump Sum	$10,000.00	1	$10,000.00	Engineer's Estimate
Subtotal				**$10,000.00**	
		SUBTOTAL		**$16,000.00**	
		SUPERVISION AND ADMIN @ 8%		$1,280.00	
		CONTINGENCY @ 30%		$4,800.00	
TOTAL CAPITAL COSTS				**$22,080.00**	
O&M COSTS					
Administrative Actions[1]					
5-Year Review	Report	$30,000	0.2	$6,000	Engineer's Estimate
Institutional Controls/Oversight	Lump Sum	$5,000	0.2	$1,000	Engineer's Estimate
Subtotal				**$1,000.00**	
Long-Term Maintenance					
Semi Annual Analyses[2]	Sample	$768	20	$15,360	DataChem Laboratories
Sample Labor, Preparation, Reporting	Episode	$5,000	2	$10,000	Engineer's Estimate
Maintenance of Fence/Warning Signs	Lump Sum	$200	1	$200	Engineer's Estimate
Subtotal				**$10,200.00**	
		SUBTOTAL (ANNUALLY)		**$11,200.00**	
		CONTINGENCY @ 30%		$3,360.00	
		TOTAL ANNUAL O&M COSTS		**$14,560.00**	
PRESENT WORTH (30 YEARS AT 5%)				**$245,902.89**	

[1] Costs assigned on a annual basis

[2] Two sampling events per year with analysis for arsenic, lead, vanadium, and dioxin/furans (8 samples + 1 dup + 1 rinse blank)

Access and Land Use Controls. Land use controls will be required because contaminant concentrations remain on-site at concentrations exceeding the levels for unrestricted reuse. Institutional controls such as access restrictions and land-use restrictions are currently in place at the site. The area is subject to random patrols by security personnel (due to the presence of the active incinerators located near the area) and a security fence and warning signs currently surround the facility. The existing fence will be maintained under this alternative.

Long-term Monitoring of Site Conditions. Long-term monitoring of groundwater would be conducted to evaluate the potential migration of contaminants into groundwater. A long-term sampling plan would be developed for SWMU 39 by the Army, USEPA, and VDEQ, to monitor the levels of contaminants in the groundwater. This would include the annual monitoring of groundwater collected from eight existing monitoring wells (39MW1, 39MW2, 39MW3, 39MW4, 39MW5, 39MW6, 39MW7, and 39MW8) displayed on **Figure 8-1**. The rationale as to the selection of these monitoring wells is as follows:

- Well 39MW1 is located upgradient of the contaminated soil and will be used to monitor changes in background conditions at the site;
- Wells 39MW2, 39MW4, 39MW7, and 39MW8 are screened in the aquifer beneath or slightly crossgradient of the contaminated soil source area. These wells would be used to monitor migration of contaminants from soil to groundwater in the source area; and,
- Wells 39MW3, 39MW5, and 39MW6 are located hydraulically downgradient of the contaminated soil. These wells would be used to monitor for contaminants farther downgradient of the source area.

The wells would be sampled twice a year for arsenic, lead, vanadium, and dioxins/furans. A monitoring plan would be developed which would detail the sampling of these wells. Eight groundwater samples and one duplicate sample would be collected biannually for a period of thirty years. If the sampling indicates that groundwater quality has been impacted, evaluation of additional corrective measures will be required.

Periodic Reviews. Although this alternative does not allow for unrestricted use and exposure, available data would be analyzed as part of the periodic review process to assess whether additional remedial actions or site controls are required.

9.3 Alternative Three – Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Land Use Controls, Groundwater Monitoring)

This alternative involves excavation of soil containing COI concentrations exceeding the Industrial Risk-Based RG (see *Section 8.0*). The estimated area to be excavated is presented on **Figure 8-1**, as the area containing contaminants above the Industrial RG. Excavated materials will be shipped to an offsite landfill for disposal. Depending upon the waste characterization results (e.g., TCLP, RCRA waste characteristics), the materials will be transported offsite to either a hazardous waste or solid waste landfill. Eight samples (39SB1C, 39SBIE, 39SB2C, 39SB2E, 39SB3C, 39SB3E, 39SB4C, and 39SB4E) were analyzed for TCLP metals during the 1998 RFI (ICF KE, 1999). TCLP results (**Appendix B-2, Table B-4**) indicated that lead was detected at concentrations below the TCLPRL. Therefore, it was assumed that the soil will be non-hazardous and will be disposed in a RCRA Subtitle D Landfill.

The estimated volume of the materials to be excavated is 1,845 yd^3. The density of the waste material was assumed to be 1.4 tons/yd^3; therefore, the total quantity of waste material to be excavated will be approximately 2,583 tons. Conventional earthmoving equipment such as bulldozers, trackhoes, or other earthmoving equipment would be used for excavation of the waste material. Waste materials would be excavated and loaded directly into trucks for off-site transport and disposal. Trucks would be weighed and manifested prior to leaving the site.

This alternative entails leaving contaminant concentrations in-place at concentrations exceeding the Residential RG; therefore, clean close out will not be achieved and land use controls will be required to prevent the property from being used for activities other than those associated with industrial reuse in the future. In addition, soil sampling will be performed every five years to demonstrate that conditions at the site have not changed.

In addition, there is an indication of low pH soil at the site, as sample 39SB05A had a pH of 4.0. As this one single soil sample was analyzed for pH, it is unknown if surface soil at the site have pH concentrations as low as 4.0. Sample 39SB05A is located in the center of the northern settling pond, within the area proposed to be excavated. It is anticipated that soil in the areas outside of the excavation area has a pH closer to that found in throughout the remainder of RFAAP (i.e., 6.49). If samples collected following completion of corrective measures at the site indicate that the pH of the soil is less than 5.5, addition of lime to increase soil pH will be considered.

The components of the excavation with waste in place, off-site disposal, and land use controls alternative used for costing purposes are detailed below. The costs for this alternative are presented as **Table 9-2**.

Reporting/Design Work Plans. The contractor will prepare site-specific work plans prior to excavation activities that will include a QA planning component, health and safety component, Work Plan, and field procedures. The work plans will be reviewed and approved by the USEPA and VDEQ prior to removal activities.

After the corrective measures have been completed and the final inspection approved by the USEPA and VDEQ, a Corrective Measures Summary Report will be completed. Writing and compilation of the information for the report will occur throughout the duration of the remedial action. The report will include site drawings, sample data, copies of manifests, and a detailed narrative of the corrective measures.

Site Set-up. Site set-up for the excavation will consist of setting up a decontamination station, mobilization of equipment and personnel, and setting up staging areas. It should be noted that mobilization costs are included with the excavation costs in **Table 9-2**. The water needs of the process are for decontamination; therefore, water will be trucked to the site and stored in a 500-gallon tank. The cost elements for preparing the work zone are presented below.

- The equipment decontamination station will be constructed with material such as high-density polyethylene (HDPE) for containment purposes. This decontamination station should be bermed to ensure containment of decontamination liquids.
- A 500-gallon tank will be used throughout the duration of the corrective measure activities to store water for use in the decontamination station.

Table 9-2
Cost for Alternative Three: Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Land Use Controls, Groundwater Monitoring)

ITEM	UNITS	UNIT COST	NUMBER	TOTAL	
CAPITAL COSTS [1,2]					
Reporting/Workplans					
Health and Safety Plan	Report	$10,000.00	1	$10,000.00	Engineer's Estimate
Quality Assurance Project Plan	Report	$10,000.00	1	$10,000.00	Engineer's Estimate
Work Plan	Report	$15,000.00	1	$15,000.00	Engineer's Estimate
Corrective Measures Summary Report	Report	$20,000.00	1	$20,000.00	Engineer's Estimate
Subtotal				**$55,000.00**	
Land Use Controls					
Deed Restrictions	Lump Sum	$10,000.00	1	$10,000.00	Engineer's Estimate
Subtotal				**$10,000.00**	
Site Set-Up					
500-gallon Storage Tank	Lump Sum	$500.00	1	$500.00	Engineer's Estimate
Decontamination Pad	Site	$1,500.00	1	$1,500.00	Engineer's Estimate
Subtotal				**$2,000.00**	
Contamination Delineation					
Direct Push Rig (Geoprobe)	Day	$1,000.00	10	$10,000.00	Engineer's Estimate
Oversight (Geologist)	Hour	$50.00	100	$5,000.00	Engineer's Estimate
Per Diem	Day	$83.00	10	$830.00	41 CFR 301
Off-Site Laboratory (arsenic, lead, vanadium, dioxin/furans)	Sample	$768.00	80	$61,440.00	Engineer's Estimate
Subtotal				**$77,270.00**	
Health and Safety					
Site Health and Safety Officer	Hour	$65.00	780	$50,700.00	Engineer's Estimate
Subtotal				**$50,700.00**	
Excavation					
QC Personnel (1)	Hour	$70.00	780	$54,600.00	Engineer's Estimate
Project Chemist (1)	Hour	$60.00	80	$4,800.00	Engineer's Estimate
Field Supervisor (1)	Hour	$60.00	780	$46,800.00	Engineer's Estimate
Field Technician (2)	Hour	$37.50	1560	$58,500.00	Engineer's Estimate
Equipment Operators (2)	Hour	$50.00	1560	$78,000.00	Engineer's Estimate
Project Manager (1)	Hour	$82.50	300	$24,750.00	Engineer's Estimate
Per Diem[3]	Day	$83.00	566	$46,978.00	41 CFR 301
3 CY Trackhoe (includes mob/demob)	Month	$8,130.00	1	$8,130.00	Engineer's Estimate
4 CY Front End Loader (includes mob/demob)	Month	$8,000.00	1	$8,000.00	Engineer's Estimate
Roller - Vibratory Compactor (includes mob/demob)	Month	$3,166.00	3	$9,498.00	Engineer's Estimate
Water Truck (includes mob/demob)	Month	$1,740.00	3	$5,220.00	Engineer's Estimate
Subtotal				**$345,276.00**	
Confirmational Sampling					
Off-Site Laboratory (arsenic, lead, vanadium, dioxin/furans)	Sample	$768.00	20	$15,360.00	Severn Trent
Subtotal				**$15,360.00**	
Waste Characterization					
Off-Site Lab Analytical (TCLP metals, RCRA Chara, Dioxin/Furans)	Sample	$1,180.00	11	$12,980.00	Severn Trent
Decon Water Sample (RCRA Waste Characterization)	Sample	$1,410.00	1	$1,410.00	Severn Trent
Subtotal				**$14,390.00**	
Waste Transportation/Disposal					
Non-Hazardous Waste Transportation/Disposal	Ton	$50.64	2583	$130,803.12	EQ Landfill
Subtotal				**$130,803.12**	
Site Restoration					
Clean Fill to Bring Both Settling Ponds to Grade	CY	$5.30	13784	$73,057.56	2003 ECHOS Unit Price Book
Topsoil (6" lifts, off-site)	CY	$10.00	919	$9,189.63	2003 ECHOS Unit Price Book
Seeding, Vegetative Cover	Acre	$3,528.00	1.0	$3,528.00	2003 ECHOS Unit Price Book
Survey Equipment/Team	Lump Sum	$1,500.00	1.0	$1,500.00	2003 ECHOS Unit Price Book
Subtotal				**$14,217.63**	
		SUBTOTAL		**$715,016.75**	
		SUPERVISION AND ADMIN @ 8%		$57,201.34	
		CONTINGENCY @ 30%		$214,505.02	
TOTAL CAPITAL COSTS				**$986,723.11**	
O&M COSTS					
Administrative Actions [4]					
5-Year Review	Report	$30,000	0.2	$6,000	Engineer's Estimate
Institutional Controls/Oversight	Lump Sum	$5,000	0.2	$1,000	Engineer's Estimate
Subtotal				**$1,000.00**	
Long-Term Maintenance					
Semi Annual Analyses[5]	Sample	$768	20	$15,360	DataChem Laboratories
Sample Labor, Preparation, Reporting	Episode	$5,000	2	$10,000	Engineer's Estimate
Subtotal				**$10,000.00**	
		SUBTOTAL (ANNUALLY)		**$11,000.00**	
		CONTINGENCY @ 30%		$3,300.00	
		TOTAL ANNUAL O&M COSTS		**$14,300.00**	
PRESENT WORTH (30 YEARS AT 5%)				**$1,206,549.16**	

[1] Costs do not assume permit requirements

[2] The estimated length of time is as follows: delineation 10 days, mobilization/site set-up 2 days, excavation 11 days, site restoration 61 days, confirmation 1 day, decon/demob 3 days

[3] Per diem costs for 78 days for H&S and QC officers, site super, field techs, and equipment operators, 20 days for PM

[4] Costs assigned on a annual basis

[5] Two sampling events per year with analysis for arsenic, lead, vanadium, and dioxin/furans (8 samples + 1 dup + 1 rinse blank)

Contamination Delineation. The area to be excavated will be delineated via surface and subsurface soil sampling prior to mobilization of the excavation personnel. Delineation will not be limited to areas identified in **Figure 8-1** where contamination is above remedial goals. The entire area within both settling ponds will be delineated to assess the area that needs remediation. For the purpose of this study, it is assumed that one surface and one subsurface soil sample (at 3 ft bgs) would be collected from a total of 80 locations (160 samples) and analyzed for arsenic, lead, vanadium, and dioxins/furans. Details on sample locations, sample depths, etc. will be developed during the work planning phase.

Health and Safety. Health and safety measures will be taken to protect on-site workers during excavation activities. For cost estimating purposes, modified Level D PPE and decontamination equipment has been assumed. It was also assumed that a health and safety officer will be required on-site during corrective measures activities.

Excavation. Prior to soil excavation, the fence surrounding the ponds will be removed. This fence is not required for current site activities, so will not be replaced following completion of the corrective measure activities. Approximately 14,100 linear feet of fencing (4 foot high chain-link fence) will be removed and disposed at a clean fill landfill. Following this, soil excavation will commence. Excavation will be performed using conventional equipment. For cost estimating purposes, it was assumed that one 3-yd^3 excavator (trackhoe) will be used to excavate the contaminated area into a stockpile[1]. A front-end loader (4-yd^3 bucket) will then be used to load the soil into tri-axle dump trucks. It is assumed that the excavation will proceed at the rate of 10-12 trucks per day (22 tons/truck). It is assumed that the activities at the incinerator can be delayed or shifted such that corrective measures activities can occur during regular working hours/weeks. The estimated length of time for the excavation is 11 days. A water truck will be required on-site during excavation activities for dust suppression purposes. Oversight personnel assumed for this alternative include one QC Engineer, one field supervisor, two field technicians, and one project manager.

Confirmation Sampling. Confirmation sampling will be conducted concurrently with excavation and will document that the remaining soil meets established cleanup levels. Excavation will continue until CMOs have been met. It is estimated that 20 samples will be collected from the bottom and sides of the excavation area and sent to an off-site laboratory for arsenic, lead, vanadium, and dioxins/furans analysis.

Waste Characterization. For the purposes of this document, analysis for the following waste characteristics is assumed for composite samples collected from the soil determined to be above RGs during the delineation phase prior to excavation. The receiving facility requires that one composite sample be collected from the waste materials per day; therefore, it is assumed that 11 composite samples will be collected from the excavated materials to assess whether the soil is a hazardous waste. In addition, IDM will be sampled prior to disposal for RCRA waste characteristics.

[1] If the waste characterization samples (described above) indicate that the soil is a hazardous waste, stockpiling is not an appropriate procedure. If hazardous, soil will be loaded directly into dump truck or roll-offs prior to transportation.

Test	Media	Method		Price*
		Extraction	Analysis	
Corrosivity, pH, 3 day TAT	Solid		SW846 9045	$20
Flash Pt. Ignitability, 3 day TAT	Solid		SW846 1010	$70
Reactivity, 3 day TAT	Solid		SW846 Chap 7	$180
Dioxins/furans, 7 day TAT	Solid		SW846 8290	$660
TCLP Metals, 3 day TAT	Solid	SW846 1311	SW846 6010	$250
Total Cost				$1180

* Based on a laboratory quote from DataChem, October 2003.

Waste Transportation and Disposal. Corrective measure activities are expected to generate approximately 2,583 tons of non-hazardous soil and 500 gallons of decontamination water. Excavated soil is anticipated to be classified as non-hazardous waste, so will be disposed in a RCRA Subtitle D Landfill. The contractor and Installation will select the final disposal facility for the waste based on several factors:

- Treatment, storage, and disposal facility (TSDF) capacity to accommodate incoming waste;
- Solicitation of bids using applicable Federal Acquisition Regulations (FARs);
- Verification of permits and insurance (at time of award); and,
- The disposal facility must meet the permit compliance requirements.

Currently, it is proposed that excavated soil that is characterized as a non-hazardous waste will be transported to Piedmont, Virginia utilizing Capital Environmental as the local broker. It is likely that the decontamination fluids will be characterized as non-hazardous waste and, therefore, will be disposed in the RFAAP Wastewater Treatment Plant at no cost to the Army.

Site Restoration. Once the excavation is complete, the ponds will be filled with soil to match the surrounding grade. Approximately 6 inches of topsoil will then be applied and the area will be graded. Erosion control measures will be implemented and excavation areas will be seeded. Upon completion of site restoration operations, the contractor will remove the temporary facilities from the area.

Access and Land Use Controls. Land use controls will be required because contaminant concentrations remain on-site at concentrations exceeding the levels for unrestricted reuse. Institutional controls such as access restrictions and land-use restrictions are currently in place at the site. The area is subject to random patrols by security personnel (due to the presence of the active incinerators located near the area).

Long-term Monitoring of Site Conditions. Long-term monitoring of groundwater would be conducted to evaluate the potential migration of contaminants into groundwater. A long-term sampling plan would be developed for SWMU 39 by the Army, USEPA, and VDEQ, to monitor the levels of contaminants in the groundwater. This would include the annual monitoring of groundwater collected from eight existing monitoring wells (39MW1, 39MW2, 39MW3, 39MW4, 39MW5, 39MW6, 39MW7, and 39MW8) displayed on **Figure 8-1**. The rationale as to the selection of these monitoring wells is as follows:

- Well 39MW1 is located upgradient of the contaminated soil and will be used to monitor changes in background conditions at the site;

- Wells 39MW2, 39MW4, 39MW7, and 39MW8 are screened in the aquifer beneath or slightly crossgradient of the contaminated soil source area. These wells would be used to monitor migration of contaminants from soil to groundwater in the source area; and,
- Wells 39MW3, 39MW5, and 39MW6 are located hydraulically downgradient of the contaminated soil. These wells would be used to monitor for contaminants farther downgradient of the source area.

The wells would be sampled twice a year for arsenic, lead, vanadium, and dioxins/furans. A monitoring plan would be developed which would detail the sampling of these wells. Eight groundwater samples and one duplicate sample would be collected biannually for a period of thirty years. If the sampling indicates that groundwater quality has been impacted, evaluation of additional corrective measures will be required. In addition, it should be noted that a groundwater investigation is currently being conducted to address groundwater on a regional basis within the Horseshoe Area of RFAAP. An evaluation of whether corrective measures are required for groundwater will be performed based on the conclusions of that study. As groundwater will be assessed as a separate study, monitoring requirements and institutional controls potentially associated with it are not discussed in this report.

Periodic Reviews. Although this alternative does not allow for unrestricted use and exposure, available data would be analyzed as part of the periodic review process to assess whether additional remedial actions or site controls are required.

9.4 Alternative Four – Excavation of Soil for Clean Close Out and Off-site Disposal

This alternative involves excavation of soil containing concentrations of COIs exceeding Residential RGs (see *Section 8.0*) to facilitate clean close out of the SWMU 39 study area. The estimated area to be excavated is presented on **Figure 8-1**, as the area containing COIs above the Residential RG. Alternative Four includes the cost items discussed in Alternative Three (*Section 9.3*) above, with longer durations for the additional volume of soil to be excavated. However, as soil containing COIs at concentrations exceeding the Residential RG will be removed, clean close out of the site will be achieved and land use controls and the five year sampling/reporting is not required.

The estimated volume of the materials to be excavated is 1,905 yd^3. The density of the waste material was assumed to be 1.4 tons/yd^3. Therefore, the total quantity of waste material to be excavated will be approximately 2,667 tons. Depending upon the waste characterization results (e.g., TCLP, RCRA waste characteristics), the materials will be transported off-site to either a hazardous waste or solid waste landfill. However, based on the results of TCLP samples collected from the site **(Appendix B-2, Table B-4)**, it was assumed that the materials present are non-hazardous and will be disposed in a RCRA Subtitle D Landfill.

The cost components for Alternative Four are discussed under Alternative Three (*Section 9.3*). The costs for this alternative are presented as **Table 9-3**.

Table 9-3
Cost for Alternative Four: Excavation of Soil for Clean Close Out and Off-site Disposal

ITEM	UNITS	UNIT COST	NUMBER	TOTAL	
CAPITAL COSTS [1,2]					
Reporting/Workplans					
Health and Safety Plan	Report	$10,000.00	1	$10,000.00	Engineer's Estimate
Quality Assurance Project Plan	Report	$10,000.00	1	$10,000.00	Engineer's Estimate
Work Plan	Report	$15,000.00	1	$15,000.00	Engineer's Estimate
Corrective Measures Summary Report	Report	$20,000.00	1	$20,000.00	Engineer's Estimate
Subtotal				**$55,000.00**	
Site Set-Up					
500-gallon Storage Tank	Lump Sum	$500.00	1	$500.00	Engineer's Estimate
Decontamination Pad	Site	$1,500.00	1	$1,500.00	Engineer's Estimate
Subtotal				**$2,000.00**	
Contamination Delineation					
Direct Push Rig (Geoprobe)	Day	$1,000.00	10	$10,000.00	Engineer's Estimate
Oversight (Geologist)	Hour	$50.00	100	$5,000.00	Engineer's Estimate
Per Diem	Day	$83.00	10	$830.00	41 CFR 301
Off-Site Laboratory (arsenic, lead, vanadium, dioxin/furans)	Sample	$768.00	80	$61,440.00	Engineer's Estimate
Subtotal				**$77,270.00**	
Health and Safety					
Site Health and Safety Officer	Hour	$65.00	790	$51,350.00	Engineer's Estimate
Subtotal				**$51,350.00**	
Excavation					
QC Personnel (1)	Hour	$70.00	790	$55,300.00	Engineer's Estimate
Project Chemist (1)	Hour	$60.00	80	$4,800.00	Engineer's Estimate
Field Supervisor (1)	Hour	$60.00	790	$47,400.00	Engineer's Estimate
Field Technician (2)	Hour	$37.50	1580	$59,250.00	Engineer's Estimate
Equipment Operators (2)	Hour	$50.00	1580	$79,000.00	Engineer's Estimate
Project Manager (1)	Hour	$82.50	300	$24,750.00	Engineer's Estimate
Per Diem [3]	Day	$83.00	573	$47,559.00	41 CFR 301
3 CY Trackhoe (includes mob/demob)	Month	$8,130.00	1	$8,130.00	Engineer's Estimate
4 CY Front End Loader (includes mob/demob)	Month	$8,000.00	1	$8,000.00	Engineer's Estimate
Roller - Vibratory Compactor (includes mob/demob)	Month	$3,166.00	3	$9,498.00	Engineer's Estimate
Water Truck (includes mob/demob)	Month	$1,740.00	3	$5,220.00	Engineer's Estimate
Subtotal				**$348,907.00**	
Confirmational Sampling					
Off-Site Laboratory (arsenic, lead, vanadium, dioxin/furans)	Sample	$768.00	20	$15,360.00	Severn Trent
Subtotal				**$15,360.00**	
Fence Removal					
Removal of 4' Chain Link Fence	LF	$7.52	14100	$106,032.00	Cost to Remove Fence at Fort Ritchie
Subtotal				**$106,032.00**	
Waste Characterization					
Off-Site Lab Analytical (TCLP metals, RCRA Chara, Dioxin/Furans)	Sample	$1,180.00	12	$14,160.00	Severn Trent
Decon Water Sample (RCRA Waste Characterization)	Sample	$1,410.00	1	$1,410.00	Severn Trent
Subtotal				**$15,570.00**	
Waste Transportation/Disposal					
Non-Hazardous Waste Transportation/Disposal	Ton	$50.00	2667	$133,350.00	EQ Landfill
Subtotal				**$133,350.00**	
Site Restoration					
Clean Fill to Bring Both Settling Ponds to Grade	CY	$5.30	13844	$73,373.20	2003 ECHOS Unit Price Book
Topsoil (6" lifts, off-site)	CY	$10.00	919	$9,189.63	2003 ECHOS Unit Price Book
Seeding, Vegetative Cover	Acre	$3,528.00	1.0	$3,528.00	2003 ECHOS Unit Price Book
Survey Equipment/Team	Lump Sum	$1,500.00	1.0	$1,500.00	2003 ECHOS Unit Price Book
Subtotal				**$14,217.63**	
		SUBTOTAL		**$819,056.63**	
		SUPERVISION AND ADMIN @ 8%		$65,524.53	
		CONTINGENCY @ 30%		$245,716.99	
TOTAL CAPITAL COSTS				**$1,130,298.15**	
O&M COSTS					
None					
		SUBTOTAL (ANNUALLY)		**$0.00**	
		CONTINGENCY @ 30%		$0.00	
		TOTAL ANNUAL O&M COSTS		**$0.00**	
PRESENT WORTH (30 YEARS AT 5%)				**$1,130,298.15**	

[1] Costs do not assume permit requirements

The estimated length of time is as follows: delineation 10 days, mobilization/site set-up 2 days, excavation 12 days, site restoration 61days, confirmation 1 day, decon/demob

[2] 3 days

[3] Per diem costs for 79 days for H&S and QC officers, site super, field techs, and equipment operators, 20 days for PM

10.0 DETAILED ANALYSIS OF CORRECTIVE ACTION ALTERNATIVES

10.1 Evaluation Criteria

The criteria used to evaluate each corrective action alternative include effectiveness, implementability, and cost, as described below.

10.1.1 Effectiveness of the Alternative

The effectiveness of an alternative was based on the ability of the alternative to address technical, human health, and ecological concerns. The effectiveness of each alternative is evaluated in this section based on the ability to:

- Meet the corrective action objective for the study area;
- Achieve remedial action goals for soil in a timely manner;
- Control the source of the release;
- Provide proven and reliable technologies; and,
- Reduce impacts to human health and the environment during corrective action implementation.

10.1.2 Implementability of the Alternative

Identified alternatives need to be readily available, easily constructed, and reliable. Evaluation is focused on:

- Ability to construct the technology; and,
- Availability of equipment, materials, and labor for construction.

10.1.3 Cost of the Alternative

Cost factors used to evaluate alternatives include costs associated with implementation of each corrective action alternative. Costs were included for project planning, project implementation reports, project administration, site restoration, and institutional controls. The cost for each alternative was developed based on a conceptual design for each alternative. These costs are present worth/equivalent cost (plus 50 percent to minus 30 percent). Actual cost of each alternative is dependent on the final scope, schedule, market conditions, and other variables. Development of the cost for each alternative included:

- Engineering level design of final remedy;
- Capital cost;
- Installation cost; and,
- Institutional controls costs (if applicable).

10.2 Effectiveness

10.2.1 Overall Protection of Human Health and the Environment

Alternative One does not meet this criterion as no measures are taken to prevent human or ecological contact with contaminated soil. Alternative Two provides some protection of human health as measures are taken to prevent contact with contaminated soil; however, no protection of ecological receptors is afforded by this alternative. For Alternatives Three and Four, soil-containing contaminants at concentrations associated with unacceptable risks to human health will be removed from the areas under the anticipated industrial future use scenario. Alternative

Four provides an additional level of protection for residential receptors. While this use scenario is not likely for SWMU 39, it allows the site to be closed without use restrictions. In addition, as discussed in *Section 8.2.1*, the proposed human health CMOs in **Table 8-1** for either industrial or residential land use are expected to result in residual COPEC soil concentrations in surface soil that are protective of the environment. Therefore, protection of ecological receptors is also afforded by these alternatives.

10.2.2 Compliance with Federal, State, and Local Regulations

No reduction in contaminant concentrations is provided by Alternatives One or Two. Therefore, these alternatives would not meet the Industrial RGs. Alternatives Three and Four will meet the Industrial RGs. In addition, Alternative Four will reduce contaminant concentrations to below the Residential RGs, facilitating clean close out of the site. Each alternative will be designed to comply with applicable or relevant and appropriate Federal, State, and local regulations. Additional information regarding the alternatives' compliance with NEPA requirements is presented in **Appendix H**.

10.2.3 Long-term Effectiveness and Permanence

Alternative One does not provide long-term effectiveness or permanence because elevated contaminant concentrations will remain in place and no active controls will be taken to reduce exposure. Alternative Two does not provide long-term effectiveness and permanence because the waste materials would remain in place; however, human contact with the contaminants would be reduced through the implementation of institutional controls. No protection of the environment would be afforded by Alternative Two. For Alternative Three, arsenic, lead, vanadium, and dioxin/furan concentrations present above the Industrial RGs will be removed from the site, thereby providing long-term effectiveness and permanence. In addition, land use controls will be implemented under this alternative that will prevent the area from being used for activities associated with unacceptable risks. Alternative Four provides the highest level of protection, as it entails removal of soil containing COI concentrations above the Residential RGs, thereby providing long-term effectiveness, regardless of the future use of the site.

10.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

No corrective measure actions are performed under Alternatives One or Two; therefore, no reduction in toxicity, mobility, or volume (TMV) is provided under this alternative. Alternatives Three and Four will not provide a reduction in the toxicity or volume of contamination as the contaminants are not destroyed, but are rather moved to a new location. However, a reduction in mobility will be provided as the COIs will be placed in a RCRA landfill.

10.2.5 Short-Term Effectiveness

There are no short-term risks associated with Alternative One, as no actions are implemented. The potential short-term risks to site workers performing the sampling activities under Alternative Two can be controlled through the use of proper field techniques. Potential short-term risks to site workers, the environment, and the community can be reduced for Alternatives Three and Four by the use of good construction practices, real-time air monitoring, standard dust-suppression techniques, and by following appropriate Department of Transportation (DOT) and Commonwealth of Virginia shipping requirements for transportation activities. The methodologies to safely perform these activities will be described in site-specific work plans and health and safety plans.

10.3 Implementability

10.3.1 Technical Feasibility

Alternative One is technically implementable, as no actions are to be implemented under this alternative. Alternatives Two, Three, and Four involve proven technologies.

10.3.2 Administrative Feasibility

Alternative One is administratively feasible, as no actions are to be implemented under this alternative. Administrative activities for Alternatives Two, Three, and Four are expected to be routine. Permitting will not be required for the activities described under Alternatives Two, Three, or Four.

10.3.3 Availability of Services and Materials

Alternatives Two, Three, and Four involve full-scale technologies that can be readily implemented. Services and materials for the alternatives are readily available.

10.4 Cost

Costing assumptions are in the description of the alternatives in *Section 9.0*. The detailed cost estimates for Alternatives Two through Four are presented in **Tables 9-1 through 9-3**, respectively. Costs for each of the alternatives are summarized in **Table 10-1**.

Table 10-1
Summary of Costs
SWMU 39 Corrective Measures Alternatives

Alternative Number	Capital Costs ($)	Annual Operation and Maintenance Total ($)	30-Year Operation and Maintenance Total ($)	Present Worth ($)
1 – No Further Action	$0	$0	$0	$0
2 – Institutional Controls (Land Use Controls, Groundwater Monitoring)	$22,100	$14,600	$223,900	$246,000
3 – Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls	$987,000	$14,300	$219,000	$1,206,000
4 – Excavation of Soil for Clean Close Out and Off-site Disposal	$1,130,000	$0	$0	$1,130,000

11.0 RANKING OF CORRECTIVE MEASURES ALTERNATIVES

The four corrective measures alternatives presented in *Section 9.0* and evaluated in *Section 10.0* are assessed in this section using a numerical ranking system. The alternatives are ranked according to the criteria discussed in *Section 10.0* that include effectiveness, implementability, and cost. Each selection criterion for each alternative was ranked 1 through 5. A score of 5 indicates the most favorable alternative. A score of 1 indicates the least favorable alternative.

It should be noted that remedial goals protective of ecological receptors are not required, as the application of alternative (as opposed to worse-case) toxicity and bioaccumulation factors generally resulted in residual COPEC concentrations achieving EEQs less than or equal to one, following planned remediation to meet human health based PRGs (*Section 8.2.1*). It should also be noted that under Alternatives 3 and 4, the pond areas would be covered with clean fill to grade (greater than two feet of fill would be placed over the pond areas) and confirmation sampling following remediation, including sampling clean backfill, in order to estimate COPEC concentrations throughout the area of exposure post-remediation, would likely result in residual concentrations even lower than those estimated in **Table 8-2**.

In addition, the criteria were weighted based on importance. Effectiveness was given a weight factor of 3, because the primary purpose of the selected action is to be protective of human health and the environment. Implementability was given a weight factor of 2. Costs were given a weight factor of 1, because this criterion was considered the least important for selection of an alternative. The ranking for the four corrective action alternatives is provided in **Table 11-1**.

Based on the ranking, Alternative Four, Excavation of Soil for Clean Close Out and Off-site Disposal is the selected corrective measure alternative for SWMU 39.

Table 11-1
Ranking Assessment of Corrective Measures Alternatives

Alternative	Effectiveness	Implementability	Cost (30-yr Present Worth)	Total Score
Alternative 1 – No Further Action	Not effective in preventing unacceptable risks to human health or the environment as contaminant concentrations above the Industrial RG remain. 3 3X [1]	This alternative does not entail activities to be implemented. Therefore, an assessment of implementability is not applicable. 10 2X [5]	$0 5 1X [5]	18
Alternative 2 – Institutional Controls (Land Use Controls, Groundwater Monitoring)	Contaminant concentrations above the Industrial RG would remain at the site. Risks to human health are reduced by implementing land use controls. No reduction in ecological risk is affected by this alternative. 6 3X [2]	Relatively simple to implement. Uses commercially-available processes from readily available sources. Administrative implementability expected to be achieved. 10 2X [5]	$246,000 4 1X [4]	20
Alternative 3 – Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Land Use Controls, Groundwater Monitoring)	Contaminant concentrations above the Industrial RG would be removed from the site. Therefore, this alternative is effective in reducing the risks to within acceptable levels. 12 3X [4]	Relatively simple to implement. Uses commercially-available processes from readily available sources. Administrative implementability expected to be achieved. 10 2X [5]	$1,206,000 1 1X [1]	23
Alternative 4 – Excavation of Soil for Clean Close Out and Off-site Disposal	Contaminant concentrations above the Residential RG would be removed from the site facilitating clean close out. Therefore, this alternative is effective in reducing the risks to within acceptable levels. Provides an additional level of protection for residential users. 15 3X [5]	Relatively simple to implement. Uses commercially-available processes from readily available sources. Administrative implementability expected to be achieved. 10 2X [5]	$1,130,000 3 1X [3]	28

Ranking Value

1 – Least favorable → 5 – Most Favorable

Weight Factor

Effectiveness	3
Implementability	2
Cost	1

Note:

9 = Score

3 X [3] = weight factor X [ranking value]

12.0 SUBSTANTIATION/JUSTIFICATION OF FINAL REMEDY

The SWMU 39 RFI/CMS identified four COIs (arsenic, lead, vanadium, and dioxins/furans as TCDD TE) as being a potential concern to human health and the environment (see *Section 8.0*). The CMO for the SWMU 39 study area is to reduce contaminant concentrations in soil to levels that are protective of industrial workers at the site. This objective is considered protective of human health and the environment in the study area because there are no current exposures to contaminated soil and contamination is not anticipated to migrate off-site. However, protection of residential receptors was also considered as alternatives that meet this more stringent objective facilitate clean close out of the site. Four alternatives were developed and evaluated to select the best remedy for the site. These alternatives include:

- Alternative One: No Further Action;
- Alternative Two: Institutional Controls (Land Use Controls, Groundwater Monitoring);
- Alternative Three: Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Land Use Controls, Groundwater Monitoring); and,
- Alternative Four: Excavation of Soil for Clean Close Out and Off-site Disposal.

Alternatives Three and Four were found to achieve the CMO, however, Alternative Four restores the site for beneficial reuse (i.e., allows for tenant use) and eliminates long-term costs. Alternatives Three and Four both entail excavation and off-site disposal as the primary remediation process.

Alternative Four was selected as the final alternative for SWMU 39 because it is implementable and provides a greater level of protection to human health and the environment not provided by the other Alternatives. Alternative Four is the sole alternative that facilitates clean close out. By achieving clean close out, Alternative Four accomplishes the Army's goal for the Installation Restoration Program and its funding source the Environmental Restoration, Army account. In addition, Alternative Four has a lower cost than Alternative Three and meets CMOs, which Alternative Two does not. This alternative can be implemented in approximately one year. This time frame is considered an estimate and the actual time to complete the corrective measures will be impacted by site-specific conditions.

This alternative includes the following:

- Delineation of soil containing arsenic, lead, vanadium, and dioxins/furans above the Residential RG;
- Excavation of the delineated area such that the remaining soil is below the Residential RG;
- Transporation and off-site disposal of soil; and,
- Site restoration activities.

Implementation of this alternative will reduce the concentrations of COIs to levels below the Residential RGs and facilitate clean close out of the site. In addition, implementation of this alternative meets the corrective action objective and is protective of human health and the environment.

13.0 REFERENCES

Adamcik, R.S., A.W. Todd, and L.B. Keith, 1979. *Demographic and Dietary Responses of Red-Tailed Hawks During a Snowshoe Hare Fluctuation*, Canadian Field Naturalist, Vol. 93, pp. 16-27.

Agency for Toxic Substances Disease Registry (ATSDR), 1992a. *Toxicological Profile for Thallium.* Agency for Toxic Substances Disease Registry, Atlanta, GA. July.

Agency for Toxic Substances Disease Registry (ATSDR), 1992b. *Toxicological Profile for Vanadium.* Agency for Toxic Substances Disease Registry, Atlanta, GA. July.

Agency for Toxic Substances Disease Registry (ATSDR), 1999. *Toxicological Profile for Aluminum.* Agency for Toxic Substances Disease Registry, Atlanta, GA. July.

Agency for Toxic Substances Disease Registry (ATSDR), 2000. *Toxicological Profile for Chromium.* Agency for Toxic Substances Disease Registry, Atlanta, GA. September.

Alliant TechSystems, Inc. (ATK), 1998. *Risk Assessment and Closure Certification for the Former Incinerator Spray Pond at the Radford Army Ammunition Plant.* Final. January 1998.

Alliant TechSystems, Inc. (ATK), 2003. *Third Quarter 2003 Sampling Event.* Hazardous Waste Management Units 4, 5, 7, 10, 16, and 39. Prepared by Draper Aden Associates for ATK.

Alexander, M., 1978. *Biodegradation of Toxic Chemicals in Water and Soil.* Proc. 176th National Meeting, Miami Beach, FL, Sept. 10-15, 1978, Vol. 93, American Chemical Society, Division of Environmental Chemistry.

American Public Health Association (APHA), 1992. *Standard Methods for the Examination of Water and Wastewater.* 18th Edition.

American Society for Testing and Materials (ASTM), 1991. *Annual Book of ASTM Standards.*

Austing, G.R., 1964. *The World of the Red-Tailed Hawk*, J. B. Lippincott Co., Philadelphia.

Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor, 1984. *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture*, prepared for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400.

Bartell, S.M., 1996. *Ecological/Environmental Risk Assessment Principles and Practice*, in Kolluru, R., S. Bartell, R. Pitblado et al. (eds), Risk Assessment Management Handbook, McGraw Hill, New York, pp. 4.27-4.28, 10.29-10.33.

Beyer, W.N., 1990. *Evaluating Soil Contamination*, Biological Report 90(2), U.S. Department of the Interior, U.S. Fish and Wildlife Service.

Bolan, N.S., D.C. Adriano, R. Natesa, and B.J. Koo, 2003. *Effects of Organic Amendments on the Reduction and Phytoavailability of Chromate in Mineral Soil*, Journal of Environmental Quality, Volume 32, Number 1, pages 120-128.

Bowen, H.J., 1979. *Environmental Chemistry of the Elements.* New York, London, Academic Press.

Brown, L. and D. Amadon, 1968. *Eagles, Hawks, and Falcons of the World*, Vol. 1, McGraw-Hill Book Company, New York.

Burt, W. H. and R. P. Grossenheider, 1980. *A Field Guide to Mammals*, Peterson Field Guide Series, Hougton Mifflin Co., Boston.

Calabrese, E.T., Stanek, E.J., Gilbert, C.E., and R.M. Barnes, 1990. *Preliminary Adult Soil Ingestion Estimates: Results of a Pilot Study.* Reg. Tox. and Pharma. 12:88-95.

Callahan, M.A. et al., 1979. *Introduction and Technical Background, Metals and Inorganics, Pesticides, and PCBs. Water-Related Environmental Fate of 129 Priority Pollutants.* Volume 1. Report to USEPA, Office of Water Planning and Standards, Washington, D.C., by Versar Incorporated, Springfield, VA. USEPA-440/4-79-029a.

Cherry, J.A., R.W. Gillham, and J.F Barker, 1983. *Contaminants in Groundwater: Chemical Processes.* U.S. Nat. Research Council Geophysics Research Board, Washington, D.C.

Crosby, D.G., A.S. Wong, J.R. Plimmer, and E.A. Woolson, 1971. *Photodecomposition of Chlorinated Dibenzo-p-dioxins.* Science, 173, 748-749.

Crössmann, G., 1984. *Thallium - A New Environmental Contamination?* Angew Bot, 58: 3-10.

CH2M-Hill, 2000. *Review of the Navy - USEPA Region IX BTAG Toxicity Reference Values for Wildlife*, prepared for US Army Biological Technical Assistance Group (BTAG) and U.S. Army Corps of Engineers, prepared by CH2M-Hill, Sacramento, California, March.

Dames & Moore, 1992. *Final Draft VI Report for the Radford Army Ammunition Plant, Virginia.* Prepared for the U.S. Army Toxic and Hazardous Materials Agency.

Downs et al., 1960 in Engineering Field Activity, West, 1998. *Development of Toxicity Reference Values for Conducting Ecological Risk Assessments at Naval Facilities in California*, Interim Final, EFA West, Naval Facilities Engineering Command, United States Navy, San Bruno, California.

Efron, B.N., 1981. *Censored Data and the Bootstrap*, Journal of the American Statistical Association, 74(374), June.

Efron, B. and R.J. Tibshirani, 1993. *An Introduction to the Bootstrap*, Monographs on Statistics and Applied Probability, No. 57, Chapman & Hall.

Efroymson, R. A., G. W. Suter, B. E. Sample, and D. S. Jones, 1997. *Preliminary Remediation Goals for Ecological Endpoints*, Oak Ridge National Laboratory. Report No. ES/ER/TM-162/R2.

Efroymson, R.A., 2001. *Uptake of Inorganic Chemicals from Soil by Plant Leaves: Regression of Field Data*, Environ. Toxicol. Chem., 20:2561-2571.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye, 1988. *The Birders Handbook: A Field Guide to the Natural History of North American Birds*, Simon and Shuster, Inc., New York.

Engineering Field Activity, West, 1998. *Development of Toxicity Reference Values for Conducting Ecological Risk Assessments at Naval Facilities in California*, Interim Final. EFA West, Naval Facilities Engineering Command, United States Navy, San Bruno, California.

Federal Remediation Technology Roundtable (FRTR), 2002. *Remediation Technologies Screening Matrix and Reference Guide, 4th Edition.* U.S. Army Environmental Center, SFIM-AEC-PCT, Aberdeen Proving Ground, MD. January.

Fetter, C.W., 1993. *Contaminant Hydrogeology.* New York: Macmillan Publishing Company.

Ford, K.L., F.M. Applehans, and R. Ober, 1992. *Development of Toxicity Reference Values for Terrestrial Wildlife*, in HMCL/Superfund, 92 Conference & Exhibition Proceedings, Hazardous Materials Control Resources Institute, Greenbelt, Maryland.

Gerritse, R.G. and van Driel, E., 1984. *The Relationship Between Adsorption of Trace Metals, Organic Matter, and pH in Temperate Soils.* Journal of Environmental Quality, 13, 197 - 204.

Gibbs, Lois Marie, 1995. *Dying from Dioxin: A Citizen's Guide to Reclaiming Our Health and Rebuilding Democracy.* Boston: South End Press.

Gilbert, R. O., 1987. *Statistical Methods for Environmental Pollution Monitoring*, van Nostrand Reinhold Co., Inc., New York, New York.

Harrison, F.L. and D.J. Bishop, 1984. *A Review of the Impact of Copper Released into Freshwater Environments.* UCRL-53488. National Technical Information Service, Springfield, VA.

Hilliard H.E., 1992. pp. 1447-66 in *Minerals Yearbook*, Vol 1 Metals and Minerals, United States Department of the Interior, Bureau of Mines.

Howard, Philip H., 1991. *Handbook of Environmental Fate and Exposure Data for Organic Chemicals.* Chelsea, MI: Lewis Publishers, Inc.

International Atomic Energy Agency (IAEA), 1994. *Handbook of Parameter Values for the Protection of Radionuclide Transfer in Temperate Environments*, Technical Reports Series No. 364, Vienna, Austria.

ICF Kaiser Engineers, Inc. (ICF KE), 1999. *RCRA Facility Investigation Reports for Solid Waste Management Units 31, 39, 48, 49, and 58.* Draft document. January 1999. Deliver Order No. 0013, Environmental Services Program Support, DACA31-94-D-0064, January.

IT Corporation (IT), 1998. *Ecological Risk Assessment Approach, Main Manufacturing Plant, New River Unit, Radford Army Ammunition Plant*, Delivery Order No. 0013, Environmental Services Program Support, DACA31-94-D-0064, October.

IT Corporation (IT), 1999. *Screening Ecological Risk Assessment, Radford Army Ammunition Plant*, Delivery Order No. 0013, Environmental Services Program Support, DACA31-94-D-0064, September.

IT Corporation (IT), 2001. *Facility-Wide Background Study Report.* Radford Army Ammunition Plant, Virginia. Final Report. December 2001. Delivery Order No. 0013, Contract No. DACA31–94–D–0064.

IT Corporation (IT), 2002a. *Radford Army Ammunition Plant, Master Work Plan Addendum 012.* Draft Final document. February 2002. Delivery Order No. 0013, Contract No. DACA31–94–D–0064.

IT Corporation (IT), 2002b. *Radford Army Ammunition Plant, Master Work Plan Addendum 009.* Draft Final document. February 2002. Delivery Order No. 008, Contract No. DACA31-94-D-0064.

Janes, S. W., 1984. *Influences of Territory Composition and Interspecific Competition on Red-Tailed Hawk Reproductive Success*, Ecology, 65:862-870.

Jardine, P.M., Fendorf, S.E., Mayes, M.A., Larsen, I.L., Brooks, S.M, and Bailey, W.B., 1999. *Environmental Science & Technology*, Volume 33, Number 17, pages 2939-2944.

Kemper, F.H., 1991. *Thallium.* In: Merian E ed. Metals and Their Compounds in the Environment.

Knox, R.C., D.A. Sabatini, and L.W. Canter, 1993. *Subsurface Transport and Fate Processes.* Lewis Publishers.

Lamparski, L.L., R.H. Stehl, and R.L. Johnson, 1980. *Photolysis of Pentachlorophenol-treated Wood.* Chlorinated dibenzo-p-dioxin formation. Environ. Sci. Technol., 14, 196-200.

Land, C. E., 1975. *Tables of Confidence Limits for Linear Functions of the Normal Mean and Variance*, in Selected Tables in Mathematical Statistics, Vol. III, American Mathematical Society, Providence, Rhode Island.

Liem, A.K.D. and R.M.C. Theelen, 1997. *Dioxins: Chemical Analysis, Exposure, and Risk Assessment.*

Lyman, Warren J. et al., 1990. *Handbook of Chemical Property Estimation Methods.* Washington, D.C.: American Chemical Society.

Makeig, K.S., 1982. *Natural Buffers for Sludge Leachate Stabilization.* Groundwater. Vol. 20, No. 4, July-August, 1982.

Mermut, A.R. et al., 1996. *Journal of Environmental Quality*, Volume 25: pp 845-53.

Miller, G.C., V.R. Hebert, M.J. Miille, R. Mitzel, and R.G. Zepp, 1989. *Photolysis of Octachlorodibenzo-p-dioxin on Soils: Production of 2,3,7,8-TCDD.* Chemosphere, 18, 1265-1274.

Nagy, K. A., 1987. *Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds*, Ecological Monographs, Vol. 57, pp.111-128.

Nestrick, T.J., L.L. Lamparski, and D.I. Townsend, 1980. *Identification of Tetrachlorodibenzo-p-dioxin Isomers at the 1-ng Level by Photolytic Degradation and Pattern Recognition Techniques.* Anal. Chem., 52, 1865-1875.

Olsen, Roger L. and Andy Davis, 1990. *Predicting the Fate and Transport of Organic Compounds in Groundwater.* HMC, May/June 1990. pp. 39-64 and July/Aug 1990. pp. 19-37.

Omernik, J. M., 1986. *Ecoregions of the United States*, Corvallis Environmental Research Laboratory, USEPA.

Palausky, J., S. Kapila, S.E. Manahan, A.F. Yanders, and R.K. Malhotra, 1986. *Studies on Vapour Phase Transport and Role of Dispersing Medium on Mobility of 2,3,7,8-TCDD in Soil.* Chemosphere, 15, 1389-1396.

Pennsylvania State University Cooperative Extension, 1995, *Soil Acidity and Aglime,* Agronomy Facts 3, 1995.

Puri, R.K., T.E. Clevenger, S. Kapila, A.F. Yanders, R.K. Malhotra, 1989. *Studies of Parameters Affecting Translocation of Tetrachlorodibenzo-p-dioxin in Soil.* Chemosphere, 18, 1291-1296.

Rosenblatt, D.H., Miller, T.A., Dacree, J.C., Muul, I., and D.R. Cogley, 1975. *Problem Definition Studies on Potential Environmental Pollutants - II.* Physical, Chemical, Toxicological, and Biological Properties of 16 Substances: U.S. Army Medical Bioengineering Research and Development Laboratory Technical Report 750-9, Fort Detrick, Frederick, Maryland, 289 p.

Sample, B. E., D. M. Opresko, and G. W. Suter, 1996. *Toxicological Benchmarks for Wildlife*: 1996 Revision, prepared for the U.S. Department of Energy by Health Sciences Research Division, Oak Ridge National Laboratory.

Sample, B.E., Beauchamp, J.J., Efroymson, R.A., Suter, G.W., and T.L. Ashwood, 1998a. *Development and Validation of Bioaccumulation Models for Earthworms*, Oak Ridge National Laboratory, Oak Ridge, TN, ER/ES/TM-220.

Sample, B.E., Beauchamp, J.J., Efroymson, R.A., and G.W. Suter, 1998b. *Development and Validation of Bioaccumulation Models for Small Mammals*, Oak Ridge National Laboratory, Oak Ridge, TN, ER/ES/TM-219.

Sample, B.E., Suter, G.W., Beauchamp, J.J., and R.A. Efroymson, 1999. *Literature-Derived Bioaccumulation Models for Earthworms: Development and Validation*, Environ. Toxicol. Chem., Vol. 18, No. 9, 2110-2120.

Smith, I.C. and Carson, B.L., 1977. *Trace Metals in the Environment.* Volume 1: Thallium. Ann Arbor, Ann Arbor Science Publishers.

Suter, G. W., 1993. *Ecological Risk Assessment*, Lewis Publishers, Boca Raton, Florida.

Tannenbaum, L., 2001. *Journal of Human and Ecological Risk Assessment*, Volume 7, No. 1, CRC Press, Boca Raton, Florida, pp. 217-219.

Tannenbaum, L., 2003. *Can Ecological Receptors Really Be at Risk*, Journal of Human and Ecological Risk Assessment, Volume 9, No. 1, CRC Press, Boca Raton, Florida.

Tokunaga, T.K, Wan, J.N., Firestone, M.K., Hazen, T.C., Schwartz, E., Sutton, S.R, and Newville, M., 2001. *Environmental Science & Technology*, Volume 35, Number 15, pages 3169-3174.

URS Corporation (URS), 2003. *Radford Army Ammunition Plant, Final Master Work Plan.* August 2003. Delivery Order No. 0027, Contract No. DACA31-00-D-0011.

U.S. Army Corps of Engineers (USACE), 1998. *Shell for Analytical Chemistry Requirements.* December.

U.S. Army Corps of Engineers (USACE), 2001. *EM200-1-3, Requirements for the Preparation of Sampling and Analysis Plans.*

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), 1976. *Installation Assessment of Radford Army Ammunition Plant.* Records Evaluation Report No. 103.

U.S. Environmental Protection Agency (USEPA), 1979. *Water Related Environmental Fate of 129 Priority Pollutants.* Prepared by Versar, Inc., Springfield, Virginia, NTIS No. PB80-204373, December.

U.S. Environmental Protection Agency (USEPA), 1983. *Methods for Chemical Analysis of Water and Wastes (MCAWW).* Environmental Monitoring and Support Laboratory. Office of Research and Development. USEPA-600/4-79-020.

U.S. Environmental Protection Agency (USEPA), 1986a. *Guidelines for Carcinogen Risk Assessment.* Fed. Reg. 51:33992-34003.

U.S. Environmental Protection Agency (USEPA), 1986b. *Guidelines for the Health Risk Assessment of Chemical Mixtures.* Fed. Reg. 51:34014-34023.

U.S. Environmental Protection Agency (USEPA), 1987. *RCRA Facility Assessment of Radford Army Ammunition Plant, Radford, VA, VAD-21-002-0730.*

U.S. Environmental Protection Agency (USEPA), 1989a. *Risk Assessment Guidance for Superfund*, Volume I, Human Health Evaluation Manual (Part A), Interim Final, Office of Emergency and Remedial Response, Washington, DC, EPA/540/1-89/002.

U.S. Environmental Protection Agency (USEPA), 1989b. *Update to the Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-Dioxins and Dibenzofurans (CDDs and CDFs)*, Part II. U.S. Environmental Protection Agency. Risk Assessment Forum, Washington, DC. March 1989.

U.S. Environmental Protection Agency (USEPA), 1990. *National Oil and Hazardous Substances Pollution Contingency Plan.* Fed. Reg. 55:8666-8865 (March 8, 1990).

U.S. Environmental Protection Agency (USEPA), 1991a. *Risk Assessment Guidance for Superfund.* Volume I: Human Health Evaluation Manual Supplemental Guidance. Standard Default Exposure Factors. Interim Final. Washington, D.C. OSWER Directive 9285.6-03. March 25, 1991.

U.S. Environmental Protection Agency (USEPA), 1991b. *Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions.* OSWER Directive 9355.0-30 Memo from Don R. Clay. April 22, 1991.

U.S. Environmental Protection Agency (USEPA), 1992a. *Supplemental Guidance to RAGS: Calculating the Concentration Term.* Office of Solid Waste and Emergency Response. Publication 9285.7-081. May 1992.

U.S. Environmental Protection Agency (USEPA), 1992b. *Guidelines for Exposure Assessment.* Federal Register 57:22888-22938. May 29, 1992.

U.S. Environmental Protection Agency (USEPA), 1992c. *Dermal Exposure Assessment: Principles and Applications.* Interim Report. Office of Research and Development, Washington, D.C. USEPA/600/8-91/001B. January 1992.

U.S. Environmental Protection Agency (USEPA), 1992d. *Installation Assessment: Radford Army Ammunition Plant, Radford, Virginia.* U.S. Environmental Protection Agency, Office of Research and Development. TS-PIC-92372. June 1992.

U.S. Environmental Protection Agency (USEPA), 1992e. *Revised Guidance on Establishing Soil Lead Cleanup Levels at CERCLA/RCRA Sites.* OSWER Directive 9355.4-08. Memo from Don R. Clay. 24 March 1992.

U.S. Environmental Protection Agency (USEPA), 1993. *Wildlife Exposure Factors Handbook,* Vols. I and II, Office of Research and Development, Washington, DC, EPA/600/R-93/187a.

U.S. Environmental Protection Agency (USEPA), 1994a. *Estimating Exposure to Dioxin-Like Compounds.* External Review Draft. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/6-88/005Ca. June 1994.

U.S. Environmental Protection Agency (USEPA), 1994b. *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities.* USEPA/540/F-94/043.

U.S. Environmental Protection Agency (USEPA), 1994c. *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children.* Office of Emergency and Remedial Response, Washington, DC. USEPA/540/R-93/081. February 1994.

U.S. Environmental Protection Agency (USEPA), 1995a. *Land Use in the CERCLA Remedy Selection Process.* OSWER Directive No. 9355.7-04. May 25, 1995.

U.S. Environmental Protection Agency (USEPA), 1995b. *Assessing Dermal Exposure from Soil.* Hazardous Waste Management Division, Office of Superfund Programs, Region III, Philadelphia, PA. December 1995.

U.S. Environmental Protection Agency (USEPA), 1995c. *Innovative Approaches for Validation of Organic and Inorganic Data – Standard Operating Procedures.* Analytical Services and Quality Assurance Branch. Region III, Philadelphia, PA. June 1995.

U.S. Environmental Protection Agency (USEPA), 1995d. *USEPA Region III Biological Technical Assistance Group (BTAG) Screening Levels,* Philadelphia, PA, 27 pgs, August 9.

U.S. Environmental Protection Agency (USEPA), 1996a. *Soil Screening Guidance: User's Guide.* Office of Solid Waste and Emergency Response. EPA/540/R-96/018. April 1996.

U.S. Environmental Protection Agency (USEPA), 1996b. *Test Methods for Evaluating Solid Waste Physical/Chemical Methods, Update III.* December.

U.S. Environmental Protection Agency (USEPA), 1996c. *Proposed Guidelines for Carcinogen Risk Assessment, Office of Research and Development.* EPA/600/P-92/003c. Washington, DC. April.

U.S. Environmental Protection Agency (USEPA), 1996d. *Risk Assessment Issue Paper for Derivation of a Provisional RfD for Iron.* National Center for Environmental Assessment. Office of Research and Development. Washington, DC. July 23.

U.S. Environmental Protection Agency (USEPA), 1996e. *Drinking Water Standards.* Office of Water. Washington, D.C.

U.S. Environmental Protection Agency (USEPA), 1997a. *Human Health Effects Assessment Summary Tables (HEAST).* Office of Health and Environmental Assessment, Environmental Assessment and Criteria Office, Cincinnati, Ohio. Prepared for Office of

Solid Waste and Emergency Response, Office of Emergency and Remedial Response, Washington, D.C.

U.S. Environmental Protection Agency (USEPA), 1997b. *Exposure Factors Handbook.* Volume I General Factors. Office of Research and Development, Washington, D.C. EPA/600/P-95/002Fa. August 1997.

U.S. Environmental Protection Agency (USEPA), 1997c. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessment,* EPA/540-R-97-006.

U.S. Environmental Protection Agency (USEPA), 1997d. *Technology Alternatives for the Remediation of Soils Contaminated with As, Cd, Cr, and Pb.* EPA/540/S-97-500. August 1997.

U.S. Environmental Protection Agency (USEPA), 1998a. *Risk Assessment Guidance for Superfund.* Volume I: Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments). Interim. Office of Emergency and Remedial Response. USEPA. Washington, D.C. 9285.7-01D. January 1998.

U.S. Environmental Protection Agency (USEPA), 1998b. *Toxicological Review of Hexavalent Chromium.* U.S. Environmental Protection Agency. Washington, DC. August 1998.

U.S. Environmental Protection Agency (USEPA), 1998c. *Clarification to the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities.* USEPA/540/F-98/030. August 1998.

U.S. Environmental Protection Agency (USEPA), 1999a. *Guidelines for Carcinogen Risk Assessment,* Review Draft. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC. NCEA-F-0644. July.

U.S. Environmental Protection Agency (USEPA), Region V, 1999b. *Ecological Data Quality Levels, RCRA Appendix IX Hazardous Constituents,* April.

U.S. Environmental Protection Agency (USEPA), 1999c. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities,* Appendix C – Media-to-Receptor Bioconcentration Factors, USEPA Office of Solid Waste and Emergency Response, EPA 530-D-99-001A, August.

U.S. Environmental Protection Agency (USEPA), 1999d. *Data Requirements and Confidence Indicators for Ecological Benchmarks Supporting Exemption Criteria for the Hazardous Waste Identification Rule (HWIR99),* Office of Solid Waste, October.

U.S. Environmental Protection Agency (USEPA), 2000a. *Radford Army Ammunition Plant Permit for Corrective Action and Waste Minimization.* Permit No. VA1210020730. 31 October 2000.

U.S. Environmental Protection Agency (USEPA), 2000b. *Memorandum Regarding Use of B-Qualified Data from Monica D. Jones (USEPA, Region III, Quality Assurance Team, 3ES20) to Lynn Flowers (USEPA, Region III, Technical Support Section, 3HS42),* dated 27 September 2000.

U.S. Environmental Protection Agency (USEPA), 2000c. *Ecological Soil Screening Level Guidance* – Draft, Office of Emergency and Remedial Response, Washington, D.C., July.

U.S. Environmental Protection Agency (USEPA), 2000d. *Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment – Status and Needs*, Office of Water, Office of Solid Waste, EPA-823-R-00-001, February.

U.S. Environmental Protection Agency (USEPA), 2001a. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. Peer Review Draft. OSWER 9355.4-24.

U.S. Environmental Protection Agency (USEPA), 2001b. *Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual* (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments). Final. Office of Emergency and Remedial Response. Washington, D.C. 9285.7-47. December 2001.

U.S. Environmental Protection Agency (USEPA), 2001c. *Radford Army Ammunition Plant Site Screening Process*, October 26.

U.S. Environmental Protection Agency (USEPA), 2002a. *Calculating Exposure Point Concentrations at Hazardous Waste Sites*. Draft. Office of Emergency and Remedial Response. OSWER 9285.6-10. Washington, DC. July.

U.S. Environmental Protection Agency (USEPA), 2002b. *Blood Lead Concentrations of U.S. Adult Females: Summary Statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III)*. Final. Technical Review Workgroup for Lead. March.

U.S. Environmental Protection Agency (USEPA), 2002c. *User's Guide for the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children Windows® Version*. EPA 9285.7-42. May.

U.S. Environmental Protection Agency (USEPA), 2003a. *Updated Dermal Exposure Assessment Guidance*. Mid-Atlantic Hazardous Site Cleanup, Office of Superfund Programs. USEPA Region III, Philadelphia, PA. June.

U.S. Environmental Protection Agency (USEPA), 2003b. *Human Health Toxicity Values in Superfund Risk Assessments*. OSWER Directive 9285.7-53. Memo from Michael B. Cook. December 5, 2003.

U.S. Environmental Protection Agency (USEPA), 2003c. *Guidelines for Carcinogen Risk Assessment*, Draft Final. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC. EPA/630/P-03/001A, NCEA-F-0644. February.

U.S. Environmental Protection Agency (USEPA), 2003d. *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil*. Office of Solid Waste and Emergency Response. OSWER 9285.7-54. January.

U.S. Environmental Protection Agency (USEPA), 2003e. *Adult Lead Model (ALM) Spreadsheets*. Office of Solid Waste and Emergency Response. On-line, http://www.epa.gov/superfund/programs/lead/products/alm05_03.xls. Last update on 19 May.

U.S. Environmental Protection Agency (USEPA), 2004a. *USEPA Region III Risk-Based Concentration (RBC) Table*. USEPA Region III, Superfund Technical Support Section. April 14, 2004.

U.S. Environmental Protection Agency (USEPA), 2004b. *Risk Assessment Guidance for Superfund (RAGS)*, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R/99/005.

U.S. Environmental Protection Agency (USEPA), 2004c. *Integrated Risk Information System (IRIS)*. Environmental Criteria and Assessment Office, Cincinnati, Ohio.

U.S. Environmental Protection Agency (USEPA), 2004d. *Provisional Peer Reviewed Toxicity Values for Superfund (PPRTV)*. Office of Superfund Remediation and Technology Innovation. On-line, http://www.hhpprtv.ornl.gov/index.shtml. Last updated on 7 June.

U.S. Environmental Protection Agency (USEPA), 2004e. *Adult Lead Model (ALM) Frequently Asked Questions (FAQs)*. Office of Solid Waste and Emergency Response. On-line, http://www.epa.gov/superfund/programs/lead/adult.htm. Last update on 25 April.

U.S. Environmental Protection Agency (USEPA), 2004f. *Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children Windows® Version*, (IEUBKwin v1.0 build 261). March.

Virginia Department of Environmental Quality (VDEQ), 2004. Voluntary Remediation Program, Table 4.1, Non-Cancer Toxicity Data. On-line, http://www.deq.state.va.us/vrprisk/raguide.html. Last update on 25 April.

Virginia Department of Game and Inland Fisheries, 1999. *Biological Survey of the Radford Army Ammunition Plant*; including Threatened, Endangered, and Species of Concern. Prepared for Radford Ammunition Plant, May.

Washington Post, 1995. *Article on the Vultures at Radford Army Ammunition Plant, Radford, Virginia*, 4 April.

Wentsel, R. S., T. W. LaPoint, M. Simini, R. T. Checkai, D. Ludwig, and L. W. Brewer, 1996. *Tri-Service Procedural Guidelines for Ecological Risk Assessments*, U.S. Army Edgewood Research, Development, and Engineering Center, Aberdeen Proving Ground, Maryland.

Whitaker Jr., J. O., 1995. *The Audubon Society Field Guide to North American Mammals*, Alfred A. Knopf, Inc., New York.

World Health Organization (WHO), 1998. *WHO Toxic Equivalency Factors (TEFs) for Dioxin-Like Compounds for Humans and Wildlife*. Summary of WHO Meeting Held in Stockholm, Sweden on June 15-18. World Health Organization, International Programme on Chemical Safety.

Yanders, A.F., C.E. Orazio, R.K. Puri, and S. Kapila, 1989. *On Translocation of 2,3,7,8-Tetrachlorodibenzo-p-dioxin: Time Dependent Analysis at the Times Beach Experimental Site*. Chemosphere, 19, 429-432.

Appendix A
Quality Assurance/Quality Control

This Appendix Contains:

Appendix A-1 Analytical Services and Procedures
Appendix A-2 Quality Assurance/Quality Control Evaluation
Appendix A-3 2002 RFI Field Audit Report

Appendix A-1
Analytical Services and Procedures

ANALYTICAL SERVICES AND PROCEDURES

ANALYTICAL SERVICES

The analytical services for the field investigation program were provided by the following USACE-validated laboratories:

- DataChem Laboratories (DCL), Salt Lake City, UT. DCL used USEPA-SW846, 3rd ed., Test Methods for Evaluating Solid Waste, Update III (USEPA, 1996e) methodologies in providing analytical support for this project for every parameter except dioxins/furans, total petroleum hydrocarbons (TPH), grain size, and total organic halides (TOX). These parameters were subcontracted by DCL. DCL used Standard Methods for the Examination of Water and Wastewater, 18th Edition (APHA, 1992) for hardness and USEPA Methods for Chemical Analysis of Water and Wastes (MCAWW) (USEPA, 1983) for perchlorate and chemical oxygen demand (COD).
- Southwest Laboratory of Oklahoma, Inc. (SWOK), Broken Arrow, OK. SWOK used USEPA-SW846, 3rd ed., Test Methods for Evaluating Solid Waste, Update III (USEPA, 1996e) methodologies in providing analytical support for dioxins/furans.
- Mountain States Analytical, Inc. (MSAI), Salt Lake City, UT. MSAI used USEPA-SW846, 3rd ed., Test Methods for Evaluating Solid Waste, Update III (USEPA, 1996e) methodologies in providing analytical support for TOX and used USEPA's Office of Water methodology (USEPA, 1999c) in providing analytical support for TPH.
- Applied Geotechnical Engineering Consultants, Inc. (AGEC), Sandy, UT. AGEC used American Society for Testing and Materials (ASTM) (ASTM, 1991) in providing support for grain size analysis.

ANALYTICAL PROCEDURES

Analytical protocols used were in accordance with USEPA-approved methods for the analysis of environmental (i.e., organic, inorganic, and physical parameters) and waste characterization samples. The methodologies for environmental samples are summarized in **Table A-1** and for waste characterization samples in **Table A-2**. A brief discussion of the methodologies is presented in the following sections below.

Organics

Target compound list (TCL) VOCs, TCL SVOCs, TCL pesticides, TCL polychlorinated biphenyls (PCBs), herbicides, explosives, including nitroglycerin (NG) and pentaerythritol tetranitrate (PETN), polynuclear aromatic hydrocarbons (PAHs), dioxins/furans, and total petroleum hydrocarbons (TPH) were analyzed using USEPA-approved methodologies. The laboratory procedures and methodologies for organic compounds are summarized below.

TCL VOCs. Samples were analyzed for TCL VOCs using USEPA SW-846 Method 5030B/8260B for aqueous samples and USEPA SW-846 5035B/8260B for solid matrices using purge and trap technology. Soil samples were collected using an EnCore sampling device and subsequently sent to the laboratory for analysis. No sodium bisulfate was added to the soils due to the possibility of effervescence and ketone formation. An inert gas is bubbled through a mixture of reagent water and 5 gram soil sample or through a 25 mL aqueous sample contained

Table A-1
Summary of Analytical Methods for Environmental Samples

Parameter	Matrix	Analytical Method
TCL VOCs	Aqueous	USEPA SW-846 5030B/8260B
	Solid	USEPA SW-846 5035B/8260B
TCL SVOCs	Aqueous	USEPA SW-846 3510C/8270C
	Solid	USEPA SW-846 3550C/8270C
TCL Pesticides	Aqueous	USEPA SW-846 3510C/8081A
	Solid	USEPA SW-846 3550C/8081A
TCL PCBs	Aqueous	USEPA SW-846 3510C/8082
	Solid	USEPA SW-846 3550C/8082
Herbicides	Aqueous	USEPA SW-846 8151A
	Solid	USEPA SW-846 8151A
Explosives	Aqueous	USEPA SW-846 8330
	Solid	USEPA SW-846 8330
Nitroglycerin	Aqueous	USEPA SW-846 8332
	Solid	USEPA SW-846 8332
PETN	Aqueous	USEPA SW-846 8332
	Solid	USEPA SW-846 8332
Polynuclear Aromatic Hydrocarbons	Aqueous	USEPA SW-846 3510C/8270C SIM
	Solid	USEPA SW-846 3550C/8270C SIM
Total Petroleum Hydrocarbons	Solid	USEPA 1664
TAL Metals	Aqueous	USEPA SW-846 3015A/6010B; 3010(Mod.)/6020; and 7470A
	Solid	USEPA SW-846 3051A/6010B; ILM05.0 Draft/6020; 7471A
TAL Dissolved Metals	Aqueous	USEPA SW-846 3015A/6010B; 3010(Mod.)/6020; and 7470A
Dioxins/Furans	Aqueous	USEPA SW-846 8290
	Solid	USEPA SW-846 8290
Perchlorate	Aqueous	USEPA 314.0
pH	Solid	USEPA SW-846 9045C
Grain Size	Solid	ASTM Method D-422
Hardness	Aqueous	SM 2340B (Calc.)
Total Organic Carbon	Aqueous	USEPA SW-846 9060A
	Solid	USEPA Lloyd Kahn
Total Organic Halides	Aqueous	USEPA SW-846 9020B
Asbestos	Solid	USEPA 600/R-93/116

Table A-2
Summary of Analytical Methods for Waste Characterization Samples

Parameter	Matrix	Analytical Method
TCLP VOCs	Aqueous	USEPA SW-846 1311/5030B/8260B
	Solid	USEPA SW-846 1311/5030B//8260B
TCLP SVOCs	Aqueous	USEPA SW-846 1311/3510C/8270C
	Solid	USEPA SW-846 1311/3550C/8270C
TCLP Metals	Aqueous	USEPA SW-846 1311/3015A/6010B/7470A
	Solid	USEPA SW-846 1311/3015A/6010B/7471A
TCLP Pesticides	Aqueous	USEPA SW-846 1311/3510C/8081A
	Solid	USEPA SW-846 1311/3550C/8081A
TCL PCBs	Aqueous	USEPA SW-846 3510C/8082
	Solid	USEPA SW-846 3550C/8082
Chemical Oxygen Demand	Aqueous	USEPA 410.4
Corrosivity as pH	Aqueous	USEPA SW-846 9040B
	Solid	USEPA SW-846 9045C
Reactive Cyanide	Aqueous	USEPA SW-846 Chapter 7.3.3
	Solid	USEPA SW-846 Chapter 7.3.3
Reactive Sulfide	Aqueous	USEPA SW-846 Chapter 7.3.4
	Solid	USEPA SW-846 Chapter 7.3.4
Ignitability	Aqueous	USEPA SW-846 1010
	Solid	USEPA SW-846 Chapter 7.1.2.2

in a specifically designed purging chamber at 40°C for solid and ambient temperature for water. The vapor was swept through a sorbent column where the purgeable compounds were trapped. After purging was completed for both solid and aqueous samples, the sorbent column was heated and backflushed with the inert gas to desorb the purgeable compounds onto a gas chromatograph programmed to separate the purgeable compounds, which are then detected with a mass spectrometer.

TCL SVOCs/PAHs. Samples were analyzed for TCL SVOCs/PAHs using USEPA SW-846 Method 8270C. The use of selective ion monitoring (SIM) using USEPA SW-846 Method 8270C SIM was employed for PAH analysis to achieve lower quantitation and detection limits in order to meet screening criteria. Solid samples were extracted using soxhlet according to USEPA SW-846 Method 3550C and aqueous samples were extracted using a continuous liquid-liquid extraction technique according to USEPA SW-846 Method 3510C. The extract was injected into a gas chromatograph programmed to separate the compounds, which are then detected with a mass spectrometer.

TCL Pesticides/PCBs. Samples were analyzed for TCL pesticides using USEPA SW-846 Method 8081A and for TCL PCBs using USEPA SW-846 Method 8082. Aqueous and solid samples were prepared for analysis using extraction techniques. Solid samples were extracted

using soxhlet method USEPA SW-846 Method 3550C for samples. Aqueous samples were extracted using a continuous liquid-liquid extraction technique by USEPA SW-846 Method 3510C. The extract was injected onto a gas chromatography programmed to separate the compounds, which are then detected with an electronic capture device (ECD). Sulfur cleanups were employed to aid in the quantification based upon the matrix interferences. Sample concentrations were confirmed on dissimilar columns.

Herbicides. Samples were analyzed for herbicides according to USEPA SW-846 Method 8151A. Aqueous and solid samples were extracted with diethyl ether and then esterified with diazomethane. The derivatives are determined by gas chromatography with an electron capture detector (GC/ECD). The results were reported as acid equivalents. Sample concentrations were confirmed on dissimilar columns.

Explosives. Samples were analyzed for explosives using USEPA SW-846 Method 8330. Aqueous samples of low concentration were extracted by a salting-out extraction procedure with acetonitrile and sodium chloride. The small volume of acetonitrile that remained undissolved above the salt water was drawn off and transferred to a smaller volumetric flask. It was back extracted by vigorous stirring with a specific volume of salt water. After equilibration, the phases were allowed to separate and the small volume of acetonitrile residing in the narrow neck of the volumetric flask was removed. The concentrated extract was diluted with reagent grade water, and an aliquot is separated on a C-18 reverse phase column. The wavelength was set at 254 nanometers and confirmed on a cyanide reverse column. Solid samples were extracted using acetonitirile in an ultrasonic bath, then filtered and chromatographed similarly to aqueous samples. Sample concentrations were confirmed on dissimilar columns.

NG/PETN. Samples were analyzed for NG/PETN using USEPA SW-846 Method 8332. Solid samples were extracted with acetonitrile in an ultrasonic bath, then filtered and mixed with a calcium chloride solution. Aqueous samples were extracted according to USEPA SW-846 Method 8330, using a double salting-out procedure with acetonitrile. The extract is mixed with calcium chloride just prior to analysis. The concentration was quantified using an isocratic HPLC system equipped with a column heater and UV detector. Sample concentrations were confirmed on dissimilar columns.

Dioxins/furans. Samples were analyzed for dioxin/furans using USEPA SW-846 Method 8290. The analytical method used high-resolution gas chromatography and high-resolution mass spectrometry (HRGC/HRMS) on purified sample extracts. This method is specific for the analysis of 2,3,7,8-tetrachlorinated dibenzofuran (2,3,7,8-TCDD), substituted penta-, hexa-, hepta- and octachlorinated dibenzo-p-dioxins and substituted penta-, hexa-, hepta- and octachlorinated dibenzofurans in water and solid samples. The extracts were injected onto a high-resolution gas chromatograph programmed to separate the compounds, which are then detected with a high-resolution mass spectrometer as confirmation.

TPH. Samples were analyzed for solids for TPH-Hexane Extractable Material (HEM) using USEPA Method 1664. A representative portion of soil sample was acidified and chemically dried with acidified sodium sulfate. The HEM was extracted with n-hexane using a sonication method. The n-hexane is then filtered into a pre-weighed vessel and evaporated. The vessel was desiccated and weighed. The HEM was re-dissolved in n-hexane. Silica gel was added to the HEM, shaken, filtered, and evaporated for silica gel treated-HEM determination.

Inorganics

Target analyte list (TAL) metals, mercury, cyanide, and hardness were analyzed using USEPA SW-846 methodologies. Perchlorate was analyzed using USEPA MCAWW methodologies. The laboratory procedures for inorganic compounds are summarized below.

TAL Metals/Hardness. TAL metals and hardness were analyzed using a combination of the following methodologies: inductively coupled plasma (ICP), ICP/ mass spectroscopy (MS), and cold vapor atomic absorption (CVAA). Trace metals were analyzed using USEPA SW-846 Methods 3015A/6010B and 3010(Mod.)/6020 for aqueous samples and Methods ILM05.0 Draft/6020 and 3051A/6010B for solid samples. Total hardness was calculated from the calcium and magnesium concentrations using Standard Method 2340B. The ICP method involved the simultaneous or sequential multi-element determination of trace elements in solution. The basis of the method is the measurement of atomic emission by optical spectrometry. Samples were nebulized and the aerosol that was produced was transported to the plasma torch where excitation occurs. Characteristic atomic-line emission spectra are produced by a radio-frequency ICP. A background correction technique was utilized to compensate for variable background contribution for the determination of trace elements.

Mercury was analyzed using CVAA according to USEPA SW-846 Method 7470A for aqueous samples and Method 7471A for solid samples. A sample aliquot was initially digested with nitric acid to free combined mercury. The mercury was then reduced to its elemental state and aerated from the solution into a closed system. The mercury vapor was passed through a cell positioned in the path of the mercury light source and the measured abundance was proportional to the concentration of mercury in the sample.

Perchlorate. Perchlorate was analyzed using ion chromatographic method USEPA MCAWW Method 314.0 for aqueous samples. Perchlorate was measured by the peak height or area generated from the sample elution through an anion separator column with a conductivity detector.

Waste Characterization

Samples collected to characterize investigative-derived materials were analyzed for hazardous waste characteristics using USEPA-approved methodologies., including toxicity characteristic leachate procedure (TCLP) VOCs, TCLP SVOCs, TCLP metals, TCLP pesticides, TCL PCBs, chemical oxygen demand (COD), corrosivity as pH, reactive cyanide, reactive sulfide, and ignitability. The laboratory procedures and methodologies are summarized below.

TCLP Extraction. Soil samples collected for material characterization were extracted using the USEPA SW-846 Method 1311. The final liquid extract was separated from the solid material and combined with the initial liquid phase (if applicable). The sample TCLP extract was then treated as an aqueous sample for analysis for VOCs, SVOCs, pesticides, and metals.

Reactivity. Reactivity comprises of reactive sulfide and reactive cyanide. Reactive sulfide was analyzed in aqueous and solid samples using USEPA SW-846 Method Chapter 7.3.4. This procedure was a colorimetric determination. Sulfide reacted with dimethyl-p-phenylenediamine in the presence of ferric chloride to produce methylene blue. Reactive cyanide was analyzed in aqueous and solid samples using USEPA SW-846 Method Chapter 7.3.3.

Ignitability. Ignitability was analyzed using USEPA SW-846 Method 1010 for aqueous samples and USEPA SW-846 Method Chapter 7.1.2.2 for solid samples. A samples was heated at a slow, constant rate with continual stirring. A small flame was directed into the cup at regular

intervals with simultaneous interruption of stirring. The flash point was the lowest temperature at which application of the test flame ignited the vapor above the sample.

Corrosivity as pH. Corrosivity as pH was analyzed using USEPA SW-846 Method 9040B for aqueous samples and Method 9045C for solid samples. A sample pH was directly measured electrometrically using either a glass electrode in combination with a reference potential or a combination electrode. For solids, samples were mixed 1:1 with reagent water prior to measurement.

COD. COD was analyzed using USEPA MCAWW Method 410.4. A sample was heated under acidic conditions at a slow, constant rate in an oven or block digestor in the presence of dichromate at 150°C for two hours. The COD was measured at 600 nm spectrophotometrically.

Physical Analyses

Grain size. Grain size distribution was determined using ASTM Method D-422 for solid samples. A No. 200 sieve was used to separate particles larger than 75 micrometer (μm) from the soil, while the distribution of particles smaller than 75 μm was determined by a sedimentation process, using a hydrometer to secure the necessary data.

TOC. Samples were analyzed for TOC using the USEPA Kahn Method for solid samples. Samples were subjected to either a catalytic combustion or wet chemical oxidation to convert the organic carbon in the sample to carbon dioxide. The carbon dioxide formed was then measured directly by an infrared detector or converted to methane and measured by a flame ionization detector. The amount of carbon dioxide or methane produced was directly proportional to the concentration of carbonaceous material.

TOX. Aqueous samples were analyzed for TOX using USEPA SW-846 Method 9020B. Samples were passed through a conditioned column containing activated carbon, which adsorbs the organohalides. The activated carbon was then combusted to convert the organohalides to hydrogen halide, which was trapped and titrated electrolytically using a microcoulometric detector.

pH. Samples were analyzed for pH using USEPA SW-846 Method 9045C for solid samples. A sample pH was directly measured electrometrically using either a glass electrode in combination with a reference potential or a combination electrode. For solids, samples are mixed 1:1 with reagent water prior to measurement.

Asbestos. Samples were analyzed for asbestos using method USEPA 600/R-93/116. Samples were ground to insure homogeneity. A polarizing light microscope equipped with 10x and 16x objectives and a 10x eyepiece was used for the analysis. If present, asbestos identities were confirmed with the appropriate refractive index liquids applying dispersion staining techniques. The area percentages of asbestos and other fibrous constituents were estimated microscopically by a visual examination of the fibers with an aspect ratio of 3:1 or greater. For the purposes of the reports generated, fiberglass was defined as fibrous glass with parallel sides and mineral wool was defined as fibrous glass with nonparallel sides.

Appendix A-2
Quality Assurance/Quality Control Evaluation

QUALITY ASSURANCE/QUALITY CONTROL EVALUATION

An independent Quality Assurance Project Plan Addendum (QAPA) was developed as part of MWP Addendum 012 (IT, 2002a). The QAPA was implemented through the integration of well-defined quality control elements for activities associated with the task assignment. The quality control criteria defined for sampling and analysis activities were developed in conjunction with specifications contained in USACE EM200-1-3, *Requirements for the Preparation of Sampling and Analysis Plans*, (USACE, 2001) as well as the *USACE Shell Guidance for Analytical Chemistry* (USACE, 1998).

Table A-3 outlines the data quality indicators as to their definitions, project goals, sampling and analytical assessments. Data quality was assessed through the evaluation of sampling activities and field measurements associated with the chemical analytical data in order to assess the reliability of the chemical analyses and the accuracy and precision of information acquired from the laboratory.

Table A-3
RFI Data Quality Indicators

Data Quality Indicator	Definition	Goal	Sampling Assessment	Analytical Assessment
Precision	Quantitative measure of the variability of a group of measurements in comparison to the average value	Low relative percent difference	Duplicate samples	MS/MSD or lab sample duplicate; Field sample duplicate
Accuracy	Bias in a measurement system	Low bias	Blank contamination	Analysis spike results (LCS, MS)
Representativeness	Degree to which the measured results accurately reflect the medium being sampled	100%	Holding times, blanks, associated documentation	Inferred from accuracy, precision, and completeness evaluation
Completeness	Percentage of measurements which are judged to be usable	98±2%	Records review	Data validation
Comparability	Qualitative parameter expressing the confidence with which one data set can be compared with another	High	Work plans, quality documents	Analytical methods
Sensitivity	Quantitative measure of the level of detection and quantitation.	High	Review of analytical method or procedures and instrumentation	Analysis of MDL studies and practical quantitation limits per analytical method and matrix

Review of Documentation

The following documentation was required by the field investigation program in order to provide a quality assessment of data collected during routine investigative activities:

- **Field Logbooks:** Hardback logbooks with numbered pages were used to log daily activities, and data collected during the course of field activities. Designated logbooks

were also used to record calibration records and equipment maintenance as they were performed. Entries into field logbooks were evaluated for completeness and accuracy.

- **Field Parameter Forms:** Documentation of collected samples was provided to the laboratory on parameter forms developed by Shaw specifically for USACE investigations. Field Parameter Forms were electronically generated based on information recorded in field logbooks and were completed at the time of shipment to be included with the Chain-of-Custody for every sample, including QC samples. The completed forms contained the required information for encoding chemical data into ERIS database.
- **Chain-of-Custody:** Samples were collected and relinquished under stringent Chain-of-Custody protocols as specified in the project QA plan. A review of the Chain-of-Custodies identified transcription errors that were corrected by drawing a single line through the incorrect information and subsequently correct information was supplied, dated, and initialed.
- **Sample Tracking Table:** Documentation of collected samples was recorded in an electronic sample tracking table on a daily basis. Field entries included the field sample identification, sample depth (where applicable), date collected, chain of custody and/or field parameter form number, and laboratory analyses requested.

Sampling activities were performed in compliance with standard operating procedures (SOPs) and each individual performing sampling was aware of the requisite protocols for collection of environmental samples. A copy of the 2002 RFI field audit report performed by the Shaw Project QA Manager is presented as **Appendix A-3**. There were no significant non-conformances found during the audit.

Data Reporting

Data packages were provided to Shaw in CLP-like deliverables with electronic data deliverable files from the laboratory. Detected target compound values above the reporting limit and within the acceptable calibration range were reported as determined to no more than three significant figures. Target analytes detected below the lower calibration standard or reporting limit and above the method detection limit were reported as estimated values. Appropriate data qualifiers were applied during validation process and recorded in an electronic database.

Data Reduction and Validation

Data validation determines the acceptability or unacceptability of the data quality based on a set of pre-defined criteria. Data validation is defined as the systematic process for reviewing a data package against a set of criteria to provide assurance that the data is adequate for its intended uses. These criteria depend upon the type(s) of data involved and the purpose for which data are collected. The intended use of the data and the associated acceptance criteria for data quality was identified before the data collection effort began. Both the organic and inorganic chemical data (except for the waste characterization) were validated. The data were validated in accordance with MWP QAP requirements (URS, 2003), USACE Shell requirements (USACE, 1998), method-specific criteria from USEPA-SW846, Third Edition, Test Methods for Evaluating Solid Waste, Update III (USEPA, 1996e), and laboratory SOPs. The data qualifier scheme was consistent with USEPA Region III conventions using the USEPA Region III Modifications to National Functional Guidelines for Inorganic Data Review (USEPA, 1993b),

USEPA Region III Modifications to the National Functional Guidelines for Organic Data Review Multi-media, Multi-concentration (USEPA, 1994c), and the USEPA Region III Dioxin/Furan Data Validation Guidance (USEPA, 1999d) as appropriate.

Data packages were validated to ensure compliance with specified analytical, Quality Assurance/Quality Control (QA/QC) requirements, data reduction procedures, data reporting requirements, and required accuracy, precision, and completeness criteria. This includes (as applicable), but is not limited to:

- Sample preservation and holding times;
- Instrument performance check;
- Calibration (initial and continuing);
- Blanks (calibration, preparatory, rinse, trip);
- Matrix spike and spike duplicate recoveries;
- Laboratory and field sample duplicate pairs;
- Surrogate spike recoveries;
- Laboratory control samples;
- Interference check sample (for metals);
- Serial dilution (for metals);
- Internal standards and retention times (for GC/GC/MS/IC); and,
- Quantitative verification.

Results were assessed for accuracy and precision of laboratory analysis to identify the limitations and quantity of data. The data validation reports are presented in the beginning of this appendix. The quality of the data collected in support of the sampling activity was considered acceptable, unless qualified rejected "R" during the validation process. Samples qualified "B" for blank contamination were considered non-detect at the MRL or level of blank contamination, whichever was greater. Samples qualified "J", "UJ", "L", "UL", or "K" were considered acceptable as estimated.

Data Review

Data obtained from both the laboratory and data validation were reviewed by the Shaw Project Chemist to assess whether the project-specific data quality objectives, as defined in the associated QAP, were met.

Data Quality Objectives

Data quality objectives were developed concurrently with the Work Plan to ensure: (1) the reliability of field sampling, chemical analyses, and physical analyses; (2) the collection of sufficient data; (3) the quality of data generated was acceptable for its intended use; and (4) valid assumptions could be inferred from the data. Attainment of data quality objectives was assessed through evaluation of data collected using the following data quality indicators:

- **Precision** - a quantitative measure of the variability of a group of measurements in comparison to the average value;
- **Accuracy** - the bias in a measurement system;
- **Representativeness** - the degree to which the measured results accurately reflect the medium being sampled. Representativeness will be assessed based on accuracy, precision, and completeness;
- **Completeness** - the percentage of measurements which are judged to be useable;
- **Comparability** - defined as a qualitative parameter expressing the confidence with which one data set can be compared with another; and,
- **Sensitivity** - describes the method detection, quantitation, and reporting limits. It also may be expressed as the slope of the analytical curve (intensity verses concentration).

Data quality was assessed through the evaluation of sampling activities and field measurements associated with the chemical data in order to verify the reliability of the chemical analyses and the accuracy and precision of information acquired from the laboratory.

Precision. Method or laboratory precision performed by the laboratory was evaluated during the validation process. Overall sampling or field precision was evaluated during the data review process. Precision is measured by calculating and evaluating the relative percent difference (RPD) between the results of field or laboratory duplicates. The RPD is calculated by the following equation:

$$\text{RPD}\ (\%) = \frac{/XA - XB/}{XM * 100}$$

Where:
XA and XB are duplicate analyses, and
XM is the mean value [(XA + XB)/2] of the duplicate analyses.

The RPD was calculated for those analytes which were detected at levels exceeding the method detection limits in both samples of the duplicate pair. Analytes that were qualified because of blank contamination (B-qualified) or were rejected (R-qualified) in either sample of the duplicate pair were excluded from the duplicate assessment. Analytical results were qualified as estimated (J) for RPDs exceeding criteria for both the sample and its duplicate pair.

Laboratory duplicate sample determinations were used to demonstrate acceptable method precision by the laboratory at the time of analysis and evaluated. Laboratory precision was performed either on the sample and its duplicate pair or the matrix spike and its spike duplicate pair. Duplicate analyses were performed to generate data in order to assess the long-term precision of the analytical method on various matrices. RPDs must be within established control limits.

- **Laboratory and Field Duplicate Analysis.** Laboratory duplicate pairs or laboratory spiked duplicate pairs were evaluated for SWMU39. Laboratory duplicate pairs or laboratory spiked duplicate pairs were within specified precision criteria for each parameter and/or compound except for chromium, magnesium, nickel, antimony, arsenic,

cadmium, lead, and thallium. Analytical results were qualified as estimated (J) for RPDs exceeding criteria for where the associated compounds were detected. While these parameters were qualified estimated due to the high RPDs, the data was still considered useable, the precision data quality goal was met, and the qualified data did not impact the data quality for the RFI. Further discussion may be found in the data validation reports located on a CD at the back of this report.

Field duplicates were collected during the RFI on a 10% frequency per matrix to identify the cumulative precision of the sampling and analytical process, which includes the homogenization of soil samples. Precision control criterion was established at 35% RPD for the soil samples. Field precision frequency was conducted on a site-wide basis. Field duplicates were not collected at SWMU 39 because a 10% frequency had not yet been obtained for soil, therefore the precision data quality goal was met and no impact reflected toward the data quality for the RFI.

Accuracy. Accuracy is the measure of bias in a system. The accuracy of the results is measured by percent recovery (%R). Laboratory analytical accuracy was assessed through the use of laboratory blanks (method and instrument), rinse blanks, laboratory control samples (LCSs), and matrix spikes (MSs). Laboratory analytical accuracy was reviewed during the validation of data. Sampling accuracy was assessed by evaluating blank contamination and the impact of contaminant contributions originating from non-point sources, such as field sampling equipment decontamination procedures, or laboratory contamination. QC samples evaluated for this assessment included equipment blanks and laboratory method or preparatory blanks. The data validation qualifiers would be applied for analytical non-conformances as outlined in the USEPA Region III validation guidance. For non-spiked samples, accuracy was measured by the following equation:

$$\%R = \frac{\text{test value}}{\text{true value}} * 100$$

For spiked samples, accuracy was measured by the following equation:

$$\%R = \frac{\text{test value - spiked value}}{\text{true value}} * 100$$

Method blanks, laboratory control samples, matrix spikes, and rinse blanks discussion follows. Method blanks, laboratory control samples, matrix spikes, and rinse blanks were evaluated.

Method and Calibration Blanks. A method blank is a volume of analyte-free water or soil that is processed through the entire analytical scheme (i.e., extraction, digestion, concentration, and analysis) as with the actual samples. Method blanks monitor potential laboratory-induced contamination. Results were qualified "B" for blank contamination by the laboratory and/or through the data validation process. In accordance with USEPA Region III data validation

guidelines, reported sample results were considered "non-detect" and qualified with the letter "B" if the detected sample concentration was within 5 times (10 times for common laboratory contaminants: methylene chloride, acetone, 2-butanone, OCDD/OCDF, and common phthalate esters) the concentration in the associated method blank. The method blank contamination assessment was evaluated during the data validation process and may be found in the data validation reports located on a CD at the back of this report. Method blanks were calculated and compared against the same matrix environmental samples on a batch specific basis. No unit conversions were necessary for method blanks since they were treated in the same manner as the samples. Calibration blanks were also compared against the environmental samples for select parameters. Calibration blanks are aqueous samples and were reported in µg/L or mg/L units. Performing blank assessments for solid matrix samples, action levels were calculated and expressed in soil units µg/kg or µg/g from the given aqueous rinse blank concentrations to be compared against actual solid sample concentrations. This conversion is dependent upon the method performed, sample amounts used, and final digestate or extract volumes used during the analytical analysis. Action levels were based upon 100% solids and 1x dilution factor and adjusted for each sample as appropriate.

- **Method and Calibration Blank Analysis.** Method and calibration blanks were within specified criteria for each parameter and/or compound except for calcium, silver, magnesium, vanadium, lead, selenium, bis(2-ethylhexyl)phthalate, di-n-octylphthalate, 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,6,7,8-HpCDF, total HpCDD, OCDD, and TOC. Select samples were qualified "B" for silver and 1,2,3,4,6,7,8-HPCDF and were considered non-detect at the MRL or level of contamination, whichever was greater. While these noted parameters were qualified "B" due to the blank contamination, the data was still considered useable, the accuracy data quality goal was met, and the qualified data did not impact the data quality for the RFI. For each of the other noted analytes, the samples were either non-detect for that compound or greater than the blank action level.

Laboratory control samples. The LCSs were analyzed to assess general method performance by the ability of the laboratory to successfully recover the target analytes from a control matrix. The LCS is similar in composition to the method blank. For aqueous analyses, spiked analyte-free reagent water was used. For soil analyses, a purified solid matrix (e.g., sand, sodium sulfate, or other purified solid) was used. The LCSs were spiked with single-component target analytes before it is carried through the preparation, cleanup, and determinative procedures. LCSs were performed at a rate of one per preparation batch per matrix. When samples were not subjected to a separate preparatory procedure (i.e., purge and trap VOC analyses, or aqueous Hg analysis), the CCV may have been used as the LCS, provided the CCV acceptance limits were used for evaluation.

- **Laboratory Control Sample Analysis.** The results of the LCS were evaluated, in conjunction with other QC information during the data validation process to ascertain the acceptability of the data generated for that batch of samples. LCSs were within specified criteria for each parameter and/or compound except for 4-amino-2,6-dinitrotoluene, acetone, 2-butanone, acetone, cis-1,3-dichloropropene, and trans-1,3-dichloropropene, and 2-hexanone. Acetone for select samples was qualified based upon these outliers. Each of the other compounds with high LCS recoveries were non-detect for associated samples, therefore no qualifiers were applied based upon these outliers. While LCS recoveries were outside criteria, the data was still considered useable, the accuracy data

quality goal was met, and the qualified data did not impact the data quality for the RFI. Further details may be found in the data validation reports located on a CD at the back of this report.

Matrix spikes. The MS was used to assess the performance of the method as applied to a particular project matrix. An MS is an environmental sample to which known concentrations of certain target analytes have been added before sample manipulation from the preparation, cleanup, and determinative procedures have been implemented. The original field sample was mixed or shaken to ensure homogeneous fractions when allowed by the method. MSs were performed at a rate of one per preparation batch or 5% whichever was more frequent per matrix. The results of the MS are evaluated, in conjunction with other QC information during the validation process to assess the effect of the matrix on the bias of the analysis.

- **Matrix Spike and Matrix Spike Duplicate Analysis.** Matrix spikes and matrix spike duplicates were within specified criteria for each parameter and/or compound except for 2,4-DB, 2,4-D, dicamba, dinoseb, chromium, silver, antimony, mercury, zinc, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, styrene, trichloroethene bromoform, chlorobenzene, dibromochloromethane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, and endrin aldehyde. Samples were qualified as applicable. While qualification was applied due to high or low MS or MSD recoveries, the data was still considered useable, the accuracy data quality goal was met, and the qualified data did not impact the data quality for the RFI. Further details may be found in the data validation reports located on a CD at the back of this report.

Rinse blanks. The blank contamination assessment was performed to assess the impact of contaminant contributions originating from non-point sources, such as field sampling equipment decontamination procedures. Rinse blanks are intended to identify cross-contamination between samples as a result of sampling equipment decontamination procedures. Rinse blanks were collected by pouring the required volume of deionized, organic-free water over the equipment and collecting the water in the appropriate sample containers. Rinse blanks were performed at a rate of one per 20 samples collected or 5% per matrix per sampling technique. The rinse blank results were evaluated to ascertain the efficiency of decontamination and assess the potential for cross-contamination. Rinse blanks were analyzed for the analytes of concern for the RFI. In accordance with USEPA Region III data validation guidelines, the detected concentration in the sample was qualified "B" for blank contamination and was considered non-detect if the sample concentration was within five times (10 times for common laboratory contaminants such as acetone, 2-butanone, methylene chloride, OCDD/OCDF, and phthalate esters) the concentration in the associated equipment blank. Rinse blanks are aqueous samples and were reported in µg/L or mg/L units. Performing blank assessments for solid matrix samples, action levels were calculated and expressed in soil units µg/kg or µg/g from the given aqueous rinse blank concentrations to be compared against actual solid sample concentrations. This conversion is dependent upon the method performed, sample amounts used, and final digestate or extract volumes used during the analytical analysis. Action levels were based upon 100% solids and 1x dilution factor and adjusted for each sample as appropriate.

- **Rinse Blank Analysis.** Soil rinse blanks included samples 061102R, 061902R1, 071002R2, and 072502RB. The maximum concentration from these rinse blanks was used for this assessment. The soil rinse blanks included samples 071002R1 and

071002R2 for dioxin/furans. Rinse blanks were within specified criteria for each parameter and/or compound except for OCDD, 1,3,5-trinitrobenzene, 2-nitrotoluene, 4-nitrotoluene, PETN, nitroglycerine, 2,4-DB, MCPP, antimony, beryllium, cadmium, lead, calcium, chromium, iron, manganese, sodium, naphthalene, 2-methylnaphthalene, acenaphthene, 4,4'-DDE, 4,4'-DDT, lindane, phenol, benzyl alcohol, 2-methylphenol, 4-methylphenol, benzoic acid, diethylphthalate, di-n-butylphthalate, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, acetone, carbon disulfide, methylene chloride, chloroform, carbon tetrachloride, bromodichloromethane, 4-methyl-2-pentanone, toluene, and m&p-xylene. Select samples were qualified "B" as applicable and were considered non-detect at the MRL or level of contamination, whichever was greater. While these parameters were qualified "B" due to the blank contamination, the data was still considered useable, the accuracy data quality goal was met, and the qualified data did not impact the data quality for the RFI. A discussion of the blank results is provided within each validation report (located on a CD at the back of this report). **Table A-4** indicates those data that are "B" flagged due to blank contamination and should be considered non-detect. Those compounds that were detected in both the blanks and the associated samples below the USEPA guidance blank action levels are listed.

Table A-4
B-Qualified Data Summary

Field ID	Analyte	Result	Lab Qual.	Units
39SB05A	Antimony	0.40	B	mg/kg
39SB05A	Silver	0.86	B	mg/kg
39SB05A	Sodium	23.9		mg/kg
39SB05A	4,4'-DDT	0.88		ug/kg
39SB05B	1,2,3,4,6,7,8-HPCDF	0.561	X	ng/kg
39SB06A	Antimony	0.52	B	mg/kg
39SB06A	Silver	0.98	B	mg/kg
39SB06A	Sodium	29.1		mg/kg
39SB06B	1,2,3,4,6,7,8-HPCDF	0.268		ng/kg
39SB06C	1,2,3,4,6,7,8-HPCDF	0.694		ng/kg
39SS07	Antimony	0.22	B	mg/kg
39SS07	Silver	0.72	B	mg/kg
39SS07	Acetone	49.0		ug/kg
39SS08	Antimony	0.29	B	mg/kg
39SS08	Silver	0.66	B	mg/kg
39SS09	Silver	0.86	B	mg/kg
39SS10	Silver	0.79	B	mg/kg
39SS10	Sodium	26.3		mg/kg
39SS11	Silver	0.76	B	mg/kg
39SS12	Silver	0.88	B	mg/kg

B = Value <MRL and >MDL. Reported value may be biased (estimated).

X = The ion-abundance ratio between the two characteristic PCDD/F ions is outside accepted 25% criteria ranges. The detected PCDD/F is reported as an estimated maximum possible concentration (EMPC).

Completeness. Completeness is a measure of the amount of information that must be collected during the field investigation to allow for successful achievement of the objectives. An adequate amount and type of data must be collected for conclusions to be valid. Missing data may reduce the precision of estimates or introduce bias, thus lowering the confidence level of the conclusions. While completeness has been historically presented as a percentage of the data that is considered usable, this does not take into account critical sample locations or critical analytical parameters.

The amount and type of data that may be lost due to sampling or analytical error cannot be predicted or evaluated in advance. The importance of lost or suspect data will be evaluated in terms of the sample location, analytical parameter, nature of the problem, decision to be made, and the consequence of an erroneous decision. Critical locations or parameters for which data is found to be inadequate will either be re-sampled and re-analyzed or the data will be appropriately qualified based on the decision of the project QA manager. The completeness goal percentage of usable data is set at 98±2%.

Sampling completeness was assessed through evaluation of the total number of samples proposed for collection in the work plan versus the actual number of samples collected and analyzed. Analytical completeness was assessed by comparing the number of useable data points collected to the total number of data points generated. Completeness is calculated using the following equations:

$$\%\ \text{Sampling Completeness} = \frac{\text{No. of actual samples collected}}{\text{No. of proposed samples}}$$

$$\%\ \text{Analytical Completeness} = \frac{\text{No. of usable data}}{\text{No. of requested analyses}}$$

For the purposes of this report, unusable data are defined to include rejected data points ("R" qualifier). No data points were rejected through the validation process.

- **Completeness Analysis.** Six surface and six subsurface soil samples were proposed for collection at SWMU 39 in MWP Addendum 12 (IT, 2002a). The field duplicate and rinse blanks were collected on a site-wide basis. Soil samples were collected and analyzed for the parameters specified in the Work Plan. The resulting sampling completeness quotient is 100% and meets pre-defined goals.

  The overall analytical percent completeness was also assessed by parameter group for the soil samples collected. Analysis of the soil samples resulted in the generation of 954 out of 954 data points deemed to be useable, resulting in an overall analytical completeness quotient of 100%. For samples 39SB05A, 39SB06A, and 39SB05C, where the 2,3,7,8-TCDF confirmation was >25%D, the lower of the two values was reported as estimated "J" and the higher value rejected "R". Since the lower of the two values was able to be reported as estimated in this case, there was no impact with the given data set. The overall completeness percentages met the pre-defined goal of 98±2% for the soil sampling event.

Representativeness. Representativeness is a measure of the degree to which the measured results accurately reflect the medium being sampled. It is a qualitative parameter that is addressed through the proper design of the sampling program in terms of sample location, number of samples, and actual material collected as a "sample" of the whole.

Sampling protocols were developed to assure that samples collected are representative of the media. Field handling protocols (e.g., storage, handling in the field, and shipping) were designed to protect the representativeness of the collected samples. Proper field documentation and QC inspections were used to establish that protocols were followed and that sample identification and integrity was maintained and met pre-defined goals.

Comparability. Comparability is the confidence with which one data set can be compared to another. Comparability was controlled through the use of SOPs that have been developed to standardize the collection of measurements and samples and approved analytical technique with defined QC criteria. USEPA-approved methodologies were used in providing laboratory analytical support for this project. Laboratory SOPs were developed from these methods. Consistent and proper calibration of equipment throughout the field exercises, as described in the MQAP and QAPA, will assist in the comparability of measurements. Field documentation and QA audits were used to establish that protocols for sampling and measurement follow appropriate SOPs and met pre-defined goals.

Sensitivity (quantitation, reporting, and detection limits). The term sensitivity is used broadly to describe the method detection, quantitation, and reporting limits established to meet project-specific data quality objectives; and not limited to the definition which describes the capability of a method or instrument to discriminate between measurement responses. The method detection limits (MDLs) and the practical quantitation limits (PQLs) published within USEPA methods are based upon a reagent water matrix, and are not necessarily reflective of typical sample matrices; therefore, care was taken in establishing limits for laboratory analysis. Methods were selected based upon their sensitivity, technological, and economical considerations while keeping the screening values and available methodology in mind and were sufficient in meeting the given levels of concern (LOCs). Each target compound for every sample was reported at a specific method reporting limit (MRL). The target analytes detected above the MDL, but less than the MRL, were reported as estimated values "J". Target analytes detected above the upper calibration standard were diluted and analyzed within established calibration windows.

The MQLs and MDLs were compared at the onset of the project. The MDL is the minimum concentration of an analyte that can be measured and reported with a 99% confidence that the analyte is above zero and is identified from the analysis of a sample in a given matrix containing the analyte. The MDLs are derived by the method based upon 40 CFR Chapter 136 Appendix B. The MDL established using this procedure was used to assess the importance of the measurement of a future sample. The laboratory MDLs derived were less than the MQLs. The laboratory has statistically derived MDLs below the MQLs. The MDL values are different and change periodically because each MDL is laboratory, instrument, analyst, matrix, and method specific.

MQLs are the values at which the laboratory has demonstrated the ability to reliably quantitate the target value of an analyte for the method performed. MQLs are based upon the lowest calibration standard used for the initial calibration curve or the lowest verification standard performed. Data is calculated over a linear range. The highest concentration of the standards is

truncated until linearity is achieved (minimum of three concentration levels must remain). The resulting highest concentration within the linear range represents the upper quantitation limit.

The laboratory used a MRL for each sample. The MRL is the USACE term for sample quantitation limit (USACE, 1998). The reporting limit is the threshold value below which the laboratory reports non-detected values as "U," "ND," or "<" and will vary for each sample based upon dilution, sample volumes, percent moistures (for solids), and the method performed. Positive values found in blanks (method, rinse, trip) above the MDL were reported. Positive results below the MRL and above the MDL were reported as estimated "J" for both inorganics and organics. The units for aqueous samples were µg/L and for solid samples were mg/kg, µg/kg, or ng/kg.

- **SWMU 39 Sensitivity Analysis.** The method sensitivities (i.e., MDLs) were adequate to meet the data quality objectives, except for the following. Comparing against the soil screening levels (SSLs), compounds 1,1,2-trichloroethane, trichloroethene, vinyl chloride, cis-1,3-dichloropropene, trans-1,3-dichloropropene, nitrobenzene, MCPA, MCPP, and arsenic had MDLs greater than the given SSLs for select samples. Comparing against the residential RBCs, MCPP, MCPA, and vinyl chloride had MDLs greater than the given residential RBCs for select samples. Comparing against the industrial RBCs, MCPA had a MDL greater than the given industrial RBCs for select samples. Some of the samples had higher sensitivities due to sample dilutions, sample volume adjustments, and/or moisture factors. Though an uncertainty may be present with these sensitivity gaps between the SSLs/RBCs and MDLs for these compounds, it is unlikely that they present an impact to the decisions regarding the RFI.

Levels of Concern

An integral part of the identification of DQOs is the establishment of LOCs. These levels were compared with analytical method reporting limits prior to analytical method selection to ensure the method was capable of addressing project DQOs, preclude occurrence of false negative issues, and assess best available technology limitations. Although LOCs selected as potential concerns may not necessarily reflect RFI-specific objectives, they were developed to ensure that the chosen analytical methods have detection limits sensitive enough to achieve compliance with appropriate site-specific screening levels or other specified criteria for soil. The laboratory MDLs were sufficient to meet (i.e., below) the LOCs for the SWMU 39 RFI. LOCs for SWMU 39 are based on soil applicable or relevant and appropriate requirements (ARARs) and To-Be-Considered Guidance (TBG). The soil TBC guidance includes:

- Facility-Wide Background inorganic concentrations (IT, 2001).
- USEPA Region III risk based concentrations (April, 2004).

Appendix A-3
2002 RFI Field Audit Report

Shaw Environmental & Infrastructure, Inc.

2113 Emmorton Park Road
Edgewood, MD 21040-1037
410.612.6350
Fax 410.612.6351

Shaw The Shaw Group Inc.™

TO: Jeff Parks, Project Manager
Tim Leahy, Field Operation Leader
Mark Thomas, Task Manager

FROM: Eric Malarek, Project QA Manager

DATE: March 24, 2003

SUBJECT: Radford Army Ammunition Plant, VA Field Audit

The purpose of this memorandum is to report on field activities audited in support of the Radford Army Ammunition Plant (RFAAP) RCRA Facility Investigation on July 11, 2002. Field activities were audited against procedures specified in the *Draft QAP Document* (May, 1997), *Draft Final Work Plan Addendum 009, SWMU 31 and Horseshoe Area Groundwater Study* (February, 2002), and *Draft Final Work Plan Addendum 012, SWMU 39, SWMU 48, SWMU 49, SWMU 50, SWMU 58, SWMU 59, AOC-FLFA, AOC-Building 4343, and New River Unit* (February, 2002). These procedures have been grouped into the following broad categories: project management, documentation and sample management, equipment calibration, field QA/QC, sample management/groundwater sampling, sample management/surface water sampling, and decontamination. The annotated audit checklist with specific observations and/or comments is attached for your information.

Audit findings were discussed with the field team members at the close of the field audit. The Field Operation Leader effectively organized project activities to achieve project objectives. The sampling team was cognizant of proper procedures and protocols for the documentation, QA/QC, groundwater, surface water, and decontamination activities. There were no significant non-conformances found during the audit. Recommendations included that for documentation that unused rows have single-line cross out for chain of custody. In general, field activities associated with the audited work phase were compliant with work plan specifications.

Attachment

The purpose of this audit was to verify that field activities were performed in accordance with standard operating procedures designed to control sample management activities. Areas evaluated as part of the audit are categorized into the following sections:

AREAS EVALUATED:

- Project Management
- Documentation and Sample Management
- Equipment Calibration
- Field QA/QC
- Sample Management/Groundwater Sampling
- Sample Management/Surface Water Sampling
- Decontamination

Personnel interviewed and present during the audit included:

Mark Thomas, Task Manager
Tim Leahy, Field Operation Leader
Dave Kateley, Field Sampler
Jack Choynowski, Field Sampler
Curt Tucker, Field Sampler

I. PROJECT MANAGEMENT

QUESTION	YES	NO	COMMENT
1. Have changes been made to the project organization?	√		Additional Samplers: Jack Choynowski and Curt Tucker
2. Did project personnel appear to be qualified for assigned tasks?	√		
3. Were project activities managed and coordinated in a manner consistent with achieving project goals?	√		

II. DOCUMENTATION AND SAMPLE MANAGEMENT

QUESTION	YES	NO	COMMENT
Work Plans			
1. Were copies of the following documents on-site and available for inspection? Health and Safety Plan Sampling and Analysis Plan Quality Assurance Project Plan Ref.: *Draft QAP Document* (June, 2001), *Draft Final Work Plan Addendum 009, SWMU 31 and Horseshoe Area Groundwater Study* (February, 2002), and *Draft Final Work Plan Addendum 012, SWMU 39, SWMU 48, SWMU 49, SWMU 50, SWMU 58, SWMU 59, AOC-FLFA, AOC-Building 4343, and New River Unit* (February, 2002).	 √ √ √		URS/Dames and Moore Master Work Plan was used.
2. Were copies of the following records on-site and available for inspection? Well and excavation permits Boring log forms Well completion diagrams Well development forms COC/FPF forms	 √ NA NA NA √		Permits included: Area Entry Permit and Hot Work Permit both dated 7/8/02 to 7/12/02.
Logbook			
1. Is the field logbook weather proof?	√		
2. Were entries made in indelible ink?	√		
3. Are the pages consecutively numbered?	√		
4. Were changes made with single-line cross out and initialed and dated?	√		
5. Were the following items included? Project name Sample location Sampler's signature and date Time and date of sample collection Sample ID Analysis name Associated QC samples Observations Field measurements	 √ √ √ √ √ √ √ √ √		NRU Surface Water/Sediment Sampling Logbook dated 06/02 was checked
5. Are H&S training records available for project staff?	√		Everyone's training records were available and up to date.
6. Were Daily CQC-Forms Completed and submitted to USACE in accordance with QAPP specifications?	NA		

NA = Not Applicable

QUESTION	YES	NO	COMMENT
Chain of Custody (COC)			
1. Were entries made in indelible ink?	√		COC #024149 reviewed.
2. Are the COC numbered?	√		
3. Were changes made with single-line cross out and initialed and dated?	√		
4. Are the unused rows have a single-line cross out drawn through and initialed and dated?		√	Recommend that unused rows have single-line cross out drawn through.
5. Were the following items included?			
Project name and number	√		
Contact name and phone number	√		
Field Sample # or ID	√		
Time and date of sample collection	√		7/10/02
Matrix	√		
Requested Analysis/Method Numbers	√		
Number of containers (totaled)	√		
Preservatives	√		
Associated QC samples	√		MS/MSD Noted.
Sampler's signature and date	√		
Field measurements	√		Depths Noted.

Field Parameter Forms (FPF)			
1. Were entries made in indelible ink?	NA		FPF forms completed on the computer. FPF #348 was checked.
2. Are the FPF consecutively numbered?	NA		
3. Were changes made with single-line cross out and initialed and dated?	NA		
4. Are the unused rows have a single-line cross out drawn through and initialed and dated?	NA		
5. Were the following items included?			
Project name and number	√		FPFs were uploaded at the end of the day, then e-mailed or sent on disk to the lab.
Contact name and phone number	√		
Matrix	√		
High concentration / high hazard	√		
Installation site, code, and area	√		
File name (CSO, CGW, CSW, CSE, CQC)	√		CSO
Site type (GRAB, RNSW, WELL, BORE, ...)	√		BORE
Site ID	√		58SB04
Field sample number	√		58SB04D
Time and date of sample collection	√		7/10/02 @10:50
Sampling technique (S, U, T, G, C, E, P, ...)	√		Grab
Requested Analysis	√		
Sample container and number (totaled)	√		
Preservatives	√		
Associated QC samples	√		
Sampler's initials and date	√		
Field measurements and observations	√		Depths 20"-24"

NA = Not Applicable

RADFORD ARMY AMMUNITION PLANT FIELD AUDIT

QUESTION	YES	NO	COMMENT
Records			
1. Were copies of drilling certificates available?	NA		
2. Were copies of excavation permits available?	NA		
3. Were copies of pertinent permits available?	√		See work plans Section Question #2
4. Were copies of personnel OSHA certificates and sample preservative MSDS available?	√		
Sampling Labeling			
1. Was the sampling identification convention consistent with the QAPP?	√		Sample 31SE14B checked.
2. Did the sample label contain the following information?			
Site name		√	Site name built into Site ID.
Sample identification	√		31SE14B
Sample collection time and date	√		7/10/02 @17:00
Sample preservative Sampler's initial	√		
Analysis	√		
3. Were entries made in indelible ink?	√		
4. Was the label covered with a clear tape?	√		
Sample Packaging			
1. Are sample containers tightly sealed and placed in an upright position?	√		
2. Is the cooler lined with garbage bag?	NA		Not Required
3. Are glass sample containers wrapped in bubble wrap or closed cell foam sheets?	√		
4. Is the ice double bagged and temperature blank included?	√		
5. Is the proper documentation placed in a waterproof bag and enclosed in the lid of the cooler?	√		Not attached to lid.
6. Is the cooler sealed tightly with a signed custody seal and then with clear packing tape?	√		
7. Is the cooler shipping documentation marked next day priority?	√		
Equipment Calibration and Maintenance			
1. Was a calibration logbook maintained?	√		Calibrated with mfg. cal soln. (expiration 11/29/03) on 7/11/02 @8:15
2. Were the following parameters recorded in the logbook?			
pH	√		Serial Number #SN003002 also recorded.
Specific conductance	√		
dissolved oxygen	NA		
PID readings	√		
Oxidation/Reduction Potential	NA		
Turbidity	√		

NA = Not Applicable

III. EQUIPMENT CALIBRATION

QUESTION	YES	NO	COMMENT
PID/FID TVA			
1. Was the PID calibrated prior to use?	√		Calibrated with Isobutylene on 7/11/02
2. Were procedures consistent with manufacturer's specifications?	√		Horiba Isobutylene read 101 and 100 (TV=100)
3. Were other calibrations performed?	√		See Water Quality Parameters
Water Quality Parameters			
1. Were the parameters calibrated at least once?	√		Calibrated with mfg. cal soln (expiration 11/29/03) on 7/11/02 @8:15
2. What was the procedure?	√		AutoCal procedure used.
3. Were standards fresh?	√		
4. Were the following standards used? pH- buffer 4 and slope Conductivity- KCl D.O. – water Depth – air Salinity – KCl Redox - quinhydrone or tranosfer? Turbidity - NTU	 √ √ NA NA NA NA √		pH read 4.00 (TV=4.00) Turbidity read 0.1 (TV=0.0)
Immunoassay Dtech Test Kits			
1. Was the Detechtor meter calibrated prior to use?	NA		
2. Were procedures consistent with manufacturer's specifications?	NA		
3. Were other calibrations performed?	NA		

NA = Not Applicable
TV = True Value

IV. FIELD QA/QC

QUESTION	YES	NO	COMMENT
Field QC Samples			
1. Have field quality control samples been collected?			
Duplicate samples (10% frequency per matrix)	√		
Rinse blanks (5% frequency per matrix per sampling technique)	√		
Trip blanks: (1 per shipping container for aqueous. VOC samples only)	√		
Source water	√		Source water Tested prior.
Field blanks	NA		
2. Were project activities adequately documented?	√		

NA = Not Applicable

V. SAMPLE MANAGEMENT/GROUNDWATER SAMPLING

QUESTION	YES	NO	COMMENT
General			
1. Were groundwater samples collected from the least contaminated progressing to the most contaminated?	√		Upgradient samples were collected first.
2. Were sampling teams established?	√		Mark Thomas, Dave Kateley, Curt Tucker, and Jack Choynowski
3. Were PID readings taken for wells with VOC having a potential of being present?	√		
3. Were water depth and level taken prior to purging? (See Page 2)	√		
4. How were EV calculated?	NA		

$EV = (\pi R_w h_w)*0.0043\ gal/in^3$

Where: R_w = radius of well casing in inches h_w = water depth inches

Well Purging			
1. Were the following steps used for bailers?			
Use a clean lanyard	NA		
Calculate EV	NA		
After 1EV measure stabilization parameters	NA		
Record on form	NA		
Continue purging	NA		
Collect stabilization measurements	NA		
Sample well	NA		
2. Were the following steps used for pumps?			
Lower pump slowly into well	√		
Attach umbilical cord to protective casing	√		Tubing & Wire
Lower water level probe into well behind pump until it touches water	√		
Begin pumping at lowest setting (above screen for evacuation and at screen interval for sampling)	√		Raised the probe up 5' to a 10' Screening Interval
Gradually increase rate until pumping rate matches recharge rate	√		Recharge rate ≈ @ 0.5 L/min.
Monitor stabilization parameters	√		

NA = Not Applicable

QUESTION	YES	NO	COMMENT
Well Sampling			
1. Were samples collected using either a bailer or pump? If low flow, rate ≤ recharge rate	√		Submersible pump was used.
2. Were samples collected in the following order? VOC, SVOC, Metals, etc.	√		
3. Were appropriate containers and preservations used?			
VOC – 3x 40 mL HCl to pH<2; Teflon septum, zero headspace	√		
SVOC – 2x 1 L amber glass; Teflon cap	√		
Pest/PCBs – 2x 1 L amber glass; Teflon cap	√		
Herbicides – 2x 1 L amber glass; Teflon cap	√		
Explosives – 2x 1 L amber glass; Teflon cap	√		
PAHs – 2x 1 L amber glass; Teflon cap	√		
Dioxin/Furans – 2x 1 L amber glass; Teflon cap	√		
Metals/Hardness – 1 L HDPE HNO3 to pH<2	NA		
pH – 1x 250 mL HDPE or glass	√		
Perchlorate – 1x 250 mL HDPE or glass	NA		
TOC – 3x 40 mL HCl or H2SO4 to pH<2; Teflon septum, zero headspace	√		
TCLP VOC – 3x 40 mL HCl to pH<2; Teflon septum, zero headspace	√		
TCLP SVOC – 1x 1 L amber glass	NA		
TCLP Pests – 1x 1 L amber glass	NA		
TCLP Metals – 1 L HDPE or glass	NA		
Ignitability: 1x – 1 L HDPE or glass	NA		
Reactive Sulfide: 1x – 1 L HDPE or glass	NA		
Reactive Cyanide: 1x – 1 L HDPE or glass	NA		
Corrosivity as pH: 1x – 250 mL HDPE or glass	NA		
COD: 1x – 250 mL HCl or H2SO4 to pH<2 glass	NA		
TOX: 1x – 250 mL H2SO4 to pH<2 glass	√		
4. Were acid/caustic preservations checked with pH paper and documented?	NA		Sample bottles pre-preserved
5. Were the following quality control samples collected?			
Duplicates	√		
rinse blanks	√		
trip blanks	√		
splits	NA		
matrix spikes	√		
matrix spike duplicate	√		
6. Were the proper sample packaging and documentation activities performed?	√		

NA = Not Applicable

QUESTION	YES	NO	COMMENT
Water Level and Well-Depth Measurement			
1. Were the following steps used for depth to water?			
Remove water level indicator and turn on sounder	√		
Test check battery and sensitivity scale	√		
Establish benchmark	√		
Slowly lower probe into well	√		
Lower until meter buzzes	√		
Adjust until the exact depth is obtained	√		
Record the depth to near .01 inch	√		
2. Were the following steps used for well depth?			
Lower cable until slack is noted in the cable	√		
Slowly raise/lower cable until well bottom is "felt"	√		
Record the depth	√		
3. Was the probe decontaminated after use?	√		
4. Were the following measurements recorded?			
Top of casing elevation	√		
Depth to water level	√		

VI. SAMPLE MANAGEMENT/SURFACE WATER SAMPLING

QUESTION	YES	NO	COMMENT
General			
1. Were sampling teams established?	√		Tim Leahy
Surface Water Sampling			
1. Were samples collected directly using the sample container?	√		
2. Were PID readings taken for surface sites with VOC having a potential of being present?	√		PID tip got wet & wasn't reading properly due to moisture.
3. Were samples collected in the following order? VOC, SVOC, Metals, etc.	√		Only VOCs, hardness and perchlorate were sampled.
4. Were acid/caustic preservations added after collection and checked with pH paper and documented?	NA		Sample bottles pre-preserved
5. Were appropriate containers and preservations used?			
VOC – 3x 40 mL HCl to pH<2; Teflon septum, zero headspace	√		RYSW03
SVOC – 2x 1 L amber glass; Teflon cap	NA		
Pest/PCBs – 2x 1 L amber glass; Teflon cap	NA		
Herbicides – 2x 1 L amber glass; Teflon cap	NA		
Explosives – 2x 1 L amber glass; Teflon cap	NA		
PAHs – 2x 1 L amber glass; Teflon cap	NA		
Dioxin/Furans – 2x 1 L amber glass; Teflon cap	NA		
Metals/Hardness – 1 L HDPE HNO3 to pH<2	√		RYSW15: The sample was collected with bottle tied to stick due to confined space. No entry made.
PH – 1x 250 mL HDPE or glass	NA		
Perchlorate – 1x 250 mL HDPE or glass	√		
TOC – 3x 40 mL HCl or H2SO4 to pH<2; Teflon septum, zero headspace	NA		
TOX: 1x – 250 mL H2SO4 to pH<2 glass	NA		
6. Were the following quality control samples collected?			
Duplicates	√		
rinse blanks	√		
trip blanks	√		
splits	NA		
matrix spikes/matrix spike duplicate	√		
7. Were the proper sample packaging and documentation activities performed?	√		See Documentation Section

NA = Not Applicable

VII. DECONTAMINATION

QUESTION	YES	NO	COMMENT
General			
1. Was a decontamination pad established?	√		
2. Was personnel decontamination required?		√	
Solid Material Samplers			
1. Were the following steps used?			
Scrub with non-phosphate detergent	NA		
Rinse off detergent with approved water	NA		
Rinse with DI water	NA		
Wrap sampler with aluminum foil or clean plastic sheeting or zip-lock bag	NA		
Proper disposal of decontamination solutions	NA		
2. Was all of the equipment properly decontaminated?	NA		
Aqueous Samplers			
1. Were the following steps used?			
a) Scrub with non-phosphate detergent	√		
b)Calculate volume of pump plus tubing and pump for 10 gallons or 3 volumes of non-phosphate detergent (submersible pump only)	NA		Dedicated tubing used.
c) Rinse off detergent with approved water	√		Source Water used.
d) Rinse pump tubing interior by at least 10 gal. of approved water (submersible pump only)	NA		Dedicated tubing used.
e) Rinse with DI water	√		
f) Rinse with nitric acid (metals only) then DIUF rinse	√		
g) Rinse with methanol (VOCs only) then DIUF rinse	√		
h) Wrap sampler with aluminum foil or clean plastic sheeting	√		Plastic Bags used.
i) Proper disposal of decontamination solutions			
2. Were the water quality probes decontaminated to manufacturer specifications or at least triple rinsed with DIUF?	√		Same as #1
3. Was all of the equipment properly decontaminated?	√		

NA = Not Applicable

Appendix B
Lithologic Boring Logs and
Previous Investigation Analytical Data Tables

This Appendix Contains:

Appendix B-1 Lithologic Boring Logs
Appendix B-2 Previous Investigation Analytical Data Tables

Appendix B-1
Lithologic Boring Logs

RADFORD ARMY AMMUNITION PLANT — SOIL BORING LOG

Project Name: Radford Army Ammunition Plant D.O. 13	Soil Boring Number: 39SB1
Site Location: SWMU 39	Ground Surface Elevation: 1694.98
Drilling Firm: Hardin and Huber, Inc.	Total Depth: 12.5 ft.
Drilling Method: 3.25" HSA ATV Mounted Rig	Start Date: 04-21-98
Logged By: L. Hass	Finish Date: 04-21-98

Depth (ft bgs)	Split Spoon Sample Recovery (in)	Blows/6in.	PID (ppm)	Sample	Material Description	USCS Class.	Symbol	Remarks
	18	3-3 5-7	0.0	39SB1A 39SB1AD 39SB1B	Reddish yellow to yellowish red silt and fine sand, 7.5YR 6/8, slight plasticity, soft but harder with depth. Yellowish red silt and fine sand, 5YR 4/6, shiny metallic/micaceous flecks abundant throughout - mostly gold and silver color.			
			NA	39SB1C Shelby Tube	NA	SM		
5	18	5-5 8-8	0.0	39SB1D	Yellowish red silt and sand, 5YR 5/8, moderately soft, low plasticity; to strong brown sand and silt, 7.5YR 5/6, low plasticity. Micaceous flecks throughout. Some black staining.			5
	18		NA	39SB1E Shelby Tube	NA			
	0	8-8 8-8	NA		NA			
10	3	6-2 1-50/4	0.0		Coarse sand and small rounded quartzite gravel (<1/4"), 7.5YR 6/2 over pinkish gray weathered bedrock.	SW		10 Water Table
	0	51/1	NA	39SB1E TCLP				
15					Refusal at 12.5 ft. bgs. NOTES: 1. Depths and elevations in feet unless otherwise noted. 2. USCS Classification based on visual-manual procedures.			15

RADFORD ARMY AMMUNITION PLANT — SOIL BORING LOG

Project Name: Radford Army Ammunition Plant D.O. 13	Soil Boring Number: 39SB2
Site Location: SWMU 39	Ground Surface Elevation: 1695.18
Drilling Firm: Hardin and Huber, Inc.	Total Depth: 20.5 ft.
Drilling Method: 3.25" Hollow Stem Auger	Start Date: 04-20-98
Logged By: L. Hass	Finish Date: 04-20-98

Depth (ft bgs)	Split Spoon Sample Recovery (in)	Blows/6in.	PID (ppm)	Sample	Material Description	USCS Class.	Symbol	Remarks
		3-4			Strong brown silt and clay 7.5YR 5/6, soft and moist, moderate plasticity; mottled with very dark brown silt and clay; light colored mica flecks <1/4 mm; trace black, glossy chunks.	ML/CL		
	14	5-9	0.0	39SB2B				
			NA	39SB2C Shelby Tube				
5		7-7		39SB2C TCLP 39SB2D	Strong brown silt and sand, 7.5YR 5/6, coarsening downwards, soft, no plasticity. Abundant light mica flecks.	SM		
	20	9-11	0.0					
		6-8			Strong brown sand with some silt, 7.5YR 5/6, no plasticity, dry. Abundant light mica flecks, and some black flecks (<1/4 mm).			
	3	14-5	0.1					
			NA	39SB2E Shelby Tube		GP		
10		3-2		39SB2E TCLP	Strong brown coarse sand and well-rounded gravel up to 1", 7.5YR 5/6, wet.			Water Table
	5	2-1	0.1					
		1-1		39SB2F	Dark yellowish brown clay, sand, and small gravel, 7.5YR 4/6, wet.	GM		
	16	1-1	0.0					
15	6	1-0	0.0		Dark yellowish brow sand, silt, and trace gravel, 7.5YR 4/6, wet, slight plasticity, sticky and loose.	SM		

RADFORD ARMY AMMUNITION PLANT — SOIL BORING LOG

Project Name: Radford Army Ammunition Plant D.O. 13	Soil Boring Number: 39SB3
Site Location: SWMU 39	Ground Surface Elevation: 1692.23
Drilling Firm: Hardin and Huber, Inc.	Total Depth: 11.5 ft.
Drilling Method: 3.25" Hollow Stem Auger	Start Date: 04-21-98
Logged By: L. Hass	Finish Date: 04-21-98

Depth (ft bgs)	Split Spoon Sample Recovery (in)	Blows/6in.	PID (ppm)	Sample	Material Description	USCS Class.	Symbol	Remarks
	12	3-4 13-15	0.0	39SB3A 39SB3B	0-1", Topsoil: black with roots and sticks. 1-12", reddish yellow clay 7.5YR 6/8, hard, low, plasticity, very small mica flecks (<1/10mm), 10-11",seam of sand and fine gravel.			
			NA	39SB3C Shelby Tube		ML/CL		
5	16	9-14 19-23	0.0	39SB3C TCLP 39SB3D 39SB3DD	Light yellow brown, silt and sand, 10YR 6/4, hard, no plasticity. Color change to strong brown at 14", 7.5YR 5/6. Light micaceous flecks throughout.			5
	6	6-12 11-10	0.0	39SB3E (%moist, & grain size)	Soil too hard to push a shelby tube full recovery, so physical samples (except bulk density) collected from tube and placed in jars, Sample very moist, sand coarsing douwnward to gravel (1/4"+), rounded quartzite.			
	5	7-6 5-4	0.0	39SB3E TCLP	Dark staining at top, 1" thick. Medium to coarse grained sand, some gravel.	SW		
10	2	5-50/4	0.0		Gray coarse sand, 10YR 5/1, rounded, quartzite gravel.			10 Water Table
					Auger refusal @ 11.5 ft bgs.			
15					NOTES: 1. Depths and elevations in feet unless otherwise noted. 2. USCS Classification based on visual-manual procedures.			15

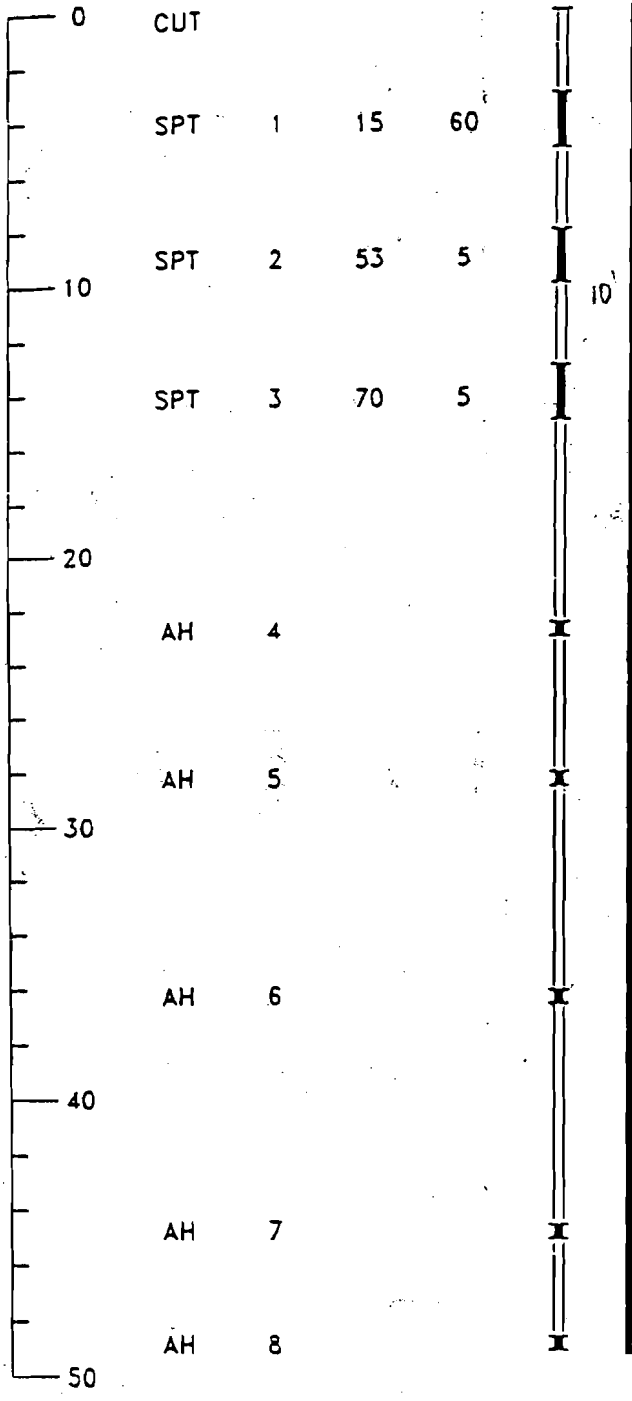
BORING	39MW1
SURFACE ELEVATION:	1701.1 FEET, MSL
LOCATION:	RADFORD AAP, VIRGINIA
START:	10:32 ON 6/2/93
FINISH:	13:49 ON 6/2/93

DEPTH (FEET)	SAMPLING METHOD	SAMPLE NO.	BLOW COUNT/FOOT	% RECOVERY	SAMPLE INTERVAL	SYMBOLS	DESCRIPTION
0	CUT	1				ML	REDDISH BROWN (5 YR 4/4) SOFT SANDY SILT, VERY MOIST, MICACEOUS, SLIGHTLY CLAYEY NO ODOR
	SPT	2	15	100		CL	REDDISH BROWN (5 YR 4/4) SLIGHTLY SANDY CLAY AND SILT, MOIST, TRACE BLACK SPECKS, NO ODOR
							GRADING
10	SPT	3	41	100		SM GM	REDDISH BROWN VERY FINE GRAINED GRAVELLY SANDY SILT, HIGHLY MICACEOUS, LESS MOIST, TRACE CLAY, NO BLACK SPECKS
							GRADING SANDIER
	SPT	4	22	15			GRADING MORE GRAVELLY
	SPT	5			17'		GRAVEL PREVENTED SPOON RECOVERY
20							ROCK AT 16.5 THIN SILT SEAM ABOVE LIGHT BROWNISH GRAY LIMESTONE ROCK
							SOLUTION CAVITY AT 20 FEET, FEW CUTTINGS TO SURFACE
							LIMESTONE W/ SOLUTION CAVITIES, NO CUTTINGS COMING TO SURFACE
						LS	PROBABLE WATER TABLE AT 20 FEET
							MUDDY
30	AH	6					POSSIBLE WATER AT 30 FEET
	AH	7					LIMESTONE (10 YR 6/1) GRAY, HARD, FINE GRAIN, SOME MUDSTONE PIECES AND SOME DARK GRAYISH BROWN LIMESTONE
	AH	8					GRADING TO VERY DARK GRAY LIMESTONE SOME YELLOWISH BROWN STAINING CALCITE INFILLING OF SOLUTION CAVITIES IN LARGER FRAGMENTS OF ROCK CUTTINGS SOME PALE BROWN SOFT SILTSTONE
40							W/ INCREASED LIGHT GRAY LIMESTONE VERY LITTLE WATER
							(VERY FEW CUTTINGS COMING TO SURFACE)
50	AH	9					SAME, W/ SOME GREENISH GRAY DOLOSTONE CHIPS
							BOREHOLE TERMINATED AT A DEPTH OF 50 FEET

LOG OF BORING

Dames & Moore

BORING	39MW2
SURFACE ELEVATION:	1700.3 FEET, MSL
LOCATION:	RADFORD AAP, VIRGINIA
START:	08:00 ON 6/3/93
FINISH:	12:57 ON 6/3/93



SYMBOLS	DESCRIPTION
SM	YELLOWISH RED SILTY SLIGHTLY CLAYEY SAND, MOIST, NO ODOR
SC	YELLOWISH RED (5 YR 4/6) SLIGHTLY CLAYEY SAND, FINE GRAINED, LOOSE SLIGHTLY MOIST, NO ODOR, HOMOGENOUS
	COARSE GRAVELS AND SILTS/SANDS GRAVELS ROUNDED, YELLOWISH RED
	GRAVELS PREVENTED SAMPLE RECOVERY
GM	SAME GRAVELS SILTS AND SANDS (POOR RECOVERY DUE TO GRAVELS)
	COBBLES 18.5-19.5 FEET
	ROCK AT 19.5 FEET
	BLUISH GRAY DOLOSTONE, AND GRAVEL PIECES (FEW CUTTINGS COMING TO SURFACE)
	CUTTINGS BECOMING MOIST AT 25 FEET, PROBABLE AREA OF WATER TABLE
	LIGHT BLUISH GRAY LIMESTONE/ DOLOSTONE
LS/DS	
	SAME W/ SOME DARKER GRAY LIMESTONE/DOLOSTONE, TRACE CALCITE
	CONTINUED LIGHT GRAY AND DARK GRAY LIMESTONE/DOLOSTONE CUTTINGS
	GRADES TO MAINLY DARK GRAY LIMESTONE/DOLOSTONE, W/ SOME CALCITE CHIPS
	BOREHOLE TERMINATED AT A DEPTH OF 49 FEET

LOG OF BORING

Dames & Moore

Project No. B94100

Date Started	09/23/97	Hole No.	39MW4
Date Completed	09/23/97	Type of Hole	Hollow Stem Auger
Logged by	J.L. Rhudy	Dia. of Hole	±8"
Ground Elev.		Top of Casing	

From	To	Thickness	Description
0.0	5.0	5.0	*Augered through topsoil, clay fill material*
5.0	7.0	2.0	*Light tan to brown, silty clay, light to moderate plasticity, some mica mottling present, moist, brown topsoil streak at 5.8-6.7' {Split Spoon Sample, PID = 0.0 ppm}, 95% Recovery*
7.0	10.0	3.0	*Augered*
10.0	12.0	2.0	*Light tan, silty clay, mottled with coarse platelets and light clay, fairly dry, homogeneous throughout split spoon {Split Spoon Sample, PID = 0.0 ppm}, 20% Recovery*
12.0	15.0	3.0	*Augered*
15.0	17.0	2.0	*Weathered quartzite in bottom of split spoon, very mottled mixture of sand and clay from 15' {Split Spoon Sample, PID = 0.0 ppm}, 35% Recovery*
17.0	22.0	5.0	*Very bright orange, cohesive, plastic, clay muck, intermingled with gray/red clay lenses, water approximately 22' below surface grade {Split Spoon Sample, PID = 0.0 ppm}, 75% Recovery*
22.0	25.0	3.0	*Augered*
25.0	27.0	2.0	*Very wet, orange plastic clay, some dolomitic fragments present, cohesive {Split Spoon Sample, PID = 0.0 ppm}, 15% Recovery*
27.0	28.1	1.1	*Augered*
28.1	TD		*Boring terminated*

MARSHALL MILLER & ASSOCIATES

RADFORD ARMY AMMUNITION PLANT — SOIL BORING/WELL

Project Name: Radford Army Ammunition Plant D.O. 13
Site Location: SWMU 39
Drilling Firm: Hardin and Huber, Inc.
Drilling Method: 3.25" Hollow Stem Auger/Air Rotary
Logged By: L. Hass

Water Level Information (ft bgs):
During Drilling: 23 — 04-16-98
During Sampling: 20.04 — 05-12-98

Northing: 321348.71
Easting: 1403684.79

Well No.: 39MW7
Pad Elev.: 1701.24
Casing Elev.: 1701.89
Start Date: 04-14-98
Finish Date: 04-16-98

Depth (ft bgs)	Split Spoon Sample Recovery (ft)	Blows/6in.	PID (ppm)	Sample	Material Description	USCS Class.	Symbol
	20	4-7 25-20	0.7		0-8", topsoil: soft silt, hardness increasing downward, roots. 8-20", Yellowish red silt and sand 5YR 4/6, brittle, increasing hardness, trace black flecks.		
	12	4-5 6-7	3.7		Yellowish-red silt and sand 5YR 4/6, slight plasticity, very trace black flecks. Increasing sand with depth.	SM	
5	12	NA	0.0		Same as above, with increasing sand.		
	18	6-7 8-9	0.0	39MW7A 39MW7AD	Yellowish red sand with coarse sand lenses about 1/2" thick, 5YR 4/6.	SW	
	20	5-5 7-9	0.0		Yellowish red, increasingly coarse sand, some small gravel up to 1/4" diam.		
10	12	9-12 15-17	0.0		Coarse sand and rounded gravel (up to 1"), riverjack, 5YR 4/6.		
	10	7-12 17-16	0.0		Very coarse, well rounded sand and gravel, 5YR 4/6, yellowish red, moist.	GW	
15	12	14-12 14-20	0.0	39MW7B	Same as above.		
	0	50/1	NA		Spoon and auger refusal at 16.5 ft on gravelly overburden. Continue through overburden using Air and Roller Cone Bit, 16.5-26 feet.		
	0"	50/1"	NA		18.5 to 21 feet: hard rock.	Bedrock	
20							

Well Diagram: 4" PVC Schedule 40 Riser; Cement/Bentonite; Bentonite; Filter Pack

RADFORD ARMY AMMUNITION PLANT — SOIL BORING/WELL

Project Name: Radford Army Ammunition Plant D.O. 13
Site Location: SWMU 39
Drilling Firm: Hardin and Huber, Inc.
Drilling Method: 3.25" Hollow Stem Auger/Air Rotary
Logged By: L. Hass

Water Level Information (ft bgs):
During Drilling: 23 — 04-16-98
During Sampling: 20.04 — 05-12-98

Northing: 321348.71
Easting: 1403684.79

Well No.: 39MW7
Pad Elev.: 1701.24
Casing Elev.: 1701.89
Start Date: 04-14-98
Finish Date: 04-16-98

Depth (ft bgs)	Split Spoon Sample	Recovery (ft)	Blows/6in.	PID (ppm)	Sample	Material Description	USCS Class.	Symbol	Well Diagram
						Boring keeps caving in. Install temporary casing 0-20ft.	Bedrock		
						21 to 25 feet: mud filled void. Water very muddy at 23 ft. No cuttings coming to surface.	ML		
						Insert temporary casing to 26 feet to seal off the mud-filled void during drilling.			
25						25-26 feet: very hard rock.			
						Roller cone bit refusal at 26 feet, Advanced air hammer 26-33 feet. Trip rods from hole, depth to bottom is 29 ft.	Bedrock		
30									
						End of Boring @ 33 ft. bgs.			
35						NOTES: 1. Depth and elevations in feet unless otherwise noted. 2. USCS Classification based on visual-manual procedures.			
40									

Well Diagram: 0.01" slot, 4" PVC Sch. 40 Screen; Filter Pack; Screen Plug

RADFORD ARMY AMMUNITION PLANT — SOIL BORING/WELL

Project Name: Radford Army Ammunition Plant D.O. 13
Site Location: SWMU 39
Drilling Firm: Hardin and Huber, Inc.
Drilling Method: 3.25" Hollow Stem Auger/Air Rotary
Logged By: L. Hass

Water Level Information (ft bgs):
During Drilling: 33 — 04-17-98
During Sampling: 16.14 — 05-13-98

Northing: 321130.02
Easting: 1403394.64

Well No.: 39MW8
Pad Elev.: 1698.59
Casing Elev.: 1699.16
Start Date: 04-16-98
Finish Date: 04-17-98

Depth (ft bgs)	Split Spoon Sample Recovery (ft)	Blows/6in.	PID (ppm)	Sample	Material Description	USCS Class.
	14	4-6 10-16	0.0		0-6", topsoil: dark brown silt, roots. 6-14", reddish yellow silt, 7.5YR 6/8, hard, some plasticity, mica flecks.	ML
	18	7-9 11-21	0.0		Stong brown silt and sand, 7.5YR 5/8, some plasticity, moderately hard and cohesive.	
5	16	5-6 13-15	0.0		Strong brown sand with some silt and clay, 7.5YR 5/8, white micaceous flecks.	SM
	18	7-14 12-15	0.0	39MW8A 39MW8AM	Same as above with small sand lenses 1/4" thick.	
	16	3-5 10-10	0.0		Strong brown sand and silt, 7.5YR 4/6, low plasticity, mica flecks.	
10	16	6-7 8-9	0.0		Interbedded silt and sand stringers, 1mm-10mm thick. Sand is fine to coarse. Strong brown, 7.5YR 4/6, low plasticity, soft.	
	5	3-3 2-10	0.0	39MW8B	Strong brown, medium-grained sand and black, sub-rounded pea-sized gravel, 7.5YR 4/6, no plasticity, soft.	SW
15	3	50 50/10	0.0		Grayish brown, weathered bedrock, crumbles to powder, 10YR 5/2.	Bedrock
					Auger refusal at 15 feet. Insert air rods with 8" air hammer. Advance rods to 20 feet.	
					15-20' cuttings are light gray very dry. Rock chips in cuttings are dark to medium gray.	
20					Advance rods 20-30 feet. Cuttings 20-23 feet are gray.	
25						

Well Diagram: 4" PVC Schedule 40 Riser; Cement; Bentonite

RADFORD ARMY AMMUNITION PLANT — SOIL BORING/WELL

Project Name: Radford Army Ammunition Plant D.O. 13
Site Location: SWMU 39
Drilling Firm: Hardin and Huber, Inc.
Drilling Method: 3.25" Hollow Stem Auger/Air Rotary
Logged By: L. Hass

Water Level Information (ft bgs):
During Drilling: 33 — 04-17-98
During Sampling: 16.14 — 05-13-98

Northing: 321130.02
Easting: 1403394.64

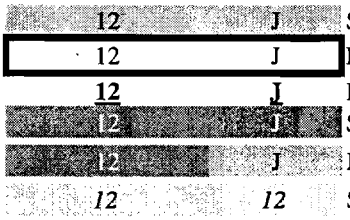
Well No.: 39MW8
Pad Elev.: 1698.59
Casing Elev.: 1699.16
Start Date: 04-16-98
Finish Date: 04-17-98

Depth (ft bgs)	Split Spoon Sample Recovery (ft)	Blows/6in.	PID (ppm)	Sample	Material Description	USCS Class.	Symbol	Well Diagram
30					23-28 feet cuttings are yellow and very dry. Rock chips are very hard. 28-33 ft., cuttings are whiteish tan. Advance rods 30-40 feet.			
35					33-37 feet, soft zone; rods advance quickly and few cuttings come to surface.	Bedrock		
40					37-40 feet, Rods advance slowly, cuttings change color to yellowish, dry. At 40 feet cuttings come up moist after 5 minutes, water comes up after 15 minutes. Overnight, water fills hole to 19 ft bgs. (water coming from soft zone 33-37 feet). Advance rods to 42 feet to leave room for caving and screen plug. End of Boring @ 42 ft. bgs.			
45					NOTES: 1. Depth and elevations in feet unless otherwise noted. 2. USCS Classification based on visual-manual procedures.			
50								

Well Diagram: 4" PVC Schedule 40 Riser; 0.01" slot, 4" PVC Sch. 40 Screen; Filter Pack; Screen Plug

Appendix B-2
Previous Investigation Analytical Data Tables

Appendix B-2
Previous Investigation Analytical Data Tables Master Legend



Shading and black font indicates an industrial RBC exceedence
Bold outline indicates a residential RBC exceedence.
Bold, underlined font indicates a background exceedence.
Shading and white font indicates a SSL exceedence.
Mixed shading indicates an industrial RBC and a SSL exceedence.
Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

RBCs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene RBCs and SSL were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene.
Inorganic results below background UTLs are not indicated as exceedences on the table.
RBC = Risk Based Concentration (April, 2004).
RBC values in table are for the more conservative chromium VI
RBC values for chromium III are 150,000 (ind) and 12,000 (res), which were not exceeded
Lead screening values from Technical Review Workgroup for Lead: Adult Lead Model Frequently Asked Questions available online at http://www.epa.gov/superfund/programs/lead/adult.htm
mg/kg = milligrams per kilogram (parts per million).
ug/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.

LQ = Lab Data Qualifiers

B = (organics) Blank contamination. Value detected in sample and associated blank.
B = (metals) Value <MRL and >MDL and is considered estimated.
E (metals) = Reported value is estimated because of the presence of interferences.
J = (organics) Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.

VQ = Validation Data Qualifiers:

B = blank contamination.Value detected in sample and associated blank.
J = estimated concentration
K = estimated concentration bias high
L = estimated concentration bias low
U = analyte not detected
UJ = estimated concentration non-detect
UL = estimated concentration non-detect bias low

Table B-1
SWMU 39 - VI Detected Soil Results - 1992

SITE ID	Comparison Criteria				39SS1	39SS2	39SS3
FIELD ID					RVFS*40	RVFS*41	RVFS*42
SAMPLING DATE					25-FEB-92	25-FEB-92	25-FEB-92
DEPTH (ft)	Industrial Soil	Residential Soil	Facility-Wide	SSL Transfer	0-0.5	0-0.5	0-0.5
MATRIX	RBC	RBC	Background	Soil to GW	CSO	CSO	CSO
Metals (mg/kg)							
Aluminum	100000	7800	40041	na	14400	14900	17500
Arsenic	1.9	0.43	15.8	0.026	2.5	2.7	2.7
Barium	7200	550	209	2100	98.4	113	94.8
Beryllium	200	16	1.02	1200	0.6	**1.2**	nd
Calcium	na	na	na	na	38500	1250	3300
Chromium	310	23	65.3	42	26	27.5	30.2
Cobalt	2000	160	72.3	na	11.2	13.4	13.5
Copper	4100	310	53.5	11000	15.1	19.8	22.1
Iron	31000	2300	50962	na	25100	26700	29100
Lead	800	400	26.8	na	21.8	nd	19.5
Magnesium	na	na	na	na	19000	4250	5060
Manganese	2000	160	2543	950	517	562	506
Nickel	2000	160	62.8	na	14.3	16.8	17.3
Potassium	na	na	na	na	1780	2080	1850
Silver	510	39	na	31	1.4	1	nd
Sodium	na	na	na	na	210	226	239
Thallium	7.2	0.55	2.11	3.6	**22.7**	**17.8**	nd
Vanadium	100	7.8	108	73	50	52.2	54.4
Zinc	31000	2300	202	14000	52.4	72.1	61.3

Note: Refer to the Master Table Legend at the beginning of this Appendix for a list of definitions and table notes

Table B-2
SWMU 39 - VI Sludge Results - 1992

SITE ID FIELD ID SAMPLING DATE DEPTH (ft) MATRIX	Comparison Criteria				39SL2 RVFS*38 25-FEB-92 0-1 CSE	39SL3 RVFS*39 25-FEB-92 0-1 CSE
	Industrial Soil RBC	Residential Soil RBC	Facility-Wide Background	SSL Transfer Soil to GW		
Metals (mg/kg)						
Aluminum	100000	7800	40041	na	17500	22800
Antimony	41	3.1	na	13	nd	nd
Arsenic	1.9	0.43	15.8	0.026	2.95	2.4
Barium	7200	550	209	2100	**429**	131
Beryllium	200	16	1.02	1200	1	**1.16**
Calcium	na	na	na	na	687	24300
Chromium	310	23	65.3	42	**206**	38.8
Cobalt	2000	160	72.3	na	8.22	14.8
Copper	4100	310	53.5	11000	**403**	21.1
Iron	31000	2300	50962	na	26600	33600
Lead	800	400	26.8	na	**21000**	**33.4**
Magnesium	na	na	na	na	2690	13700
Manganese	2000	160	2543	950	147	617
Nickel	2000	160	62.8	na	57.2	20.5
Potassium	na	na	na	na	1420	2650
Silver	510	39	na	31	0.934	1.27
Sodium	na	na	na	na	203	245
Thallium	7.2	0.55	2.11	3.6	**28**	**32.3**
Vanadium	100	7.8	108	73	54	68
Zinc	31000	2300	202	14000	145	74.7
SVOCs (ug/kg)						
Bis(2-Ethylhexyl)phthalate	200000	46000	na	2900000	nd	nd
Butylbenzylphthalate	20000000	1600000	na	17000000	nd	nd
Di-n-butylphthalate	10000000	780000	na	5000000	1600	nd
Fluoranthene	4100000	310000	na	6300000	140	nd
Phenanthrene	3100000	230000	na	680000	140	nd
Pyrene	3100000	230000	na	680000	250	nd

Note: Refer to the Master Table Legend at the beginning of this Appendix for a list of definitions and table notes

Table B-3
SWMU 39 - RFI Detected Results in Soil - 1998

Analyte				Sample ID	39MW7A					39MW7B					39MW8A				
				Sample Date	4/14/98					4/14/98					4/17/98				
				Sample Depth	6-9					14-16					6-8				
	I-RBC	r-RBC	Background	SSL Transfer	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PAHs (ug/kg)																			
Chrysene	390000	87000	na	150000	2	U		*2*	*2*	1.9	U		*1.9*	*1.9*	2	U		*2*	*2*
Indeno(1,2,3-cd)pyrene	3900	870	na	13000	2	U		*2*	*2*	1.9	U		*1.9*	*1.9*	2	U		*2*	*2*
Pyrene	3100000	230000	na	680000	2	U		*2*	*2*	1.9	U		*1.9*	*1.9*	2	U		*2*	*2*
SVOCs (ug/kg)																			
Bis(2-ethylhexyl)phthalate	200000	46000	na	2900000	380	U		*380*	*380*	350	U		*350*	*350*	400	U		*400*	*400*
Di-n-butylphthalate	10000000	780000	na	5000000	380	U		*380*	*380*	350	U		*350*	*350*	400	U		*400*	*400*
Diethylphthalate	82000000	6300000	na	450000	380	U		*380*	*380*	350	U		*350*	*350*	400	U		*400*	*400*
Metals (mg/kg)																			
Aluminum	100000	7800	40041	na	13700			*0.69*	*0.69*	5510			*0.62*	*0.62*	23900			*0.7*	*0.7*
Antimony	41	3.1	na	13	0.76	B	J	*0.58*	*0.58*	0.52	U		*0.52*	*0.52*	1	B	J	*0.58*	*0.58*
Arsenic	1.9	0.43	15.8	0.026	2.6			*0.69*	*0.69*	2			*0.62*	*0.62*	3.1			*0.7*	*0.7*
Barium	7200	550	209	2100	65.5		L	*0.12*	*0.12*	37.8		L	*0.1*	*0.1*	117		L	*0.12*	*0.12*
Beryllium	200	16	1.02	1200	0.52	B		*0.12*	*0.12*	0.4	B	J	*0.1*	*0.1*	0.78			*0.12*	*0.12*
Calcium	na	na	na	na	782			*2.7*	*2.7*	619			*2.4*	*2.4*	1350			*2.7*	*2.7*
Chromium	310	23	65.3	42	22.2			*0.12*	*0.12*	15			*0.1*	*0.1*	32.4			*0.12*	*0.12*
Cobalt	2000	160	72.3	na	10		L	*0.12*	*0.12*	5	B	L	*0.1*	*0.1*	13.4		L	*0.12*	*0.12*
Copper	4100	310	53.5	11000	14.1		K	*0.12*	*0.12*	11.4		B	*0.1*	*0.1*	21.7			*0.12*	*0.12*
Iron	31000	2300	50962	na	26000			*2.1*	*2.1*	16400			*1.9*	*1.9*	36400			*2.1*	*2.1*
Lead	800	400	26.8	na	9.3			*0.23*	*0.23*	4.9			*0.21*	*0.21*	11.9			*0.23*	*0.23*
Magnesium	na	na	na	na	3050			*3.6*	*3.6*	1730			*3.2*	*3.2*	5000			*3.6*	*3.6*
Manganese	2000	160	2543	950	348			*0.12*	*0.12*	320			*0.1*	*0.1*	471			*0.12*	*0.12*
Nickel	2000	160	62.8	na	11.9		K	*0.12*	*0.12*	8.7		K	*0.1*	*0.1*	18.9		K	*0.12*	*0.12*
Potassium	na	na	na	na	1500		K	*5.1*	*5.1*	670		K	*4.6*	*4.6*	2870			*5.1*	*5.1*
Selenium	510	39	na	19	0.46	U	UL	*0.46*	*0.46*	0.42	U	UL	*0.42*	*0.42*	0.47	U	UL	*0.47*	*0.47*
Sodium	na	na	na	na	116	B	B	*3.5*	*3.5*	88.4	B	B	*3.1*	*3.1*	168	B	J	*3.5*	*3.5*
Thallium	7.2	0.55	2.11	3.6	1.2	B	K	*0.69*	*0.69*	0.62	U		*0.62*	*0.62*	0.7	U	UL	*0.7*	*0.7*
Vanadium	100	7.8	108	73	43.2		K	*0.12*	*0.12*	15.4		K	*0.1*	*0.1*	65.6		K	*0.12*	*0.12*
Zinc	31000	2300	202	14000	43.6		K	*0.23*	*0.23*	24.2		K	*0.21*	*0.21*	66.7		K	*0.23*	*0.23*

Note: Refer to the Master Table Legend at the beginning of this Appendix
for a list of definitions and table notes

Table B-3
SWMU 39 - RFI Detected Results in Soil - 1998

Analyte	Sample ID				39MW8B					39SB1A					39SB1B				
	Sample Date				4/17/98					4/21/98					4/21/98				
	Sample Depth				12-16					0-0.5					1-2				
	i-RBC	r-RBC	Background	SSL Transfer	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PAHs (ug/kg)																			
Chrysene	390000	87000	na	150000	2	U		*2*	*2*	22	U		*22*	*22*	2.1	U		*2.1*	*2.1*
Indeno(1,2,3-cd)pyrene	3900	870	na	13000	2	U		*2*	*2*	6.9	J	J	*6.9*	*6.9*	2.1	U		*2.1*	*2.1*
Pyrene	3100000	230000	na	680000	2	U		*2*	*2*	22	U		*22*	*22*	2.1	U		*2.1*	*2.1*
SVOCs (ug/kg)																			
Bis(2-ethylhexyl)phthalate	200000	46000	na	2900000	67	J	J	*390*	*390*	430	U		*430*	*430*	410	U		*410*	*410*
Di-n-butylphthalate	10000000	780000	na	5000000	390	U		*390*	*390*	820			*430*	*430*	410	U		*410*	*410*
Diethylphthalate	82000000	6300000	na	450000	390	U		*390*	*390*	68	J	J	*430*	*430*	410	U		*410*	*410*
Metals (mg/kg)																			
Aluminum	100000	7800	40041	na	8390			*0.71*	*0.71*	23600			*0.77*	*0.77*	24000			*0.74*	*0.74*
Antimony	41	3.1	na	13	0.59	U		*0.59*	*0.59*	1.5	B	J	*0.64*	*0.64*	1.2	B	J	*0.61*	*0.61*
Arsenic	1.9	0.43	15.8	0.026	2.9			*0.71*	*0.71*	2.9			*0.77*	*0.77*	3.9			*0.74*	*0.74*
Barium	7200	550	209	2100	55.9		L	*0.12*	*0.12*	114		L	*0.13*	*0.13*	113		L	*0.12*	*0.12*
Beryllium	200	16	1.02	1200	0.39	B	B	*0.12*	*0.12*	0.44	B	B	*0.13*	*0.13*	0.85			*0.12*	*0.12*
Calcium	na	na	na	na	85800			*2.7*	*2.7*	518	B	J	*3*	*3*	904			*2.8*	*2.8*
Chromium	310	23	65.3	42	19.9			*0.12*	*0.12*	42.9			*0.13*	*0.13*	32.1			*0.12*	*0.12*
Cobalt	2000	160	72.3	na	6.9		L	*0.12*	*0.12*	7.1		L	*0.13*	*0.13*	12.9		L	*0.12*	*0.12*
Copper	4100	310	53.5	11000	14.6			*0.12*	*0.12*	**336**			*0.13*	*0.13*	**196**			*0.12*	*0.12*
Iron	31000	2300	50962	na	22800			*2.1*	*2.1*	28500			*2.3*	*2.3*	38100			*2.2*	*2.2*
Lead	800	400	26.8	na	6.2			*0.24*	*0.24*	**7070**			*0.26*	*0.26*	**537**			*0.25*	*0.25*
Magnesium	na	na	na	na	51000			*3.6*	*3.6*	3930			*4*	*4*	4630			*3.8*	*3.8*
Manganese	2000	160	2543	950	392			*0.12*	*0.12*	113			*0.13*	*0.13*	189			*0.12*	*0.12*
Nickel	2000	160	62.8	na	8.4		K	*0.12*	*0.12*	19.5		K	*0.13*	*0.13*	19.6		K	*0.12*	*0.12*
Potassium	na	na	na	na	1620			*5.2*	*5.2*	2710			*5.7*	*5.7*	3260			*5.4*	*5.4*
Selenium	510	39	na	19	0.47	U	UL	*0.47*	*0.47*	0.89		L	*0.51*	*0.51*	0.49	U	UL	*0.49*	*0.49*
Sodium	na	na	na	na	363	B	J	*3.5*	*3.5*	173	B	J	*3.9*	*3.9*	169	B	J	*3.7*	*3.7*
Thallium	7.2	0.55	2.11	3.6	0.71	U	UL	*0.71*	*0.71*	0.77	U	UL	*0.77*	*0.77*	0.74	U	UL	*0.74*	*0.74*
Vanadium	100	7.8	108	73	29.9		K	*0.12*	*0.12*	66.1		K	*0.13*	*0.13*	67.5		K	*0.12*	*0.12*
Zinc	31000	2300	202	14000	22.6		K	*0.24*	*0.24*	75.7		K	*0.26*	*0.26*	71.8		K	*0.25*	*0.25*

Note: Refer to the Master Table Legend at the beginning of this Appendix for a list of definitions and table notes

Table B-3
SWMU 39 - RFI Detected Results in Soil - 1998

Analyte				Sample ID	39SB1D					39SB2B					39SB2D				
				Sample Date	4/21/98					4/20/98					4/20/98				
				Sample Depth	4-6					1-2					4-6				
	i-RBC	r-RBC	Background	SSL Transfer	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PAHs (ug/kg)																			
Chrysene	390000	87000	na	150000	2.1	U		*2.1*	*2.1*	2.1	U		*2.1*	*2.1*	2	U		*2*	*2*
Indeno(1,2,3-cd)pyrene	3900	870	na	13000	2.1	U		*2.1*	*2.1*	2.1	U		*2.1*	*2.1*	2	U		*2*	*2*
Pyrene	3100000	230000	na	680000	2.1	U		*2.1*	*2.1*	2.1	U		*2.1*	*2.1*	2	U		*2*	*2*
SVOCs (ug/kg)																			
Bis(2-ethylhexyl)phthalate	200000	46000	na	2900000	410	U		*410*	*410*	410	U		*410*	*410*	400	U		*400*	*400*
Di-n-butylphthalate	10000000	780000	na	5000000	410	U		*410*	*410*	410	U		*410*	*410*	400	U		*400*	*400*
Diethylphthalate	82000000	6300000	na	450000	410	U		*410*	*410*	410	U		*410*	*410*	400	U		*400*	*400*
Metals (mg/kg)																			
Aluminum	100000	7800	40041	na	20900			*0.73*	*0.73*	28300			*0.74*	*0.74*	18100			*0.71*	*0.71*
Antimony	41	3.1	na	13	0.86	B	J	*0.61*	*0.61*	1.2	B	J	*0.62*	*0.62*	0.69	B	J	*0.59*	*0.59*
Arsenic	1.9	0.43	15.8	0.026	2.6			*0.73*	*0.73*	3.4			*0.74*	*0.74*	3			*0.71*	*0.71*
Barium	7200	550	209	2100	114		L	*0.12*	*0.12*	121		L	*0.12*	*0.12*	94.9		L	*0.12*	*0.12*
Beryllium	200	16	1.02	1200	0.67		B	*0.12*	*0.12*	0.93			*0.12*	*0.12*	0.67		B	*0.12*	*0.12*
Calcium	na	na	na	na	1170			*2.8*	*2.8*	1290			*2.9*	*2.9*	1200			*2.7*	*2.7*
Chromium	310	23	65.3	42	39			*0.12*	*0.12*	35.5			*0.12*	*0.12*	25.9			*0.12*	*0.12*
Cobalt	2000	160	72.3	na	11.6		L	*0.12*	*0.12*	16.3		L	*0.12*	*0.12*	12.1		L	*0.12*	*0.12*
Copper	4100	310	53.5	11000	30.4			*0.12*	*0.12*	25.9			*0.12*	*0.12*	15.9			*0.12*	*0.12*
Iron	31000	2300	50962	na	31900			*2.2*	*2.2*	42600			*2.2*	*2.2*	31000			*2.1*	*2.1*
Lead	800	400	26.8	na	21.4			*0.24*	*0.24*	19.2			*0.25*	*0.25*	10.5			*0.24*	*0.24*
Magnesium	na	na	na	na	4510			*3.8*	*3.8*	5510			*3.8*	*3.8*	4110			*3.7*	*3.7*
Manganese	2000	160	2543	950	409			*0.12*	*0.12*	579			*0.12*	*0.12*	393			*0.12*	*0.12*
Nickel	2000	160	62.8	na	16.7		K	*0.12*	*0.12*	21.6		K	*0.12*	*0.12*	15		K	*0.12*	*0.12*
Potassium	na	na	na	na	3090			*5.3*	*5.3*	3710			*5.5*	*5.5*	2320			*5.2*	*5.2*
Selenium	510	39	na	19	0.49	U	UL	*0.49*	*0.49*	0.5	U	UL	*0.5*	*0.5*	0.65		L	*0.48*	*0.48*
Sodium	na	na	na	na	219	B	J	*3.6*	*3.6*	248	B	J	*3.7*	*3.7*	191	B	J	*3.6*	*3.6*
Thallium	7.2	0.55	2.11	3.6	0.73	U	UL	*0.73*	*0.73*	1	B	L	*0.74*	*0.74*	0.71	U	UL	*0.71*	*0.71*
Vanadium	100	7.8	108	73	60.3		K	*0.12*	*0.12*	76.4		K	*0.12*	*0.12*	52.5		K	*0.12*	*0.12*
Zinc	31000	2300	202	14000	70.5		K	*0.24*	*0.24*	73.9		K	*0.25*	*0.25*	59.1		K	*0.24*	*0.24*

Note: Refer to the Master Table Legend at the beginning of this Appendix
for a list of definitions and table notes

Table B-3
SWMU 39 - RFI Detected Results in Soil - 1998

Analyte				Sample ID	39SB2F					39SB3A					39SB3B				
				Sample Date	4/20/98					4/21/98					4/21/98				
				Sample Depth	12-14					0-0.5					1-2				
	I-RBC	r-RBC	Background	SSL Transfer	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PAHs (ug/kg)																			
Chrysene	390000	87000	na	150000	2	U		*2*	*2*	2	J	J	*2*	*2*	2.1	U		*2.1*	*2.1*
Indeno(1,2,3-cd)pyrene	3900	870	na	13000	2	U		*2*	*2*	12	U		*12*	*12*	2.1	U		*2.1*	*2.1*
Pyrene	3100000	230000	na	680000	2	U		*2*	*2*	1	J	J	*1*	*1*	2.1	U		*2.1*	*2.1*
SVOCs (ug/kg)																			
Bis(2-ethylhexyl)phthalate	200000	46000	na	2900000	430	U		*430*	*430*	450	U		*450*	*450*	430	U		*430*	*430*
Di-n-butylphthalate	10000000	780000	na	5000000	430	U		*430*	*430*	450	U		*450*	*450*	430	U		*430*	*430*
Diethylphthalate	82000000	6300000	na	450000	430	U		*430*	*430*	450	U		*450*	*450*	430	U		*430*	*430*
Metals (mg/kg)																			
Aluminum	100000	7800	40041	na	18700			*0.77*	*0.77*	37300			*0.79*	*0.79*	37400			*0.75*	*0.75*
Antimony	41	3.1	na	13	0.64	U		*0.64*	*0.64*	0.66	U		*0.66*	*0.66*	0.95	B	J	*0.63*	*0.63*
Arsenic	1.9	0.43	15.8	0.026	9.2			*0.77*	*0.77*	5.3			*0.79*	*0.79*	6			*0.75*	*0.75*
Barium	7200	550	209	2100	59.5		L	*0.13*	*0.13*	178		L	*0.13*	*0.13*	162		L	*0.13*	*0.13*
Beryllium	200	16	1.02	1200	0.89			*0.13*	*0.13*	**1.3**			*0.13*	*0.13*	**1.4**			*0.13*	*0.13*
Calcium	na	na	na	na	1730			*2.9*	*2.9*	1980			*3*	*3*	1470			*2.9*	*2.9*
Chromium	310	23	65.3	42	35.7			*0.13*	*0.13*	50.5			*0.13*	*0.13*	47.5			*0.13*	*0.13*
Cobalt	2000	160	72.3	na	11.1		L	*0.13*	*0.13*	15.3		L	*0.13*	*0.13*	24.2		L	*0.13*	*0.13*
Copper	4100	310	53.5	11000	34.4			*0.13*	*0.13*	42.3			*0.13*	*0.13*	44.3			*0.13*	*0.13*
Iron	31000	2300	50962	na	29400			*2.3*	*2.3*	44500			*2.4*	*2.4*	**52800**			*2.3*	*2.3*
Lead	800	400	26.8	na	17.7			*0.26*	*0.26*	**249**			*0.26*	*0.26*	**73.6**			*0.25*	*0.25*
Magnesium	na	na	na	na	12800			*4*	*4*	6100			*4.1*	*4.1*	4350			*3.9*	*3.9*
Manganese	2000	160	2543	950	342			*0.13*	*0.13*	198			*0.13*	*0.13*	294			*0.13*	*0.13*
Nickel	2000	160	62.8	na	26.2		K	*0.13*	*0.13*	26.9		K	*0.13*	*0.13*	24.3		K	*0.13*	*0.13*
Potassium	na	na	na	na	4490			*5.6*	*5.6*	3080			*5.8*	*5.8*	3040			*5.5*	*5.5*
Selenium	510	39	na	19	0.51	U	UL	*0.51*	*0.51*	0.53	U	UL	*0.53*	*0.53*	0.5	U	UL	*0.5*	*0.5*
Sodium	na	na	na	na	251	B	J	*3.8*	*3.8*	288	B	J	*4*	*4*	241	B	J	*3.8*	*3.8*
Thallium	7.2	0.55	2.11	3.6	0.77	U	UL	*0.77*	*0.77*	0.79	U	UL	*0.79*	*0.79*	0.75	U	UL	*0.75*	*0.75*
Vanadium	100	7.8	108	73	49.8		K	*0.13*	*0.13*	89.9		K	*0.13*	*0.13*	92.7		K	*0.13*	*0.13*
Zinc	31000	2300	202	14000	44.8		K	*0.26*	*0.26*	94.6		K	*0.26*	*0.26*	120		K	*0.25*	*0.25*

Note: Refer to the Master Table Legend at the beginning of this Appendix
for a list of definitions and table notes

Table B-3
SWMU 39 - RFI Detected Results in Soil - 1998

Analyte	Sample ID				39SB3D					39SB4B					39SB4D					39SB4F				
	Sample Date				4/21/98					4/20/98					4/20/98					4/20/98				
	Sample Depth				4-6					1-2					4-6					6-8				
	i-RBC	r-RBC	Background	SSL Transfer	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PAHs (ug/kg)																								
Chrysene	390000	87000	na	150000	2.2	U		*2.2*	*2.2*	2.1	U		*2.1*	*2.1*	2	U		*2*	*2*	2.1	U		*2.1*	*2.1*
Indeno(1,2,3-cd)pyrene	3900	870	na	13000	2.2	U		*2.2*	*2.2*	2.1	U		*2.1*	*2.1*	2	U		*2*	*2*	2.1	U		*2.1*	*2.1*
Pyrene	3100000	230000	na	680000	2.2	U		*2.2*	*2.2*	2.1	U		*2.1*	*2.1*	2	U		*2*	*2*	2.1	U		*2.1*	*2.1*
SVOCs (ug/kg)																								
Bis(2-ethylhexyl)phthalate	200000	46000	na	2900000	390	U		*390*	*390*	420	U		*420*	*420*	410	U		*410*	*410*	410	U		*410*	*410*
Di-n-butylphthalate	10000000	780000	na	5000000	390	U		*390*	*390*	420	U		*420*	*420*	410	U		*410*	*410*	410	U		*410*	*410*
Diethylphthalate	82000000	6300000	na	450000	390	U		*390*	*390*	420	U		*420*	*420*	410	U		*410*	*410*	410	U		*410*	*410*
Metals (mg/kg)																								
Aluminum	100000	7800	40041	na	22700			*0.72*	*0.72*	22400			*0.74*	*0.74*	34500			*0.74*	*0.74*	31100			*0.72*	*0.72*
Antimony	41	3.1	na	13	0.6	U		*0.6*	*0.6*	1.1	B	J	*0.62*	*0.62*	1.1	B	J	*0.62*	*0.62*	0.6	U		*0.6*	*0.6*
Arsenic	1.9	0.43	15.8	0.026	3			*0.72*	*0.72*	4.1			*0.74*	*0.74*	3.5			*0.74*	*0.74*	2.9			*0.72*	*0.72*
Barium	7200	550	209	2100	108		L	*0.12*	*0.12*	**216**		**L**	*0.12*	*0.12*	124		L	*0.12*	*0.12*	125		L	*0.12*	*0.12*
Beryllium	200	16	1.02	1200	0.78			*0.12*	*0.12*	**1.1**			*0.12*	*0.12*	0.81			*0.12*	*0.12*	0.72		B	*0.12*	*0.12*
Calcium	na	na	na	na	1640			*2.7*	*2.7*	1750			*2.8*	*2.8*	1510			*2.9*	*2.9*	1480			*2.8*	*2.8*
Chromium	310	23	65.3	42	32.4			*0.12*	*0.12*	31.7			*0.12*	*0.12*	42.1			*0.12*	*0.12*	44.4			*0.12*	*0.12*
Cobalt	2000	160	72.3	na	11.3		L	*0.12*	*0.12*	17.2		L	*0.12*	*0.12*	16.9		L	*0.12*	*0.12*	9.2		L	*0.12*	*0.12*
Copper	4100	310	53.5	11000	24			*0.12*	*0.12*	19.3			*0.12*	*0.12*	25.4			*0.12*	*0.12*	21.9			*0.12*	*0.12*
Iron	31000	2300	50962	na	23500			*2.2*	*2.2*	27900			*2.2*	*2.2*	36900			*2.2*	*2.2*	31900			*2.2*	*2.2*
Lead	800	400	26.8	na	11.9			*0.24*	*0.24*	17.7			*0.25*	*0.25*	16.3			*0.25*	*0.25*	13.2			*0.24*	*0.24*
Magnesium	na	na	na	na	5360			*3.7*	*3.7*	3020			*3.8*	*3.8*	4830			*3.8*	*3.8*	5180			*3.7*	*3.7*
Manganese	2000	160	2543	950	145			*0.12*	*0.12*	1110			*0.12*	*0.12*	359			*0.12*	*0.12*	262			*0.12*	*0.12*
Nickel	2000	160	62.8	na	18.3		K	*0.12*	*0.12*	16.4		K	*0.12*	*0.12*	22.3		K	*0.12*	*0.12*	20.7		K	*0.12*	*0.12*
Potassium	na	na	na	na	2280			*5.3*	*5.3*	1890			*5.4*	*5.4*	2770			*5.5*	*5.5*	3050			*5.3*	*5.3*
Selenium	510	39	na	19	0.6		L	*0.48*	*0.48*	1.2		L	*0.49*	*0.49*	0.5	U	UL	*0.5*	*0.5*	0.48	U	UL	*0.48*	*0.48*
Sodium	na	na	na	na	218	B	J	*3.6*	*3.6*	206	B	J	*3.7*	*3.7*	232	B	J	*3.7*	*3.7*	231	B	J	*3.6*	*3.6*
Thallium	7.2	0.55	2.11	3.6	0.98	B	L	*0.72*	*0.72*	0.74	U	UL	*0.74*	*0.74*	0.86	B	L	*0.74*	*0.74*	0.75	B	L	*0.72*	*0.72*
Vanadium	100	7.8	108	73	58.6		K	*0.12*	*0.12*	53.2		K	*0.12*	*0.12*	78.7		K	*0.12*	*0.12*	74.8		K	*0.12*	*0.12*
Zinc	31000	2300	202	14000	63.2		K	*0.24*	*0.24*	76.7		K	*0.25*	*0.25*	84.8		K	*0.25*	*0.25*	71.5		K	*0.24*	*0.24*

Note: Refer to the Master Table Legend at the beginning of this Appendix
for a list of definitions and table notes

Table B-5
SWMU 39 - ATK Quarterly Sampling Results - Groundwater- August 2003

Analyte	Sample ID		39MW1-Q3/03					39MW3-3-Q3/03					39MW3-Q3/03					39MW4-Q3/03					39MW5-Q3/03					39MW6-Q3/03				
	Sample Date		8/13/03					8/13/03					8/13/03					8/13/03					8/13/03					8/14/03				
	Sample Depth		-					-					-					-					-					-				
	MCL	tw-RBC	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
SVOCs (ug/L)																																
2,4-Dinitrotoluene	na	7.3	10	U		*1*	*10*	10	U		*1*	*10*	10	U		*1*	*10*	10	U		*1*	*10*	10	U		*1*	*10*	10	U		*1*	*10*
2,6-Dinitrotoluene	na	3.6	10	U		*1*	*10*	10	U		*1*	*10*	10	U		*1*	*10*	10	U		*1*	*10*	10	U		*1*	*10*	10	U		*1*	*10*
Diethylphthalate	na	2900	10	U		*1.1*	*10*	10	U		*1.1*	*10*	10	U		*1.1*	*10*	10	U		*1.1*	*10*	10	U		*1.1*	*10*	10	U		*1.1*	*10*
Di-n-butylphthalate	na	360	10	U		*1.6*	*10*	10	U		*1.6*	*10*	10	U		*1.6*	*10*	10	U		*1.6*	*10*	10	U		*1.6*	*10*	10	U		*1.6*	*10*
Pesticides (ug/L)																																
Endrin	2	1.1	0.2	U		*0.0166*	*0.4*	0.2	U		*0.0166*	*0.4*	0.2	U		*0.0166*	*0.4*	0.2	U		*0.0166*	*0.4*	0.2	U		*0.0166*	*0.4*	0.2	U		*0.0166*	*0.4*
Lindane	NA	0.052	0.1	U		*0.0087*	*0.1*	0.1	U		*0.0087*	*0.1*	0.1	U		*0.0087*	*0.1*	0.1	U		*0.0087*	*0.1*	0.1	U		*0.0087*	*0.1*	0.1	U		*0.0087*	*0.1*
Methoxychlor	40	18	0.5	U		*0.108*	*1*	0.5	U		*0.108*	*1*	0.5	U		*0.108*	*1*	0.5	U		*0.108*	*1*	0.5	U		*0.108*	*1*	0.5	U		*0.108*	*1*
Toxaphene	3	0.061	5	U		*0.525*	*5*	5	U		*0.525*	*5*	5	U		*0.525*	*5*	5	U		*0.525*	*5*	5	U		*0.525*	*5*	5	U		*0.525*	*5*
Herbicides (ug/L)																																
2,4,5-TP (Silvex)	50	29	2.5	U		*0.13*	*2.5*	2.5	U		*0.13*	*2.5*	2.5	U		*0.13*	*2.5*	2.5	U		*0.13*	*2.5*	2.5	U	J	*0.13*	*2.5*	2.5	U		*0.13*	*2.5*
2,4-D	70	36	2.5	U		*0.78*	*2.5*	2.5	U		*0.78*	*2.5*	2.5	U		*0.78*	*2.5*	2.5	U		*0.78*	*2.5*	2.5	U	J	*0.78*	*2.5*	2.5	U		*0.78*	*2.5*
Metals (ug/L)																																
Antimony	6	1.5	5	U		*1.7*	*5*	5	U		*1.7*	*5*	5	U		*1.7*	*5*	5	U		*1.7*	*5*	5	U		*1.7*	*5*	5	U		*1.7*	*5*
Arsenic	10	0.045	5	U		*0.9*	*5*	5	U		*0.9*	*5*	5	U		*0.9*	*5*	5	U		*0.9*	*5*	5	U		*0.9*	*5*	5	U		*0.9*	*5*
Barium	2000	260	42.6			*0.1*	*1*	86.1			*0.1*	*1*	81.1			*0.1*	*1*	99.9			*0.1*	*1*	193			*0.1*	*1*	323			*0.1*	*1*
Beryllium	4	7.3	1	U		*0.1*	*1*	1	U		*0.1*	*1*	1	U		*0.1*	*1*	1	U		*0.1*	*1*	1	U		*0.1*	*1*	1	U		*0.1*	*1*
Cadmium	5	1.8	1	U		*0.3*	*1*	1	U		*0.3*	*1*	1	U		*0.3*	*1*	1	U		*0.3*	*1*	1	U		*0.3*	*1*	1	U		*0.3*	*1*
Chromium	100	11	5	U		*0.8*	*5*	5.3			*0.8*	*5*	5	U		*0.8*	*5*	5	U		*0.8*	*5*	5	U		*0.8*	*5*	5	U		*0.8*	*5*
Iron	300	1100	50	U		*3*	*50*	50	U		*3*	*50*	50	U		*3*	*50*	50	U		*3*	*50*	138			*3*	*50*	1470			*3*	*50*
Lead	15	na	5	U		*1*	*5*	5	U		*1*	*5*	5	U		*1*	*5*	5	U		*1*	*5*	5	U		*1*	*5*	5	U		*1*	*5*
Manganese	50	73	2	U		*0.1*	*2*	2	U		*0.1*	*2*	2	U		*0.1*	*2*	2.6			*0.1*	*2*	104			*0.1*	*2*	54.5			*0.1*	*2*
Mercury	2	1.1	0.2	U		*0.1*	*0.5*	0.2	U		*0.1*	*0.5*	0.2	U		*0.1*	*0.5*	0.2	U		*0.1*	*0.5*	0.2	U		*0.1*	*0.5*	0.2	U		*0.1*	*0.5*
Nickel	na	73	5	U		*0.9*	*5*	5	U		*0.9*	*5*	5	U		*0.9*	*5*	5	U		*0.9*	*5*	5	U		*0.9*	*5*	5	U		*0.9*	*5*
Selenium	50	18	5	U		*1.6*	*5*	5	U		*1.6*	*5*	5	U		*1.6*	*5*	5	U		*1.6*	*5*	5	U		*1.6*	*5*	5	U		*1.6*	*5*
Silver	100	18	2	U		*0.6*	*2*	2	U		*0.6*	*2*	2	U		*0.6*	*2*	2	U		*0.6*	*2*	2	U		*0.6*	*2*	2	U		*0.6*	*2*
Sodium	na	na	3380			*11.9*	*100*	23500			*11.9*	*100*	22700			*11.9*	*100*	10700			*11.9*	*100*	15400			*11.9*	*100*	8650			*11.9*	*100*
Misc. (ug/L)																																
Total Organic Carbon	na	na	1950			*54*	*1000*	1440			*54*	*1000*	1760			*54*	*1000*	2820			*54*	*1000*	3000			*54*	*1000*	5790			*54*	*1000*
Total Organic Halides	na	na	10	U		*10*	*10*	10	U		*10*	*10*	10	U		*10*	*10*	10	U		*10*	*10*	10	U		*10*	*10*	10	U		*10*	*10*
Chloride	na	na	1830			*8*	*100*	11700			*8*	*100*	9130			*8*	*100*	1570			*8*	*100*	8600			*8*	*100*	3630			*8*	*100*
Fluoride	4000	na	185			*20*	*100*	254			*20*	*100*	254			*20*	*100*	127			*20*	*100*	593			*20*	*100*	251			*20*	*100*
Nitrate (as N)	10000	na	930			*7*	*100*	2020			*7*	*100*	1700			*7*	*100*	282			*7*	*100*	169			*7*	*100*	173			*7*	*100*
Sulfate	na	na	18000			*16*	*5000*	74800			*16*	*5000*	71400			*16*	*5000*	71400			*16*	*5000*	41300			*16*	*5000*	25500			*16*	*5000*
Total Recoverable Phenolics	na	na	5	U		*3*	*5*	5	U		*3*	*5*	5	U		*3*	*5*	5	U		*3*	*5*	5	U		*3*	*5*	5	U		*3*	*5*

Note: This table presents analyzed constituents rather than detected constituents because the analytical list for each group is not the standard TCL/TAL list.
Note: Refer to the Master Table Legend at the beginning of this Appendix for a list of definitions and table notes

Table B-6
SWMU 39 - RFI Detected Results in Groundwater- 1998

Analyte	Sample ID		39MW2-2					39MW7-1					39MW8-1				
	Sample Date		5/13/98					5/12/98					5/13/98				
	Sample Depth		36.97-46.97					20-30					33-43				
	MCL	tw-RBC	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PAHs (ug/L)			None Detected														
SVOCs (ug/L)			None Detected														
Metals (ug/L)																	
Aluminum	50	3600	18.1	B	B	*6*	*6*	682	J	J	*6*	*6*	53.3	B	B	*6*	*6*
Barium	2000	260	62.5	B	L	*1*	*1*	59.9	B	L	*1*	*1*	156	B	L	*1*	*1*
Calcium	na	na	118000			*23*	*23*	64200			*23*	*23*	96800			*23*	*23*
Chromium	100	11	2	B	J	*1*	*1*	9.7	B	J	*1*	*1*	1.3	B	J	*1*	*1*
Cobalt	na	73	10.9	B	L	*1*	*1*	6.4	B	L	*1*	*1*	3	B	L	*1*	*1*
Copper	1300	150	19	B	B	*1*	*1*	22.1	B	B	*1*	*1*	7.7	B	B	*1*	*1*
Iron	300	1100	18	U	U	*18*	*18*	1020			*18*	*18*	67.1	B	B	*18*	*18*
Magnesium	na	na	47400			*31*	*31*	24900			*31*	*31*	33500			*31*	*31*
Manganese	50	73	1.5	B	B	*1*	*1*	64.6			*1*	*1*	18		B	*1*	*1*
Nickel	na	73	6.1	B	K	*1*	*1*	7.7	B	K	*1*	*1*	3.4	B	K	*1*	*1*
Potassium	na	na	2940	B	K	*44*	*44*	2450	B	K	*44*	*44*	6620		K	*44*	*44*
Sodium	na	na	19300		K	*30*	*30*	9960		K	*30*	*30*	7900		K	*30*	*30*
Zinc	5000	1100	8	B	J	*2*	*2*	7.2	B	J	*2*	*2*	18	B	J	*2*	*2*
Misc. (ug/L)			None Detected														

Note: Refer to the Master Table Legend at the beginning of this Appendix for a list of definitions and table notes

Appendix C
Sample Location Coordinates and Elevations

Appendix C
2002 RFI/RI Sample Location Coordinates and Elevations

Site ID	Northing	Easting	Elevation
Bag Loading Area			
BLASB01	283759.34	1368917.41	2084.76
BLASB02	283502.61	1368951.35	2084.35
BLASB03	283341.75	1369107.91	2084.86
BLASD01	283903.51	1369209.54	2073.65
BLASD02	283115.70	1368168.26	2072.20
BLASW/SD04	283971.07	1367733.04	2003.67
BLASW/SD05	284400.83	1368617.19	1994.87
BLASS01	283735.43	1368904.58	2087.90
BLASS02	283747.77	1368919.86	2085.32
BLASS03	283723.57	1369027.29	2088.47
BLASS04	283732.33	1368791.41	2086.38
BLASS05	283590.26	1368532.63	2086.33
BLASS06	283353.92	1368682.97	2086.15
BLASS07	283109.21	1368757.63	2082.85
BLASS08	283247.04	1369015.59	2068.37
BLASS09	283468.23	1369148.14	2086.32
BLASS10	283521.12	1369131.36	2085.47
BLASS11	283651.84	1369055.02	2081.54
BLATR01	283784.45	1368843.33	2084.80
BLATR02	283690.21	1369522.45	2076.28
BLATR03	283241.96	1369122.06	2084.10
Building Debris Disposal Trench			
DTSB46	284166.38	1371883.27	1960.03
DTSB47	284128.88	1371950.70	1958.73
DTSW/SD05	284005.92	1372244.52	1952.75
DTSW/SD06	284086.19	1372031.44	1954.19
DTSW/SD07	284096.56	1371844.27	1953.76
DTSW/SD08	284144.86	1371572.38	1956.36
DTSW/SD09	284186.47	1371237.62	1958.86
DTSW/SD10	283930.50	1372438.79	1948.05
Igniter Assembly Area			
IASB06	286793.22	1366464.42	2127.94
IASB07	286836.19	1366537.77	2127.80
IASB08	286844.39	1366540.86	2128.29
IASB09	286836.85	1366552.22	2122.26
IASB10	286914.21	1366737.27	2124.12
IASB11	286979.25	1366847.43	2120.85
IASB12	287192.44	1367238.81	2121.22
IASB13	286025.74	1367290.50	2112.37
IASB14	286028.60	1367313.30	2107.72
IASB15	286008.67	1367303.03	2108.68
IASD04	287910.37	1367497.94	2114.74
IASD05	287657.23	1367299.29	2118.76
IASD06	287170.01	1367537.44	2108.59
IASD07	286025.18	1367841.73	2080.95
IASD08	286514.15	1366312.47	2105.73

Appendix C
2002 RFI/RI Sample Location Coordinates and Elevations

Site ID	Northing	Easting	Elevation
IASD09	286338.22	1366718.88	2122.81
IASD10	285779.61	1367016.88	2111.93
IASD11	286747.03	1366543.95	2126.90
IASD12	286943.25	1366899.46	2119.96
IASS01	286917.34	1366709.66	2123.41
IASS02	286897.08	1366725.28	2121.09
IASS03	286988.86	1366823.72	2121.87
IASS04	286947.80	1366843.37	2123.94
IASS05	286894.43	1367088.92	2126.78
IATR01	287823.59	1367495.93	2122.32
IATR02	287109.19	1366902.82	2126.63
IATR03	286905.87	1366899.75	2128.09
IATR04	287025.14	1367291.87	2121.66
IATR05	286459.03	1367090.96	2118.92
IATR06	286083.39	1367320.73	2109.75
IATR07	286161.33	1367703.26	2093.21
IATR08	285414.85	1366624.76	2081.53
Northern Burning Ground			
NBGSB11	288870.45	1368833.53	2154.81
NBGSB12	288871.04	1368826.40	2118.54
NBGSB13	288885.28	1368831.82	2128.63
NBGSB14	288893.22	1368805.31	2115.73
NBGSB15	288922.64	1368810.35	2110.33
NBGSB16	288859.88	1368801.27	2135.99
NBGSB17	288818.07	1368645.78	2130.78
NBGSB18	288797.04	1368646.91	2122.95
NBGSB19	288801.32	1368670.82	2130.48
NBGSD01	289003.59	1368849.12	2101.81
Rail Yard			
RYSB08	286615.43	1368757.30	2041.52
RYSB09	284542.93	1367320.88	2033.13
RYSD01	286830.09	1369221.73	2030.06
RYSW/SD03	286473.61	1369453.72	2013.26
RYSW/SD04	286368.75	1369597.05	2016.95
RYSW/SD05	286264.79	1369793.40	2002.11
RYSD06	284899.91	1370631.43	1971.93
RYSD07	285279.54	1368461.72	2039.99
RYSD08	284683.05	1368403.52	2003.63
RYSD09	284540.72	1367223.66	2035.61
RYSD10	284362.09	1366945.98	2037.34
RYSW/SD12	284208.69	1367255.84	2013.41
RYSW/SD13	283950.73	1367533.00	2007.47
RYSS01	285974.05	1368568.78	2045.32
RYSS02	285178.41	1368053.61	2047.59
RYSS03	284855.42	1368029.77	2041.99
RYSS04	286911.05	1369352.62	2048.07
RYSS05	286849.89	1369465.50	2048.13

Appendix C
2002 RFI/RI Sample Location Coordinates and Elevations

Site ID	Northing	Easting	Elevation
RYSS06	286296.66	1368624.47	2043.12
RYSS07	286140.09	1369021.93	2054.61
RYSS08	286142.52	1368914.54	2047.75
RYSS09	285772.89	1368473.07	2043.17
RYSS10	285630.88	1368573.94	2039.95
RYSS11	285640.85	1368771.27	2042.85
RYSS12	285400.47	1368530.00	2043.83
RYSS13	285181.89	1367961.93	2045.67
RYSS14	284630.09	1367511.38	2039.10
RYSS15	284796.18	1367441.78	2046.45
RYSS16	284074.95	1366562.65	2065.39
RYSW02	286579.33	1369337.92	2020.67
RYSW15	284877.53	1368094.86	2049.27
RYTR01	286633.00	1369318.92	2044.84
RYTR02	285973.88	1369088.62	2046.17
RYTR03	284670.93	1367814.54	2048.24
Western Burning Ground			
WBGSB22	284851.29	1366227.70	2059.31
WBGSB23	284790.45	1366222.56	2047.80
WBGSB24	284961.73	1366250.12	2051.85
WBGSB25	284935.45	1366172.97	2042.82
WBGSW/SD07	284894.86	1365981.81	2035.08
WBGSW/SD08	284475.46	1366635.69	2031.46
WBGSW/SD09	284307.45	1366821.35	2023.52
WBGSW/SD10	284671.29	1366304.58	2033.71
WBGSD11	284645.80	1366262.78	2041.21
WBGSD12	284767.63	1366126.27	2038.34
WBGSW/SD13	284429.37	1366592.28	2027.15
WBGSW/SD14	283749.40	1367174.17	2013.71
WBGSW/SD15	284590.53	1365617.15	2043.91
SWMU 31			
31SB5	319274.11	1397144.57	1696.65
31SE07	319082.44	1396997.74	1678.92
31SE08	319195.52	1397149.85	1687.90
31SE09	319115.09	1397190.57	1685.51
31SE10	319032.18	1397061.01	1685.90
31SE11	319259.24	1397221.85	1684.85
31SE12	319285.59	1397386.15	1686.62
31SE13	319336.53	1397453.76	1693.18
31SE14	319395.27	1397412.05	1692.46
31SW10	319032.18	1397061.01	1685.90
31SW12	319285.59	1397386.15	1686.62
31SW14	319375.01	1397477.91	1693.98
SWMU 39			
39SS08	321302.51	1403422.04	1700.60
39SS07	321268.19	1403446.59	1701.35
39SB05	321280.53	1403572.97	1695.95

Table B-4
SWMU 39 - RFI Detected TCLP Metals Results in Soil - 1998

SITE ID		39SB1C	39SB1E	39SB2C	39SB2E	39SB3C	39SB3E	39SB4C	39SB4E
FIELD ID		39SB1C	39SB1E	39SB2C	39SB2E	39SB3C	39SB3E	39SB4C	39SB4E
DATE SAMPLED		21-APR-98	21-APR-98	20-APR-98	20-APR-98	21-APR-98	21-APR-98	20-APR-98	20-APR-98
DEPTH (ft)	TCLP	2-6	12-12.5	2-6	8-12	2-6	6-8	2-6	6-10
MATRIX	Criteria	CSO	CSO	CSO	CSO	CSO	CSO	CSO	CSO
UNITS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Arsenic	5000	6 U	6 U	6 U	6 U	6 U	8 J	6 U	6 U
Barium	100000	518 J	215	433 J	160 J	343 J	493 J	352 J	393 J
Cadmium	1000	1 J	1 U	1 UJ	1	4.1 J	2.5 J	1 UJ	1 UJ
Lead	5000	2 UJ	2 U	5.2 B	2 UJ	2 UJ	5.8 B	2.4 B	14.2

Note: Refer to the Master Table Legend at the beginning of this Appendix for a list of definitions and table notes

Appendix C
2002 RFI/RI Sample Location Coordinates and Elevations

Site ID	Northing	Easting	Elevation
39SS10	321191.31	1403579.29	1701.35
39SB06	321168.54	1403484.18	1697.50
39SS12	321132.53	1403758.27	1700.54
39SS09	321359.21	1403646.31	1701.70
39SS11	321111.42	1403466.10	1698.86
SWMU 48			
48SB08	319794.89	1409321.52	1821.46
48SB09	319798.39	1409276.73	1818.62
48SB10	319883.83	1409354.18	1829.80
SWMU 49			
49SB02	319580.55	1409695.49	1822.51
49SS01	319564.90	1409729.76	1826.82
SWMU 50			
50SB04	319589.68	1409465.00	1817.07
50SB05	319535.10	1409565.65	1817.72
50SS01	319720.75	1409575.01	1817.54
50SS02	319594.60	1409300.53	1813.66
50SS03	319490.84	1409427.01	1814.32
SWMU 58			
58SB04	320598.06	1404050.91	1771.09
58SS04	320789.00	1404151.25	1736.95
SWMU 59			
59SB01	319758.86	1409727.32	1822.39
59SS03	319836.99	1409715.36	1826.83
59SS04	319833.15	1409669.00	1827.62
59SS05	319657.37	1409707.51	1822.70
Building 4343			
B43SB34	318498.04	1399103.57	1810.50
B43SB35	318221.52	1399079.40	1832.03
B43SS01	318172.98	1399050.16	1831.32
B43SS02	318551.51	1399055.04	1807.16
B43SS03	318560.34	1399094.03	1810.54
Former Lead Furnace Area			
LFSB12	313403.07	1404006.95	1885.30
LFSB13	313283.58	1403971.45	1875.13
LFSB14	313268.78	1404005.57	1888.08
LFSB15	313253.86	1403925.02	1875.74
LFSB16	313298.16	1403964.35	1871.75
LFSB17	313320.86	1403964.67	1872.85
LFSS01	313377.33	1403978.38	1875.17
LFSS02	313309.24	1404015.18	1888.10
LFSS03	313242.30	1403943.03	1880.75

Appendix D
Contaminant Fate and Transport

CONTAMINANT FATE AND TRANSPORT

D.1 TRANSFORMATION AND FATE OF CONTAMINANTS

When contaminants are exposed to the environment, the potential for transformations of the chemical exists. The endpoint of the transformation process is referenced as the "fate" of the chemical. The ultimate "fate" refers to the expected final state that an element, compound, or group of compounds will achieve following release to the environment. The fate processes for organic contaminants may include sorption, volatilization, hydrolysis, and abiotic and biotic degradation, while the fate processes for inorganic contaminants may include ion exchange, chemical speciation, and oxidation/reduction. These fate processes dictate how contaminants will be transported in the environment. Contaminants can be transported with little attenuation or retardation due to these fate processes, or they can be delayed or transformed so that little migration occurs. Various fate processes, as well as the properties that may affect the fate of contaminants, are discussed below.

D.1.1 Contaminant Properties Affecting Fate

The physical and chemical properties of contaminants play a large role in determining their fate after release to the environment. The following section provides a discussion of several of these key properties.

D.1.1.1 Specific Gravity

Specific gravity is the ratio of the density of a compound to the density of water. It is a measure of the tendency of a compound to float (specific gravity <1) or sink (specific gravity >1) in water. Contaminants that are immiscible in water can exist as separate phase liquids and are referred to as Light Non-Aqueous Phase Liquids (LNAPLs) if their specific gravity is less than one, or Dense Non-Aqueous Phase Liquids (DNAPLs) if their specific gravity is greater than one.

D.1.1.2 Water Solubility

The solubility of a compound in water is the maximum or saturated concentration of the compound in pure water at a specific temperature. Compounds with high solubility in water tend to remain in the aqueous phase and not partition to soil or sediment, are less likely to volatilize from water, and are generally more likely to biodegrade. Conversely, compounds with low water solubilities tend to partition to soil or sediment, volatilize more readily from water, and are less likely to be biodegradable. The solubility of inorganic chemicals varies widely from insoluble to greater than 100,000 mg/L, depending on temperature, pH, ORP, and the concentrations of dissolved constituents such as humic and fulvic acids.

D.1.1.3 Vapor Pressure

Vapor pressure is a property of a chemical in its pure state, which indicates how readily it will volatilize to the atmosphere. Volatilization from water is dependent upon vapor pressure and Henry's Law Constant. Vapor pressures for chemicals in their pure states range from 0.001 to 760 mm mercury (mm Hg) for liquids to less than 10^{-10} mm Hg for solids.

D.1.1.4 Henry's Law Constant

The Henry's Law Constant of a compound is essentially the air/water partition coefficient. In dimensional form, the Henry's Law Constant is the ratio of the vapor pressure to the water

solubility (in atm-m^3/mole). The Henry's Law Constant indicates how a chemical will partition between air and water at equilibrium, and can be used to calculate the rate of volatilization of a chemical from water.

D.1.1.5 Organic Carbon/Water Partition Coefficient

The organic carbon/water partition coefficient (K_{oc}) is a measure of the tendency for a chemical to be sorbed to the organic fraction of soil and sediment. Normal K_{oc} values range from 1 to 10^7 L/kg, with higher values indicating greater sorption potential by the soil and lower values indicating high leaching capabilities for the contaminants from the waste source into surface runoff and groundwater.

D.1.1.6 Octanol/Water Partition Coefficient

The octanol/water partition coefficient (K_{ow}) is a measure of the distribution of a compound at equilibrium between n-octanol and water. The octanol/water partition coefficient, K_{ow}, gives an indication of how a compound will preferentially distribute into a solvent or water, and is a measure of how hydrophobic a compound is. A chemical with a high K_{ow} is hydrophobic and may be relatively immobile in an aqueous system (e.g., contaminant sorbs to soil particles), but may be mobilized in the presence of an organic solvent.

D.1.2 Fate of Organic Contaminants

D.1.2.1 Sorption

Sorption and desorption are two major mechanisms affecting the fate of contaminants in the subsurface. Sorption includes both adsorption and absorption. Adsorption is defined as the accumulation occurring at an interface, while absorption is the partitioning between two phases (Knox et al., 1993).

Sorption is the process by which a compound is retained onto a solid particle rather than remaining dissolved in solution. The sorption of contaminants to the soil matrix is an important factor affecting their transport in terrestrial environments. The sorption of contaminants to suspended sediments and bottom sediment is an important factor affecting chemical transport in aquatic environments.

In general, sorption reactions may be classified as either sorbent or solvent-motivated. Sorbent-motivated sorption occurs when an attraction between the sorbent (subsurface material) and the solute (contaminant), and the contaminant accumulates at the surface due to the affinity of the surface for the contaminant. An example of sorbent-motivated sorption would be a highly polar or ionizable contaminant interaction with the cation exchange sites of clay minerals. This type of sorption typically occurs with inorganics and is more commonly referred to as ion exchange. Solvent-motivated sorption occurs when the contaminant is hydrophobic, such as nonpolar organics, which prefer nonpolar phases to the polar water phase. Hydrophobic contaminants will accumulate at an interface or partition into a nonpolar phase (e.g., associate with the organic content of the subsurface medium) rather than partition into the water phase. The sorption of most neutral organic constituents falls into the category of hydrophobic, or solvent-motivated sorption (Knox et al., 1993). The best indicators of the partitioning of a compound between soil and water are the organic carbon/water partition coefficient (K_{oc}), the soil/water distribution coefficient (K_d), the octanol/water partition coefficient (K_{ow}), and the retardation factor (R).

For nonionic organic chemicals and aquifer materials, sorption is largely controlled by the clay and organic carbon content of the soil. The distribution of an organic chemical between water

and a specific soil matrix is characterized by the organic carbon/water partition coefficient, K_{oc}. This coefficient, which is based on the specific organic carbon content of the soil, is typically measured empirically using a linear adsorption isotherm where the partitioning between the two phases is determined by the following equation (Olsen and Davis, 1990):

$$K_d = \frac{C_s}{C_w} \qquad \textit{Equation 1}$$

where:

K_d = Soil/water distribution coefficient (L/kg)
C_s = Mass of the solute on the solid phase per unit mass of the solid phase (mg/kg)
C_w = Mass of the solute per unit volume of solution (mg/L)

The soil/water distribution coefficient, K_d, obtained from the above equation is then normalized to correct for variations in the organic carbon content of differing soil matrices to calculate K_{oc}:

$$K_{oc} = \frac{K_d}{f_{oc}} \qquad \textit{Equation 2}$$

where:

K_{oc} = Organic carbon/water partition coefficient (L/kg)
K_d = Soil/water distribution coefficient (L/kg)
f_{oc} = Fraction of organic carbon in the soil

The normalization of the adsorption coefficient to ascertain K_{oc} correlates well with other adsorption coefficient estimation methods which use other properties of the chemical such as water solubility or octanol/water partitioning (Callahan et al., 1979).

If the empirical K_d or K_{oc} value for the chemical is not available, the most widely accepted method of estimating the organic carbon/water partition coefficient involves the octanol/water partition coefficient, K_{ow}. The octanol/water partition coefficient, K_{ow}, has been correlated to water solubility, the organic carbon/water partition coefficient, and bioconcentration factors for aquatic life and represents the extent of partitioning by a chemical between organic and aqueous phases (Lyman et al., 1990). The relationship between K_{oc} and K_{ow} is expressed as a regression equation:

$$\log K_{oc} = a \log K_{ow} + b \qquad \textit{Equation 3}$$

where a and b are constants derived from specific data sets which represent differing classes of chemicals such as pesticides, aromatic compounds, and chlorinated hydrocarbons. Chemicals with low K_{ow} (i.e., less than 10 L/kg) are considered relatively hydrophilic and tend to have high water solubilities and small K_{oc} values. Conversely, hydrophobic compounds typically have K_{ow} values greater than 10^4 L/kg (Lyman et al., 1990). In general, the more hydrophobic a contaminant is, the more likely the contaminant will be sorbed to soil.

From Equation 1, when C_s is equal to zero, K_d also equals zero. Under this condition, no adsorption or retardation of the chemical occurs. This implies that the contaminant moves at the same velocity as the groundwater and in this case, the contaminant is termed a conservative or nonreactive solute. However, the velocity of the contaminant front can be substantially different for solutes that are adsorbed within the soil matrix. The retardation factor is defined as the ratio of the groundwater flow velocity to the contaminant front velocity:

$$R = 1 + \rho_b \frac{K_d}{n_e} \qquad \textit{Equation 4}$$

where:

R	=	Retardation factor (dimensionless)
θ_b	=	Bulk density of the soil (g/mL)
K_d	=	Distribution coefficient (mL/g)
n_e	=	Effective porosity of the soil (dimensionless)

The retardation factor indicates the extent of retardation of contaminant migration in groundwater due to adsorption. A retardation factor of 1.0 indicates that the contaminant has little tendency to bind to soils and, hence, moves freely in the groundwater. By contrast, the larger the R, the greater the tendency for a contaminant to bind to the soil matrix and the slower it will move in the groundwater. The retardation factor cannot fall below 1.0.

Other factors which affect the adsorption of chemicals to the soil matrix include temperature, pH of the soil and water, particle size distribution, and surface area of solids. The value of the distribution coefficient K_d usually decreases with increasing temperature because adsorption is an exothermic process. Neutral and slightly polarized organic compounds are somewhat affected by pH. Chemicals that tend to ionize are significantly affected by pH (Lyman et al., 1990). When the pH of the groundwater is approximately 1.0 to 1.5 units above the negative log of the acid dissociation constant (pK_a), adsorption becomes significant. A comparison of the pK_a of an organic acid with the pH of the groundwater indicates the potential importance of the dissociation of the organic compound in determining the degree of partitioning. The size of affected soil particles also plays a role in a contaminant's sorption characteristics. Particles of small size, such as particles of fine silt or clay, will have a greater tendency to adsorb chemicals.

D.1.2.2 Volatilization

Volatilization is a process whereby a compound changes state from the aqueous phase to the vapor phase. Compounds that do not adsorb onto soil/sediment or dissolve in water have the greatest tendency to volatilize. The volatility of a compound can be evaluated from its K_{oc} and by assessing its Henry's Law Constant. The value of K_{oc} indicates the degree of sorption of a compound to soil/sediment. A compound with a high K_{oc} value will have a reduced volatility because the compound sorbs extensively to the soil/sediment surface. The Henry's Law Constant can be considered the partition coefficient of the contaminant between the aqueous phase and the gas phase. A Henry's Law Constant of greater than 10^{-3} atm-m^3/mol indicates a high volatility, and a Henry's Law Constant of less than 10^{-5} atm-m^3/mol indicates a low volatility. **Table D-1** provides a rough outline of relative volatility of a solute according to its Henry's Law Constant.

Table D-1
Volatility of Compounds Based on Henry's Law Constants

Volatility	Henry's Law Constant
Volatilization is very slow, at a rate controlled by slow diffusion through air	$< 10^{-5}$ atm-m^3/mol
Volatilization is not rapid but significant	10^{-5} atm-m^3/mol to 10^{-3} atm-m^3/mol
Volatilization is rapid	$> 10^{-3}$ atm-m^3/mol

The Henry's Law Constant is related to other physical properties of the compound, the most important of which are vapor pressure and water solubility. Compounds exhibiting high vapor pressures and low water solubilities tend to have high volatilization rates. In fact, in the absence of literature values, Henry's Law Constants can be estimated from the following equation (Olsen and Davis, 1990):

$$H = \frac{(V_p)(MW)(16.04)}{(WS)(T)} \qquad \textit{Equation 5}$$

where:

V_p = Vapor pressure of the chemical (mm Hg)
MW = Molecular weight of the chemical (g/mol)
WS = Solubility in water (mg/L)
T = Temperature (^oK)
H = Henry's Law Constant ([mg/L]/[mg/L])

From this equation, it is evident that the volatilization of a compound to air will depend on its vapor pressure, water solubility, and temperature. Other important factors affecting volatilization include wind speed, the depth of the aquifer, and the geology of the unsaturated zone.

D.1.2.3 Hydrolysis

Hydrolysis is the reaction of a compound with water. It usually involves the introduction of a hydroxyl (-OH) group into an organic compound, usually at a point of unbalanced charge distribution (Cherry et al., 1983). The hydrolysis reaction can displace halogens, and may be catalyzed by the presence of acids, bases, or metal ions. Therefore, the rate of hydrolysis is pH and metal-ion concentration dependent. Surface effects also may affect the rate of hydrolysis. Halogenated aliphatics are susceptible to hydrolysis, with reactions proceeding most rapidly for monohalogenated compounds, and much more slowly as the number of halogen ions increases (Fetter, 1993).

Hydrolysis applies to a limited number of chemicals. These contain hydrolyzable groups, such as esters, aliphatic halogens, amides, carbamates, and phosphate esters (Howard, 1991). Compounds that are not susceptible include: alkanes, alkenes, aldehydes, amines, and carboxy-containing compounds (Olsen and Davis, 1990).

D.1.2.4 Abiotic Degradation

Abiotic degradation is the chemical degradation of compounds without the assistance of biological activities. In the natural environment, the most common abiotic degradation processes are hydrolysis and hydroxyl radical reactions. Other abiotic degradation processes include direct photolysis, dehydrohalogenation, and oxidation.

Hydrolysis, as mentioned above, is a chemical reaction in which compounds react with water molecules in the environment, resulting in the introduction of a hydroxyl group (-OH) and the loss of a leaving group (-X), typically a halogen.

$$RX + H_2O \rightarrow ROH + HX\ (or\ H^+, X^-) \qquad Equation\ 6$$

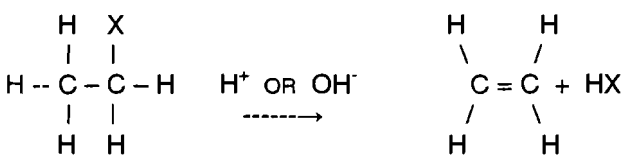
These reactions are catalyzed mainly by hydronium (H_3O^+) and/or hydroxyl ions (OH^-). Therefore, as mentioned above, hydrolysis reactions are pH dependent. Selected metals may also catalyze a hydrolysis reaction (Olsen and Davis, 1990).

Hydroxyl radical reactions are reactions with hydroxyl radicals photochemically generated from sunlight. These reactions may occur mostly in the atmosphere and to a lesser degree in surface water. Once the free radicals are formed, they will react with organic molecules to form an intermediate organic-free radical, which usually reacts further with other compounds. For most chemicals in the atmosphere, reaction with photochemically-generated hydroxyl radicals is the most common degradation process. For many chemicals, experimental reaction rate constants for reactions involving hydroxyl radicals are available in the scientific literature and are used to calculate an estimated half-life by assuming an average hydroxyl radical concentrations of $5x10^5$ molecules/cm^3 in non-smog conditions (Howard, 1991).

Occasionally, other reactions besides hydroxyl radical reactions occur in the atmosphere such as ozone oxidation and direct photolysis. Direct photolysis is a photochemical alteration of the compound as a result of the compound absorbing direct sunlight. The possibility of direct photolysis in air or water can be partially assessed by examining the UV spectrum of the chemical. If the chemical does not absorb sunlight at wavelengths greater than 290 nm, the chemical cannot directly photolyze.

Dehydrohalogenation is an elimination reaction in which an alkyl derivative will eliminate HX to form an alkene, where X is commonly a halogen, hydroxyl radical, or ester group:

Equation 7



D.1.2.5 Biotic Degradation

Biodegradation is the process in which the chemical degradation of a compound is assisted by soil microorganisms (e.g., fungi, bacteria). Reactions include oxidation, reduction, hydrolysis, and sometimes rearrangement of the molecule. Though biodegradation may occur very slowly for some compounds, the eventual mineralization of almost every organic compound in the

terrestrial and aquatic environment can be attributed to biodegradation (Alexander, 1978). A typical range of half lives for different degradation rates are summarized in **Table D-2**.

Rates of biotic degradation depend on many factors. Microorganisms require a carbon source (e.g., organic matter), an electron acceptor (e.g., oxygen, nitrate), nutrients (e.g., nitrogen, phosphorus), and various trace elements in order to maintain existing cells and produce new cells. Many environmental factors can also serve to limit the occurrence of microbial metabolism in the subsurface. These factors include pH, temperature, toxics, substrate concentration, and the presence of microbes. Most bacteria find the optimum pH range to be 6.5 to 7.5 and are not able to survive at pH values greater than 9.5 or below 4.0 (Knox et al., 1993). Microbial activity generally increases with increasing temperature. The presence of certain compounds may also be toxic to microorganisms. Heavy metals, acids, bases, or high concentrations of the substrate can serve to limit microbial activity. Finally, for biotic degradation to occur in the subsurface, microbes capable of metabolizing (or cometabolizing) the substrate must be present.

Table D-2
Rate of Biodegradation Based on Half Lives

Biodegradation Rate	Approximate Biodegradation Half-Life
Fast	1 day to 7 days
Moderately Fast	7 days to 4 weeks
Slow	4 weeks to 6 months
Resistant	6 months to 1 year

Complete biotic degradation of organic chemicals by microorganisms, utilizing enzymes to facilitate degradation, ultimately produces microbial cells, water, and carbon dioxide, which eventually lead to mineralization of the compound. Whether or not a chemical is transformed by enzymes depends on the configuration alignment of the enzyme with the organic chemical during the reaction. If an ideal configuration of the enzyme with organic chemicals occurs, the reaction will occur. Persistent chemicals have less favorable alignments, and non-reacting or recalcitrant chemicals fail to bond or produce favorable alignments.

Biotic degradation can be either aerobic or anaerobic. An aerobic reaction occurs in the presence of oxygen. Aerobic reactions occur in oxygen-rich environments such as surface soil (i.e., 0 to 6 inches bgs) and upper layers of sediment. An aerobic reaction is usually an oxidation reaction. An anaerobic reaction occurs in the absence of oxygen. Anaerobic reactions occur in such places as the saturated zone in terrestrial environments and the bottom layer of sediment in aquatic environments. Because of the lack of oxygen in these environments, an anaerobic reaction usually favors dehydrohalogenation reactions or reductive reactions.

D.1.3 Fate of Inorganic Contaminants

D.1.3.1 Ion Exchange

Metals in soil are generally immobile, particularly under neutral or alkaline conditions, and tend to sorb to soil particles. As described in *Section D.1.2.1*, sorption can be considered as either

sorbent- or solvent-motivated. Solvent-motivated sorption (partitioning) typically occurs for nonpolar, hydrophobic organic chemicals in groundwater by accumulation occurring on the organic content of the media. Ion exchange is sorbent-motivated sorption and occurs for inorganic chemicals due to an affinity of the solid surface for the compound. Typically, the sorbent surface contains a charge deficiency and requires the accumulation of ions near the solid/liquid interface to neutralize the surface charge. In subsurface media, the mineral fraction most commonly involved in ion exchange is the clay fraction (Knox et al., 1993). Ion exchange occurs when the sorbent charge deficiency can be neutralized more efficiently by ions in solution than by those ions currently adsorbed. For example, if sodium ions (monovalent) have accumulated and calcium ions (divalent) suddenly appear, the excess surface charge can be more efficiently neutralized by the calcium ions than by sodium. Thus, the sodium ions will desorb, the calcium ions will adsorb, and an exchange of ions occurs. The cation exchange capacity of a given aquifer material indicates the probable type and amount of clay minerals present, and can be used as an indication of the ability of a soil to attenuate cations found in the groundwater (Makeig, 1982).

D.1.3.2 Chemical Speciation

Most inorganic chemicals occur in more than one ionic form, or species, in soils and groundwater. These species, which form as a result of hydrolysis, oxidation/reduction, and complexation reactions, may have different valences and mobilities in groundwater due to different affinities for adsorption and different solubility controls. Simple ionic species often combine with ligands to form ionic or neutral-charge aqueous complexes. The major inorganic ligands in groundwater are generally Cl^-, HCO_3^{-2}, CO_2, and SO_4^{-2}, and in some cases, NH_3, NO_3^- and F^- (Cherry et al., 1983). Environmental conditions which affect speciation of inorganic chemicals include pH, redox potential, and inorganic ligands.

D.1.3.3 Oxidation/Reduction

Oxidation and reduction ("redox") refers to the transfer of electrons and the resultant species change of ions or compounds. Oxidation is the loss of electrons, while reduction is the gain of electrons. Redox processes are important because they can cause changes in the mobility of many inorganic compounds. The ability of a redox reaction to occur is a function of the redox potential. The redox potential is defined in terms of the negative logarithm of the free-electron activity and is referred to as pE. The redox potential can also be expressed in terms of volts (E_h). Low values of pE indicate high electron activity and favor electron-rich species (reduced). High values of pE indicate low electron activity and favor electron-poor species (oxidized).

D.2 TRANSPORT OF CONTAMINANTS

Contaminant transport refers to the mechanisms and rates of migration of contaminants away from the source area. Migration pathways often include air, water, soil, and the interfaces between the phases of the contaminant (i.e., solid, liquid, or gas). Mechanisms controlling the movement of contaminants include advection, dispersion, diffusion, volatilization, and sorption. These mechanisms are dictated by the physical and chemical nature of the environmental media and their interaction with the potential COCs. Water pathways include surface water, storm water runoff, groundwater, infiltration/percolation, and precipitation. The air pathways include uptake into the atmosphere and deposition from it either in a dry or wet form. The soil pathways include sediment and soil transported by erosion or by site activities such as construction and movement through the vadose zone as soil gas. Transport across an interface is primarily due to

partitioning. The degree of partitioning will depend on the volatility, solubility, and sorptive capacity of the phases. The primary transport mechanism across the water-air and soil-air interfaces are volatilization and sorption, while transport across the soil-water interface is controlled by sorption/desorption and dissolution (solubilization).

D.2.1 Advection

Contaminant transport by advection occurs when the contaminant is moved in and with the bulk flow of either water or the atmosphere. The primary advective transport pathway at Building 4343 is migration into surface water.

D.2.2 Diffusion

Transport by diffusion is the result of a concentration gradient in the contaminant plume or the soil gas within the vadose zone. The rate of diffusion is expressed by the diffusivity coefficient, which is affected by temperature, pressure, density, and soil porosity. Diffusion in soil is strongly dependent on the effective porosity of the soil. Residual clays have high porosity but low effective (interconnected) porosity. Transport due to diffusion in clays is usually minimal.

D.2.3 Volatilization

Volatilization occurs when a liquid changes its phase to a gas. This is primarily a mechanism for organic contaminants migrating from the soil or surface water to the air. Volatilization is a mass transfer process that is limited by a compound's solubility in water, molecular weight, vapor pressure, K_{oc} value, and by the local temperature.

D.2.4 Sorption

As discussed previously, sorption is a general term used in place of the specific terms absorption or adsorption. Adsorption describes the process whereby a contaminant is bound to the surface of a medium, whereas absorption occurs when the contaminant is bound within the medium. The distinction between the two is not always relevant, but the fact that a contaminant has been sorbed indicates that it has been bound to its new medium and will be transported with this new medium. This transport mechanism may be significant when a high concentration of suspended solids is found in water samples.

Desorption is the release (leaching) of a contaminant from the sorbent phase. Sorption/desorption is a primary mechanism of transport for water and soil pathways. In a water-soil environment, soil is the adsorbent and the contaminants are the adsorbates. Sorption/desorption of organic and inorganic compounds within soil-water systems is assessed by several physical and chemical properties of both the compound and the soil or sediment (*Section D.1.2.1*).

Appendix E
Human Health Risk Assessment Tables and Statistical Comparison Results

This Appendix Contains:

Appendix E-1 Human Health Risk Assessment Tables
Appendix E-2 Statistical Comparison Results

Appendix E-1
Human Health Risk Assessment Tables

Table E-1
Occurrence, Distribution and Selection of Chemicals of Potential Concern
Current/Future - Surface Soil

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Surface Soil	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.37E-06 J	5.44E-05	mg/kg	39SB05A	3/3	N/A	5.44E-05	N/A	N/A	N/A	N/A	Yes	NTX
(0 - 2 ft.)	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.02E-05	1.04E-04	mg/kg	39SB05A	5/5	N/A	1.04E-04	N/A	N/A	N/A	N/A	Yes	NTX
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1.76E-07	4.30E-06	mg/kg	39SB05A	3/5	1.71E-07 - 2.00E-07	4.30E-06	N/A	N/A	N/A	N/A	Yes	NTX
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	3.85E-07 J	3.52E-05 J	mg/kg	39SB05A	4/5	1.29E-07 - 1.29E-07	3.52E-05	N/A	N/A	N/A	N/A	Yes	NTX
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	2.93E-07	5.47E-06	mg/kg	39SB05A	3/5	2.63E-07 - 3.29E-07	5.47E-06	N/A	N/A	N/A	N/A	Yes	NTX
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	1.19E-07	1.19E-05	mg/kg	39SB05A	3/5	1.26E-07 - 1.30E-07	1.19E-05	N/A	N/A	N/A	N/A	Yes	NTX
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	3.90E-07	8.19E-06	mg/kg	39SB05A	3/5	2.06E-07 - 2.58E-07	8.19E-06	N/A	N/A	N/A	N/A	Yes	NTX
	72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	2.00E-07	7.65E-07	mg/kg	39SB05A	2/5	3.30E-08 - 1.54E-07	7.65E-07	N/A	N/A	N/A	N/A	Yes	NTX
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	6.74E-07	1.49E-05	mg/kg	39SB05A	4/5	2.00E-07 - 2.00E-07	1.49E-05	N/A	N/A	N/A	N/A	Yes	NTX
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	1.93E-07	4.78E-06	mg/kg	39SB05A	3/5	1.11E-07 - 1.24E-07	4.78E-06	N/A	N/A	N/A	N/A	Yes	NTX
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1.20E-07	3.03E-06	mg/kg	39SB05A	3/5	1.70E-07 - 1.70E-07	3.03E-06	N/A	N/A	N/A	N/A	Yes	NTX
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	1.31E-07	1.98E-05	mg/kg	39SB05A	4/5	1.47E-07 - 1.47E-07	1.98E-05	N/A	N/A	N/A	N/A	Yes	NTX
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	5.35E-07 J	1.03E-05	mg/kg	39SB05A	3/5	1.16E-07 - 1.30E-07	1.03E-05	N/A	N/A	N/A	N/A	Yes	NTX
	NA	2,3,7,8-TCDD TE (RME)	8.31E-07	2.07E-05	mg/kg	39SB05A	5/5	N/A	2.07E-05	N/A	4.300E-06	N/A	N/A	Yes	ASL
	NA	2,3,7,8-TCDD TE	8.23E-07	2.07E-05	mg/kg	39SB05A	5/5	N/A	2.07E-05	N/A	4.300E-06	N/A	N/A	Yes	ASL
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	3.93E-07	3.53E-06 J	mg/kg	39SB05A	3/5	1.08E-07 - 1.22E-07	3.53E-06	N/A	N/A	N/A	N/A	Yes	NTX
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.72E-07 J	3.54E-07	mg/kg	39SB05A	2/5	3.30E-08 - 1.27E-07	3.54E-07	N/A	4.258E-06 C	N/A	N/A	No	BSL
	3268-87-9	Octachlorodibenzodioxin	2.69E-04 J	7.75E-03	mg/kg	39SB06B	5/5	N/A	7.75E-03	N/A	N/A	N/A	N/A	Yes	NTX
	39001-02-0	Octachlorodibenzofuran	9.32E-07	3.08E-05 J	mg/kg	39SB05A	5/5	N/A	3.08E-05	N/A	N/A	N/A	N/A	Yes	NTX
	38998-75-3	Total Heptachlorodibenzofuran	5.31E-07	8.44E-05	mg/kg	39SB05A	5/5	N/A	8.44E-05	N/A	N/A	N/A	N/A	Yes	NTX
	37871-00-4	Total Heptachlorodibenzo-p-dioxin	1.80E-05	2.02E-04	mg/kg	39SB05A	5/5	N/A	2.02E-04	N/A	N/A	N/A	N/A	Yes	NTX
	55684-94-1	Total Hexachlorodibenzofuran	2.59E-07	1.27E-04	mg/kg	39SB05A	4/5	1.26E-07 - 1.26E-07	1.27E-04	N/A	N/A	N/A	N/A	Yes	NTX
	34465-46-8	Total Hexachlorodibenzo-p-dioxin	1.60E-06	1.21E-04	mg/kg	39SB05A	5/5	N/A	1.21E-04	N/A	N/A	N/A	N/A	Yes	NTX
	30402-15-4	Total Pentachlorodibenzofuran	4.83E-07	7.29E-05	mg/kg	39SB05A	4/5	1.11E-07 - 1.11E-07	7.29E-05	N/A	N/A	N/A	N/A	Yes	NTX
	36088-22-9	Total Pentachlorodibenzo-p-dioxin	3.11E-07	3.58E-05	mg/kg	39SB05A	3/5	1.70E-07 - 1.70E-07	3.58E-05	N/A	N/A	N/A	N/A	Yes	NTX
	30402-14-3	Total Tetrachlorodibenzofuran	9.28E-07	5.73E-05	mg/kg	39SB05A	3/5	1.08E-07 - 1.22E-07	5.73E-05	N/A	N/A	N/A	N/A	Yes	NTX
	41903-57-5	Total Tetrachlorodibenzo-p-dioxin	6.71E-07	1.77E-05	mg/kg	39SB05A	3/5	1.26E-07 - 1.27E-07	1.77E-05	N/A	N/A	N/A	N/A	Yes	NTX
	55-63-0	Nitroglycerin	1.80E-01 J	1.98E+01	mg/kg	39SB06A	2/5	3.31E-01 - 3.68E-01	1.98E+01	N/A	4.562E+01 C	N/A	N/A	No	BSL
	7429-90-5	Aluminum	1.08E+04	3.74E+04	mg/kg	39SB3B	19/19	N/A	3.74E+04	4.00E+04	7.821E+03 N	N/A	N/A	Yes	ASL
	7440-36-0	Antimony	9.50E-01 J	1.40E+00 J	mg/kg	39SB1A	5/15	5.53E-01 - 7.14E+00	1.40E+00	N/A	3.129E+00 N	N/A	N/A	No	BSL
	7440-38-2	Arsenic	4.30E-01 J	7.26E+00	mg/kg	39SS08	19/19	N/A	7.26E+00	1.58E+01	4.258E-01 C	N/A	N/A	No	ASL
	7440-39-3	Barium	9.48E+01	2.16E+02 L	mg/kg	39SB4B	19/19	N/A	2.16E+02	2.09E+02	5.475E+02 N	N/A	N/A	No	BSL
	7440-41-7	Beryllium	6.28E-01	1.40E+00	mg/kg	39SB3B	17/18	5.00E-01 - 5.00E-01	1.40E+00	1.02E+00	1.564E+01 N	N/A	N/A	No	BSL
	7440-43-9	Cadmium	8.00E-02 J	7.11E-01 J	mg/kg	39SS08	6/19	1.17E-01 - 7.00E-01	7.11E-01	6.90E-01	3.911E+00 N	N/A	N/A	No	BSL
	7440-70-2	Calcium	2.63E+02	3.85E+04	mg/kg	39SS1	19/19	N/A	3.85E+04	N/A	N/A	1,000,000	RDA	No	BSL
	7440-47-3	Chromium	1.44E+01	9.51E+01	mg/kg	39SB06A	19/19	N/A	9.51E+01	6.53E+01	2.350E+01 N	N/A	N/A	Yes	ASL
	7440-48-4	Cobalt	7.50E+00 L	2.90E+01	mg/kg	39SS10	19/19	N/A	2.90E+01	7.23E+01	1.600E+02 N	N/A	N/A	No	BSL
	7440-50-8	Copper	1.42E+01	3.75E+02	mg/kg	39SB06A	19/19	N/A	3.75E+02	5.35E+01	3.129E+02 N	N/A	N/A	Yes	ASL
	7439-89-6	Iron	1.63E+04 J	5.28E+04	mg/kg	39SB3B	19/19	N/A	5.28E+04	5.10E+04	2.300E+03 N	N/A	N/A	Yes	ASL
	7439-92-1	Lead	1.77E+01	1.65E+04	mg/kg	39SB06A	18/19	1.05E+01 - 1.05E+01	1.65E+04	2.68E+01	N/A	400	USEPA	Yes	ASL

E-3

Table E-1
Occurrence, Distribution and Selection of Chemicals of Potential Concern
Current/Future - Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
	7439-95-4	Magnesium	1.27E+03	1.90E+04	mg/kg	39SS1	19/19	N/A	1.90E+04	N/A	N/A	1,000,000	RDA	No	BSL
	7439-96-5	Manganese	9.69E+01 J	1.38E+03 J	mg/kg	39SS10	19/19	N/A	1.38E+03	2.54E+03	1.564E+02 N	N/A	N/A	No	ASL
	7439-97-6	Mercury (Inorganic)	2.90E-02 J	1.02E-01 L	mg/kg	39SB06A	10/19	5.00E-02 - 1.40E-01	1.02E-01	1.30E-01	2.300E+00 N	N/A	N/A	No	BSL
	7440-02-0	Nickel	1.43E+01	3.81E+01	mg/kg	39SS08	19/19	N/A	3.81E+01	6.28E+01	1.564E+02 N	N/A	N/A	No	BSL
	7440-09-7	Potassium	1.40E+03	3.71E+03	mg/kg	39SB2B	19/19	N/A	3.71E+03	N/A	N/A	1,000,000	RDA	No	BSL
	7782-49-2	Selenium	5.78E-01 L	1.20E+00 L	mg/kg	39SB4B	2/19	2.50E-01 - 1.23E+00	1.20E+00	N/A	3.911E+01 N	N/A	N/A	No	BSL
	7440-22-4	Silver	9.72E-01	1.35E+00	mg/kg	39SS1	2/11	2.50E-01 - 1.23E+00	1.35E+00	N/A	3.911E+01 N	N/A	N/A	No	BSL
	7440-23-5	Sodium	3.15E+01	2.88E+02 J	mg/kg	39SB3A	16/16	N/A	2.88E+02	N/A	N/A	1,000,000	RDA	No	BSL
	7440-28-0	Thallium	1.30E-01 J	2.27E+01	mg/kg	39SS1	13/19	7.40E-01 - 6.62E+00	2.27E+01	2.11E+00	5.475E-01 N	N/A	N/A	Yes	ASL
	7440-62-2	Vanadium	2.19E+01	9.27E+01 K	mg/kg	39SB3B	19/19	N/A	9.27E+01	1.08E+02	7.800E+00 N	N/A	N/A	Yes	ASL
	7440-66-6	Zinc	5.24E+01	3.01E+02 J	mg/kg	39SS12	19/19	N/A	3.01E+02	2.02E+02	2.346E+03 N	N/A	N/A	No	BSL
	72-54-8	4,4'-DDD	3.10E-04 J	3.10E-04 J	mg/kg	39SS07	1/6	7.78E-04 - 2.70E-01	3.10E-04	N/A	2.661E+00 C	N/A	N/A	No	BSL
	5103-71-9	alpha-Chlordane	1.35E-03	1.35E-03	mg/kg	39SB06A	1/6	7.36E-04 - 3.30E-01	1.35E-03	N/A	1.820E+00 C	N/A	N/A	No	BSL
	72-20-8	Endrin	3.79E-03	3.79E-03	mg/kg	39SB06A	1/6	7.36E-04 - 4.50E-01	3.79E-03	N/A	2.346E+00 N	N/A	N/A	No	BSL
	7421-93-4	Endrin aldehyde	6.81E-04 J	6.81E-04 J	mg/kg	39SB05A	1/6	7.36E-04 - 5.30E-01	6.81E-04	N/A	2.350E+00 N	N/A	N/A	No	BSL
	53494-70-5	Endrin ketone	2.82E-03	2.82E-03	mg/kg	39SB06A	1/6	7.36E-04 - 5.30E-01	2.82E-03	N/A	2.350E+00 N	N/A	N/A	No	BSL
	5103-74-2	gamma-Chlordane	1.41E-03	1.41E-03	mg/kg	39SB06A	1/6	7.36E-04 - 3.30E-01	1.41E-03	N/A	1.820E+00 C	N/A	N/A	No	BSL
	72-43-5	Methoxychlor	2.35E-03	2.35E-03	mg/kg	39SS07	1/6	7.78E-04 - 3.30E-01	2.35E-03	N/A	3.911E+01 N	N/A	N/A	No	BSL
	121-14-2	2,4-Dinitrotoluene	2.33E-01	2.33E-01	mg/kg	39SB06A	1/14	1.40E-01 - 4.50E-01	2.33E-01	N/A	9.390E-01 C	N/A	N/A	No	BSL
	84-66-2	Diethyl phthalate	5.90E-02	5.90E-02 J	mg/kg	39SB1A	1/9	2.40E-01 - 4.50E-01	5.90E-02	N/A	6.257E+03 N	N/A	N/A	No	BSL
	84-74-2	Di-n-butyl phthalate	5.23E-01	5.23E-01	mg/kg	39SB1A	1/9	6.10E-02 - 4.50E-01	5.23E-01	N/A	7.821E+02 N	N/A	N/A	No	BSL

(1) Maximum concentration used for screening.

(2) N/A - Refer to supporting information for background discussion.
Background values derived from site-specific statistical analysis. See text for supporting information.

(3) Screening toxicity values from USEPA Region 3 RBC Table (April 2004). See text for derivation of Nutrient RDAs.

(4) Rationale Codes Selection Reason:
Infrequent Detection but Associated Historically (HIST)
Above Screening Levels (ASL)
Group A Carcinogen (GAC)
Break Down Product (BDP)
Elevated Detected Concentration (EDC)
No Toxicity Information Available (NTX)

Deletion Reason:
Below Screening and/or ARAR/TBC Level (BSL)

Definitions:
N/A = Not Applicable or Not Available
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
K = Estimated Value, Biased High
L = Estimated Value, Biased Low
C = Carcinogenic
N = Non-Carcinogenic
RDA = Recommended Daily Allowance

Table E-2
Summary of Screening for Non-Detected Chemicals
Current/Future - Surface Soil

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Above Screening Value? (Y/N)
	99-35-4	1,3,5-Trinitrobenzene			mg/kg		0/8	1.00E-01 - 4.88E-01	4.88E-01	N/A	2.346E+02 N	N/A	N/A	No
	99-65-0	1,3-Dinitrobenzene			mg/kg		0/8	1.00E-01 - 4.96E-01	4.96E-01	N/A	7.821E-01 N	N/A	N/A	No
	118-96-7	2,4,6-Trinitrotoluene			mg/kg		0/8	2.00E-01 - 4.56E-01	4.56E-01	N/A	3.900E+00 N	N/A	N/A	No
	35572-78-2	2-amino-4,6-Dinitrotoluene			mg/kg		0/5	2.00E-01 - 2.00E-01	2.00E-01	N/A	1.600E+00 N	N/A	N/A	No
	88-72-2	2-Nitrotoluene			mg/kg		0/5	4.00E-01 - 4.00E-01	4.00E-01	N/A	2.800E+00 N	N/A	N/A	No
	99-08-1	3-Nitrotoluene			mg/kg		0/5	4.00E-01 - 4.00E-01	4.00E-01	N/A	1.564E+02 N	N/A	N/A	No
	19406-51-0	4-amino-2,6-Dinitrotoluene			mg/kg		0/5	2.00E-01 - 2.00E-01	2.00E-01	N/A	1.600E+00 N	N/A	N/A	No
	99-99-0	4-Nitrotoluene			mg/kg		0/5	4.00E-01 - 4.00E-01	4.00E-01	N/A	7.821E+01 N	N/A	N/A	No
	121-82-4	Cyclonite			mg/kg		0/8	2.00E-01 - 5.87E-01	5.87E-01	N/A	5.807E+00 C	N/A	N/A	No
	2691-41-0	HMX			mg/kg		0/8	2.00E-01 - 6.66E-01	6.66E-01	N/A	3.911E+02 N	N/A	N/A	No
	78-11-5	Pentaerythritol tetranitrate			mg/kg		0/5	3.31E-01 - 3.68E-01	3.68E-01	N/A	N/A	N/A	N/A	No
	479-45-8	Tetryl			mg/kg		0/8	2.00E-01 - 7.31E-01	7.31E-01	N/A	7.821E+01 N	N/A	N/A	No
	93-76-5	2,4,5-T			mg/kg		0/3	1.10E-01 - 1.22E-01	1.22E-01	N/A	7.821E+01 N	N/A	N/A	No
	93-72-1	2,4,5-TP (Silvex)			mg/kg		0/3	1.10E-01 - 1.22E-01	1.22E-01	N/A	6.257E+01 N	N/A	N/A	No
	94-75-7	2,4-D			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	N/A	7.821E+01 N	N/A	N/A	No
	94-82-6	2,4-DB			mg/kg		0/3	1.10E+00 - 1.22E+00	1.22E+00	N/A	6.257E+01 N	N/A	N/A	No
	72-55-9	4,4'-DDE			mg/kg		0/6	7.36E-04 - 3.10E-01	3.10E-01	N/A	1.879E+00 C	N/A	N/A	No
	50-29-3	4,4'-DDT			mg/kg		0/5	7.36E-04 - 3.10E-01	3.10E-01	N/A	1.879E+00 C	N/A	N/A	No
	309-00-2	Aldrin			mg/kg		0/6	7.36E-04 - 3.30E-01	3.30E-01	N/A	3.760E-02 C	N/A	N/A	Yes
	319-84-6	alpha-BHC			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	N/A	1.014E-01 C	N/A	N/A	Yes
	319-85-7	beta-BHC			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	N/A	3.548E-01 C	N/A	N/A	No
	75-99-0	Dalapon			mg/kg		0/3	1.10E+00 - 1.22E+00	1.22E+00	N/A	2.346E+02 N	N/A	N/A	No
	319-86-8	delta-BHC			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	N/A	4.910E-01 C	N/A	N/A	No
	1918-00-9	Dicamba			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	N/A	2.346E+02 N	N/A	N/A	No
	120-36-5	Dichloroprop			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	N/A	N/A	N/A	N/A	No
	60-57-1	Dieldrin			mg/kg		0/6	7.36E-04 - 3.10E-01	3.10E-01	N/A	3.990E-02 C	N/A	N/A	Yes
	959-98-8	Endosulfan I			mg/kg		0/6	7.36E-04 - 6.20E-01	6.20E-01	N/A	4.690E+01 N	N/A	N/A	No
	33213-65-9	Endosulfan II			mg/kg		0/6	7.36E-04 - 6.20E-01	6.20E-01	N/A	4.690E+01 N	N/A	N/A	No
	1031-07-8	Endosulfan sulfate			mg/kg		0/6	7.36E-04 - 6.20E-01	6.20E-01	N/A	4.690E+01 N	N/A	N/A	No
	58-89-9	gamma-BHC (Lindane)			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	N/A	4.913E-01 C	N/A	N/A	No
	76-44-8	Heptachlor			mg/kg		0/6	7.36E-04 - 1.30E-01	1.30E-01	N/A	1.419E-01 C	N/A	N/A	No
	1024-57-3	Heptachlor epoxide			mg/kg		0/6	7.36E-04 - 3.30E-01	3.30E-01	N/A	7.020E-02 C	N/A	N/A	Yes
	94-74-6	MCPA			mg/kg		0/3	1.10E+02 - 1.22E+02	1.22E+02	N/A	3.911E+00 N	N/A	N/A	Yes
	93-65-2	MCPP			mg/kg		0/3	1.10E+02 - 1.22E+02	1.22E+02	N/A	7.821E+00 N	N/A	N/A	Yes
	8001-35-2	Toxaphene			mg/kg		0/6	3.68E-02 - 2.60E+00	2.60E+00	N/A	5.807E-01 C	N/A	N/A	Yes
	12674-11-2	Aroclor 1016			mg/kg		0/8	3.68E-02 - 1.40E+00	1.40E+00	N/A	5.475E+00 C	50	TSCA	No
	11104-28-2	Aroclor 1221			mg/kg		0/8	7.36E-02 - 1.40E+00	1.40E+00	N/A	3.194E-01 C	50	TSCA	Yes
	11141-16-5	Aroclor 1232			mg/kg		0/8	3.68E-02 - 1.40E+00	1.40E+00	N/A	3.194E-01 C	50	TSCA	Yes
	53469-21-9	Aroclor 1242			mg/kg		0/8	3.68E-02 - 1.40E+00	1.40E+00	N/A	3.194E-01 C	50	TSCA	Yes
	12672-29-6	Aroclor 1248			mg/kg		0/8	3.68E-02 - 2.00E+00	2.00E+00	N/A	3.194E-01 C	50	TSCA	Yes
	11097-69-1	Aroclor 1254			mg/kg		0/8	3.68E-02 - 2.30E+00	2.30E+00	N/A	1.560E-01 N	50	TSCA	Yes
	11096-82-5	Aroclor 1260			mg/kg		0/8	3.68E-02 - 2.60E+00	2.60E+00	N/A	3.194E-01 C	50	TSCA	Yes
	120-82-1	1,2,4-Trichlorobenzene			mg/kg		0/9	4.00E-02 - 4.50E-01	4.50E-01	N/A	7.821E+01 N	N/A	N/A	No

Table E-2
Summary of Screening for Non-Detected Chemicals
Current/Future - Surface Soil

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Above Screening Value? (Y/N)
	95-50-1	1,2-Dichlorobenzene			mg/kg		0/9	1.10E-01 - 4.50E-01	4.50E-01	N/A	7.039E+02 N	N/A	N/A	No
	122-66-7	1,2-Diphenylhydrazine			mg/kg		0/9	1.40E-01 - 4.50E-01	4.50E-01	N/A	7.984E-01 C	N/A	N/A	No
	541-73-1	1,3-Dichlorobenzene			mg/kg		0/9	1.30E-01 - 4.50E-01	4.50E-01	N/A	2.300E+02 N	N/A	N/A	No
	106-46-7	1,4-Dichlorobenzene			mg/kg		0/9	9.80E-02 - 4.50E-01	4.50E-01	N/A	2.661E+01 C	N/A	N/A	No
	95-95-4	2,4,5-Trichlorophenol			mg/kg		0/9	1.00E-01 - 1.10E+00	1.10E+00	N/A	7.821E+02 N	N/A	N/A	No
	88-06-2	2,4,6-Trichlorophenol			mg/kg		0/9	1.70E-01 - 4.50E-01	4.50E-01	N/A	5.807E+01 C	N/A	N/A	No
	120-83-2	2,4-Dichlorophenol			mg/kg		0/9	1.80E-01 - 4.50E-01	4.50E-01	N/A	2.346E+01 N	N/A	N/A	No
	105-67-9	2,4-Dimethylphenol			mg/kg		0/9	4.10E-01 - 6.90E-01	6.90E-01	N/A	1.564E+02 N	N/A	N/A	No
	51-28-5	2,4-Dinitrophenol			mg/kg		0/9	1.20E+00 - 2.20E+00	2.20E+00	N/A	1.564E+01 N	N/A	N/A	No
	606-20-2	2,6-Dinitrotoluene			mg/kg		0/14	8.50E-02 - 4.50E-01	4.50E-01	N/A	9.390E-01 C	N/A	N/A	No
	91-58-7	2-Chloronaphthalene			mg/kg		0/9	3.60E-02 - 4.50E-01	4.50E-01	N/A	6.257E+02 N	N/A	N/A	No
	95-57-8	2-Chlorophenol			mg/kg		0/9	6.00E-02 - 4.50E-01	4.50E-01	N/A	3.911E+01 N	N/A	N/A	No
	91-57-6	2-Methylnaphthalene			mg/kg		0/9	4.90E-02 - 4.50E-01	4.50E-01	N/A	3.100E+01 N	N/A	N/A	No
	88-74-4	2-Nitroaniline			mg/kg		0/9	6.20E-02 - 2.20E+00	2.20E+00	N/A	2.300E+01 N	N/A	N/A	No
	88-75-5	2-Nitrophenol			mg/kg		0/9	1.40E-01 - 4.50E-01	4.50E-01	N/A	N/A	N/A	N/A	No
	88-85-7	2-sec-butyl-4,6-dinitrophenol			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	N/A	7.821E+00 N	N/A	N/A	No
	NA	3&4-Methylphenol			mg/kg		0/6	4.10E-01 - 4.50E-01	4.50E-01	N/A	N/A	N/A	N/A	No
	91-94-1	3,3'-Dichlorobenzidine			mg/kg		0/9	8.00E-01 - 6.30E+00	6.30E+00	N/A	1.419E+00 C	N/A	N/A	Yes
	99-09-2	3-Nitroaniline			mg/kg		0/9	4.50E-01 - 2.20E+00	2.20E+00	N/A	2.300E+01 N	N/A	N/A	No
	534-52-1	4,6-Dinitro-o-cresol			mg/kg		0/9	5.50E-01 - 2.20E+00	2.20E+00	N/A	7.800E-01 N	N/A	N/A	Yes
	100-01-6	4-Nitroaniline			mg/kg		0/9	4.10E-01 - 2.20E+00	2.20E+00	N/A	2.300E+01 N	N/A	N/A	No
	100-02-7	4-Nitrophenol			mg/kg		0/9	1.40E+00 - 2.20E+00	2.20E+00	N/A	6.257E+01 N	N/A	N/A	No
	83-32-9	Acenaphthene			mg/kg		0/9	2.10E-02 - 2.20E-01	2.20E-01	N/A	4.693E+02 N	N/A	N/A	No
	208-96-8	Acenaphthylene			mg/kg		0/9	3.30E-02 - 4.30E-01	4.30E-01	N/A	2.350E+02 N	N/A	N/A	No
	120-12-7	Anthracene			mg/kg		0/9	2.10E-03 - 3.30E-02	3.30E-02	N/A	2.346E+03 N	N/A	N/A	No
	92-87-5	Benzidine			mg/kg		0/3	8.50E-01 - 8.50E-01	8.50E-01	N/A	2.800E-03 C	N/A	N/A	Yes
	56-55-3	Benzo(a)anthracene			mg/kg		0/9	2.10E-03 - 1.70E-01	1.70E-01	N/A	8.750E-01 C	N/A	N/A	No
	50-32-8	Benzo(a)pyrene			mg/kg		0/9	2.10E-03 - 2.50E-01	2.50E-01	N/A	8.750E-02 C	N/A	N/A	Yes
	205-99-2	Benzo(b)fluoranthene			mg/kg		0/9	4.10E-03 - 2.10E-01	2.10E-01	N/A	8.750E-01 C	N/A	N/A	No
	191-24-2	Benzo(g,h,i)perylene			mg/kg		0/9	4.10E-03 - 2.50E-01	2.50E-01	N/A	2.350E+02 N	N/A	N/A	No
	207-08-9	Benzo(k)fluoranthene			mg/kg		0/9	2.10E-03 - 6.60E-02	6.60E-02	N/A	8.750E+00 C	N/A	N/A	No
	65-85-0	Benzoic Acid			mg/kg		0/9	2.00E+00 - 6.10E+00	6.10E+00	N/A	3.129E+04 N	N/A	N/A	No
	100-51-6	Benzyl alcohol			mg/kg		0/9	1.90E-01 - 8.80E-01	8.80E-01	N/A	2.346E+03 N	N/A	N/A	No
	111-91-1	bis(2-Chloroethoxy)methane			mg/kg		0/9	5.90E-02 - 4.50E-01	4.50E-01	N/A	N/A	N/A	N/A	No
	111-44-4	bis(2-Chloroethyl)ether			mg/kg		0/9	3.30E-02 - 4.50E-01	4.50E-01	N/A	5.807E-01 C	N/A	N/A	No
	108-60-1	bis(2-Chloroisopropyl)ether			mg/kg		0/9	2.00E-01 - 4.50E-01	4.50E-01	N/A	9.125E+00 C	N/A	N/A	No
	117-81-7	bis(2-Ethylhexyl) phthalate			mg/kg		0/9	4.10E-01 - 6.20E-01	6.20E-01	N/A	4.562E+01 C	N/A	N/A	No
	85-68-7	Butyl benzyl phthalate			mg/kg		0/9	1.70E-01 - 4.50E-01	4.50E-01	N/A	1.564E+03 N	N/A	N/A	No
	86-74-8	Carbazole			mg/kg		0/6	4.10E-01 - 4.50E-01	4.50E-01	N/A	3.194E+01 C	N/A	N/A	No
	218-01-9	Chrysene			mg/kg		0/9	2.00E-03 - 1.20E-01	1.20E-01	N/A	8.750E+01 C	N/A	N/A	No
	53-70-3	Dibenz(a,h)anthracene			mg/kg		0/9	4.10E-03 - 2.10E-01	2.10E-01	N/A	8.750E-02 C	N/A	N/A	Yes
	132-64-9	Dibenzofuran			mg/kg		0/9	3.50E-02 - 4.50E-01	4.50E-01	N/A	3.129E+01 N	N/A	N/A	No
	131-11-3	Dimethylphthalate			mg/kg		0/9	1.70E-01 - 4.50E-01	4.50E-01	N/A	7.821E+04 N	N/A	N/A	No

Table E-2
Summary of Screening for Non-Detected Chemicals
Current/Future - Surface Soil

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Above Screening Value? (Y/N)
	117-84-0	Di-n-octyl phthalate			mg/kg		0/9	1.90E-01 - 4.50E-01	4.50E-01	N/A	3.100E+02 N	N/A	N/A	No
	206-44-0	Fluoranthene			mg/kg		0/9	4.10E-03 - 6.80E-02	6.80E-02	N/A	3.129E+02 N	N/A	N/A	No
	86-73-7	Fluorene			mg/kg		0/9	4.10E-03 - 4.30E-02	4.30E-02	N/A	3.129E+02 N	N/A	N/A	No
	118-74-1	Hexachlorobenzene			mg/kg		0/9	3.30E-02 - 4.50E-01	4.50E-01	N/A	3.992E-01 C	N/A	N/A	Yes
	87-68-3	Hexachlorobutadiene			mg/kg		0/9	2.30E-01 - 4.50E-01	4.50E-01	N/A	1.560E+00 N	N/A	N/A	No
	77-47-4	Hexachlorocyclopentadiene			mg/kg		0/9	4.10E-01 - 6.20E+00	6.20E+00	N/A	4.693E+01 N	N/A	N/A	No
	67-72-1	Hexachloroethane			mg/kg		0/9	1.50E-01 - 4.50E-01	4.50E-01	N/A	7.800E+00 N	N/A	N/A	No
	193-39-5	Indeno(1,2,3-cd)pyrene			mg/kg		0/9	2.10E-03 - 2.90E-01	2.90E-01	N/A	8.750E-01 C	N/A	N/A	No
	78-59-1	Isophorone			mg/kg		0/9	3.30E-02 - 4.50E-01	4.50E-01	N/A	6.723E+02 C	N/A	N/A	No
	91-20-3	Naphthalene			mg/kg		0/9	2.10E-02 - 2.20E-01	2.20E-01	N/A	1.564E+02 N	N/A	N/A	No
	98-95-3	Nitrobenzene			mg/kg		0/14	4.50E-02 - 4.50E-01	4.50E-01	N/A	3.911E+00 N	N/A	N/A	No
	62-75-9	n-Nitroso-di-methylamine			mg/kg		0/3	1.40E-01 - 1.40E-01	1.40E-01	N/A	1.250E-02 C	N/A	N/A	Yes
	621-64-7	n-Nitroso-di-n-propylamine			mg/kg		0/9	2.00E-01 - 4.50E-01	4.50E-01	N/A	9.120E-02 C	N/A	N/A	Yes
	86-30-6	n-Nitroso-di-phenylamine			mg/kg		0/9	1.90E-01 - 4.50E-01	4.50E-01	N/A	1.304E+02 C	N/A	N/A	No
	95-48-7	o-Cresol			mg/kg		0/9	2.90E-02 - 4.50E-01	4.50E-01	N/A	3.911E+02 N	N/A	N/A	No
	106-47-8	p-Chloroaniline			mg/kg		0/9	8.00E-01 - 8.80E-01	8.80E-01	N/A	3.129E+01 N	N/A	N/A	No
	59-50-7	p-Chloro-m-cresol			mg/kg		0/9	9.50E-02 - 8.80E-01	8.80E-01	N/A	N/A	N/A	N/A	No
	106-44-5	p-Cresol			mg/kg		0/3	2.40E-01 - 2.40E-01	2.40E-01	N/A	3.911E+01 N	N/A	N/A	No
	87-86-5	Pentachlorophenol			mg/kg		0/9	1.30E+00 - 2.20E+00	2.20E+00	N/A	5.323E+00 C	N/A	N/A	No
	85-01-8	Phenanthrene			mg/kg		0/9	2.10E-03 - 3.30E-02	3.30E-02	N/A	2.350E+02 N	N/A	N/A	No
	108-95-2	Phenol			mg/kg		0/9	1.10E-01 - 4.50E-01	4.50E-01	N/A	2.300E+03 N	N/A	N/A	No
	129-00-0	Pyrene			mg/kg		0/9	1.00E-03 - 3.30E-02	3.30E-02	N/A	2.346E+02 N	N/A	N/A	No
	71-55-6	1,1,1-Trichloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	2.190E+03 N	N/A	N/A	No
	79-34-5	1,1,2,2-Tetrachloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	3.194E+00 C	N/A	N/A	No
	79-00-5	1,1,2-Trichloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.121E+01 C	N/A	N/A	No
	75-34-3	1,1-Dichloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.821E+02 N	N/A	N/A	No
	75-35-4	1,1-Dichloroethene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	3.900E+02 N	N/A	N/A	No
	107-06-2	1,2-Dichloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.019E+00 C	N/A	N/A	No
	78-87-5	1,2-Dichloropropane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	9.393E+00 C	N/A	N/A	No
	78-93-3	2-Butanone			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	4.693E+03 N	N/A	N/A	No
	591-78-6	2-Hexanone			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	3.129E+02 N	N/A	N/A	No
	101-55-3	4-Bromophenyl phenylether			mg/kg		0/9	3.30E-02 - 4.50E-01	4.50E-01	N/A	N/A	N/A	N/A	No
	7005-72-3	4-Chlorophenyl phenylether			mg/kg		0/9	3.30E-02 - 4.50E-01	4.50E-01	N/A	N/A	N/A	N/A	No
	108-10-1	4-Methyl-2-pentanone			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	N/A	N/A	N/A	No
	67-64-1	Acetone			mg/kg		0/4	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.000E+03 N	N/A	N/A	No
	71-43-2	Benzene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.161E+01 C	N/A	N/A	No
	75-27-4	Bromodichloromethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.030E+01 C	N/A	N/A	No
	74-83-9	Bromomethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.095E+01 N	N/A	N/A	No
	75-15-0	Carbon disulfide			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.821E+02 N	N/A	N/A	No
	56-23-5	Carbon tetrachloride			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	4.913E+00 C	N/A	N/A	No
	108-90-7	Chlorobenzene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.564E+02 N	N/A	N/A	No
	75-00-3	Chloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	2.203E+02 C	N/A	N/A	No
	74-87-3	Chloromethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	4.913E+01 C	N/A	N/A	No

63

Table E-2
Summary of Screening for Non-Detected Chemicals
Current/Future - Surface Soil

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Above Screening Value? (Y/N)
	156-59-2	cis-1,2-Dichloroethene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.821E+01 N	N/A	N/A	No
	10061-01-5	cis-1,3-Dichloro-1-propene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	6.400E+00 C	N/A	N/A	No
	124-48-1	Dibromochloromethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.604E+00 C	N/A	N/A	No
	100-41-4	Ethylbenzene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.821E+02 N	N/A	N/A	No
	75-09-2	Methylene chloride			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	8.516E+01 C	N/A	N/A	No
	95-47-6	o-Xylene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.564E+04 N	N/A	N/A	No
	130-312	p&m-Xylene			mg/kg		0/5	9.80E-03 - 1.20E-02	1.20E-02	N/A	N/A	N/A	N/A	No
	100-42-5	Styrene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.564E+03 N	N/A	N/A	No
	127-18-4	Tetrachloroethene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.228E+01 C	N/A	N/A	No
	108-88-3	Toluene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.564E+03 N	N/A	N/A	No
	156-60-5	trans-1,2-Dichloroethene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.564E+02 N	N/A	N/A	No
	10061-02-6	trans-1,3-Dichloropropene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	6.390E+00 C	N/A	N/A	No
	75-25-2	Tribromomethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	8.085E+01 C	N/A	N/A	No
	79-01-6	Trichloroethene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.600E+00 C	N/A	N/A	No
	67-66-3	Chloroform			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.800E+01 N	N/A	N/A	No
	75-01-4	Vinyl Chloride			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	9.000E-02 C	N/A	N/A	No
	124-48-1	Dibromochloromethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.604E+00 C	N/A	N/A	No

(1) Maximum concentration used for screening.

(2) N/A - Refer to supporting information for background discussion.
Background values derived from site-specific statistical analysis. See text for supporting information.

(3) Screening toxicity values from USEPA Region 3 RBC Table (April 2004). See text for derivation of Nutrient RDAs.

Definitions:
N/A = Not Applicable or Not Available
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic
RDA = Recommended Daily Allowance

Table E-3
Occurrence, Distribution and Selection of Chemicals of Potential Concern
Future - Total Soil

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Total Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Total Soil (0 - 10 ft.)	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.37E-06 J	5.44E-05	mg/kg	39SB05A	4/4	N/A	5.44E-05	N/A	N/A	N/A	N/A	Yes	NTX
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.02E-05	1.04E-04	mg/kg	39SB05A	7/7	N/A	1.04E-04	N/A	N/A	N/A	N/A	Yes	NTX
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1.76E-07	4.30E-06	mg/kg	39SB05A	4/7	1.71E-07 - 2.17E-07	4.30E-06	N/A	N/A	N/A	N/A	Yes	NTX
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	3.85E-07 J	3.52E-05 J	mg/kg	39SB05A	5/7	1.29E-07 - 1.30E-07	3.52E-05	N/A	N/A	N/A	N/A	Yes	NTX
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	2.93E-07	5.47E-06	mg/kg	39SB05A	4/7	2.63E-07 - 3.29E-07	5.47E-06	N/A	N/A	N/A	N/A	Yes	NTX
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	1.19E-07	1.19E-05	mg/kg	39SB05A	4/7	1.26E-07 - 1.30E-07	1.19E-05	N/A	N/A	N/A	N/A	Yes	NTX
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	3.90E-07	8.19E-06	mg/kg	39SB05A	4/7	2.06E-07 - 2.58E-07	8.19E-06	N/A	N/A	N/A	N/A	Yes	NTX
	72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	2.00E-07	7.65E-07	mg/kg	39SB05A	2/7	3.30E-08 - 1.54E-07	7.65E-07	N/A	N/A	N/A	N/A	Yes	NTX
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	6.74E-07	1.49E-05	mg/kg	39SB05A	5/7	2.00E-07 - 2.19E-07	1.49E-05	N/A	N/A	N/A	N/A	Yes	NTX
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	1.93E-07	4.78E-06	mg/kg	39SB05A	4/7	1.11E-07 - 1.24E-07	4.78E-06	N/A	N/A	N/A	N/A	Yes	NTX
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1.20E-07	3.03E-06	mg/kg	39SB05A	4/7	1.70E-07 - 1.89E-07	3.03E-06	N/A	N/A	N/A	N/A	Yes	NTX
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	1.31E-07	1.98E-05	mg/kg	39SB05A	5/7	1.47E-07 - 1.48E-07	1.98E-05	N/A	N/A	N/A	N/A	Yes	NTX
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	5.35E-07 J	1.03E-05	mg/kg	39SB05A	4/7	1.16E-07 - 1.30E-07	1.03E-05	N/A	N/A	N/A	N/A	Yes	NTX
	NA	2,3,7,8-TCDD TE (RME)	7.94E-07	2.07E-05	mg/kg	39SB05A	7/7	N/A	2.07E-05	N/A	4.300E-06	N/A	N/A	Yes	ASL
	NA	2,3,7,8-TCDD TE	8.23E-07	2.07E-05	mg/kg	39SB05A	7/7	N/A	2.07E-05	N/A	4.300E-06	N/A	N/A	Yes	ASL
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	3.93E-07	3.53E-06 J	mg/kg	39SB05A	4/7	1.08E-07 - 1.22E-07	3.53E-06	N/A	N/A	N/A	N/A	Yes	NTX
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.72E-07 J	3.54E-07	mg/kg	39SB05A	2/7	3.30E-08 - 1.36E-07	3.54E-07	N/A	4.258E-06 C	N/A	N/A	No	BSL
	3268-87-9	Octachlorodibenzodioxin	2.69E-04 J	7.75E-03	mg/kg	39SB06B	7/7	N/A	7.75E-03	N/A	N/A	N/A	N/A	Yes	NTX
	39001-02-0	Octachlorodibenzofuran	9.32E-07	3.08E-05 J	mg/kg	39SB05A	7/7	N/A	3.08E-05	N/A	N/A	N/A	N/A	Yes	NTX
	38998-75-3	Total Heptachlorodibenzofuran	5.31E-07	8.44E-05	mg/kg	39SB05A	7/7	N/A	8.44E-05	N/A	N/A	N/A	N/A	Yes	NTX
	37871-00-4	Total Heptachlorodibenzo-p-dioxin	1.80E-05	2.02E-04	mg/kg	39SB05A	7/7	N/A	2.02E-04	N/A	N/A	N/A	N/A	Yes	NTX
	55684-94-1	Total Hexachlorodibenzofuran	2.59E-07	1.27E-04	mg/kg	39SB05A	5/7	1.26E-07 - 1.26E-07	1.27E-04	N/A	N/A	N/A	N/A	Yes	NTX
	34465-46-8	Total Hexachlorodibenzo-p-dioxin	1.60E-06	1.21E-04	mg/kg	39SB05A	7/7	N/A	1.21E-04	N/A	N/A	N/A	N/A	Yes	NTX
	30402-15-4	Total Pentachlorodibenzofuran	4.83E-07	7.29E-05	mg/kg	39SB05A	5/7	1.11E-07 - 1.17E-07	7.29E-05	N/A	N/A	N/A	N/A	Yes	NTX
	36088-22-9	Total Pentachlorodibenzo-p-dioxin	3.11E-07	3.58E-05	mg/kg	39SB05A	4/7	1.70E-07 - 1.89E-07	3.58E-05	N/A	N/A	N/A	N/A	Yes	NTX
	30402-14-3	Total Tetrachlorodibenzofuran	9.28E-07	5.73E-05	mg/kg	39SB05A	4/7	1.08E-07 - 1.22E-07	5.73E-05	N/A	N/A	N/A	N/A	Yes	NTX
	41903-57-5	Total Tetrachlorodibenzo-p-dioxin	6.71E-07	1.77E-05	mg/kg	39SB05A	4/7	1.26E-07 - 1.36E-07	1.77E-05	N/A	N/A	N/A	N/A	Yes	NTX
	7429-90-5	Aluminum	1.08E+04	3.74E+04	mg/kg	39SB3B	28/28	N/A	3.74E+04	4.00E+04	7.821E+03 N	N/A	N/A	Yes	ASL
	7440-36-0	Antimony	5.85E-01 J	1.40E+00 J	mg/kg	39SB1A	11/24	5.53E-01 - 7.14E+00	1.40E+00	N/A	3.129E+00 N	N/A	N/A	No	BSL
	7440-38-2	Arsenic	4.30E-01 J	7.26E+00	mg/kg	39SS08	28/28	N/A	7.26E+00	1.58E+01	4.258E-01 C	N/A	N/A	Yes	ASL
	7440-39-3	Barium	7.36E+01 L	2.16E+02 L	mg/kg	39SB4B	28/28	N/A	2.16E+02	2.09E+02	5.475E+02 N	N/A	N/A	No	BSL
	7440-41-7	Beryllium	5.45E-01	1.40E+00	mg/kg	39SB3B	23/24	5.00E-01 - 5.00E-01	1.40E+00	1.02E+00	1.564E+01 N	N/A	N/A	No	BSL
	7440-43-9	Cadmium	8.00E-02 J	7.11E-01 J	mg/kg	39SS08	7/28	1.17E-01 - 7.00E-01	7.11E-01	6.90E-01	3.911E+00 N	N/A	N/A	No	BSL
	7440-70-2	Calcium	2.63E+02	3.85E+04	mg/kg	39SS1	26/26	N/A	3.85E+04	N/A	N/A	1,000,000	RDA	No	BSL
	7440-47-3	Chromium	1.44E+01	9.51E+01	mg/kg	39SB06A	28/28	N/A	9.51E+01	6.53E+01	2.350E+01 N	N/A	N/A	Yes	ASL
	7440-48-4	Cobalt	7.50E+00 L	2.90E+01	mg/kg	39SS10	28/28	N/A	2.90E+01	7.23E+01	1.600E+02 N	N/A	N/A	No	BSL
	7440-50-8	Copper	1.42E+01 K	3.75E+02	mg/kg	39SB06A	28/28	N/A	3.75E+02	5.35E+01	3.129E+02 N	N/A	N/A	Yes	ASL
	7439-89-6	Iron	1.63E+04 J	5.28E+04	mg/kg	39SB3B	28/28	N/A	5.28E+04	5.10E+04	2.300E+03 N	N/A	N/A	Yes	ASL
	7439-92-1	Lead	1.01E+01	1.65E+04	mg/kg	39SB06A	27/28	1.05E+01 - 1.05E+01	1.65E+04	2.68E+01	N/A	400	USEPA	Yes	ASL

Table E-3
Occurrence, Distribution and Selection of Chemicals of Potential Concern
Future - Total Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
	7439-95-4	Magnesium	1.27E+03	1.90E+04	mg/kg	39SS1	28/28	N/A	1.90E+04	N/A	N/A	1,000,000	RDA	No	BSL
	7439-96-5	Manganese	9.69E+01 J	1.38E+03 J	mg/kg	39SS10	28/28	N/A	1.38E+03	2.54E+03	1.564E+02 N	N/A	N/A	No	ASL
	7439-97-6	Mercury (Inorganic)	2.60E-02 J	3.90E-01	mg/kg	39SB3D	13/28	5.00E-02 - 1.40E-01	3.90E-01	1.30E-01	2.300E+00 N	N/A	N/A	No	BSL
	7440-02-0	Nickel	1.36E+01 K	3.81E+01	mg/kg	39SS08	28/28	N/A	3.81E+01	6.28E+01	1.564E+02 N	N/A	N/A	No	BSL
	7440-09-7	Potassium	1.40E+03	3.71E+03	mg/kg	39SB2B	28/28	N/A	3.71E+03	N/A	N/A	1,000,000	RDA	No	BSL
	7782-49-2	Selenium	4.18E-01 L	1.20E+00 L	mg/kg	39SB4B	4/28	2.50E-01 - 1.23E+00	1.20E+00	N/A	3.911E+01 N	N/A	N/A	No	BSL
	7440-22-4	Silver	9.72E-01	1.35E+00	mg/kg	39SS1	2/20	2.30E-01 - 1.23E+00	1.35E+00	N/A	3.911E+01 N	N/A	N/A	No	BSL
	7440-23-5	Sodium	3.15E+01	2.88E+02 J	mg/kg	39SB3A	24/24	N/A	2.88E+02	N/A	N/A	1,000,000	RDA	No	BSL
	7440-28-0	Thallium	1.30E-01 J	2.27E+01	mg/kg	39SS1	19/28	7.00E-01 - 6.62E+00	2.27E+01	2.11E+00	5.475E-01 N	N/A	N/A	Yes	ASL
	7440-62-2	Vanadium	2.19E+01	9.27E+01 K	mg/kg	39SB3B	28/28	N/A	9.27E+01	1.08E+02	7.800E+00 N	N/A	N/A	Yes	ASL
	7440-66-6	Zinc	5.04E+01 K	3.01E+02 J	mg/kg	39SS12	28/28	N/A	3.01E+02	2.02E+02	2.346E+03 N	N/A	N/A	No	BSL
	72-54-8	4,4'-DDD	3.10E-04 J	3.10E-04 J	mg/kg	39SS07	1/6	7.78E-04 - 2.70E-01	3.10E-04	N/A	2.661E+00 C	N/A	N/A	No	BSL
	5103-71-9	alpha-Chlordane	1.35E-03	1.35E-03	mg/kg	39SB06A	1/6	7.36E-04 - 3.30E-01	1.35E-03	N/A	1.820E+00 C	N/A	N/A	No	BSL
	72-20-8	Endrin	3.79E-03	3.79E-03	mg/kg	39SB06A	1/6	7.36E-04 - 4.50E-01	3.79E-03	N/A	2.346E+00 N	N/A	N/A	No	BSL
	7421-93-4	Endrin aldehyde	6.81E-04 J	6.81E-04 J	mg/kg	39SB05A	1/6	7.36E-04 - 5.30E-01	6.81E-04	N/A	2.350E+00 N	N/A	N/A	No	BSL
	53494-70-5	Endrin ketone	2.82E-03	2.82E-03	mg/kg	39SB06A	1/6	7.36E-04 - 5.30E-01	2.82E-03	N/A	2.350E+00 N	N/A	N/A	No	BSL
	5103-74-2	gamma-Chlordane	1.41E-03	1.41E-03	mg/kg	39SB06A	1/6	7.36E-04 - 3.30E-01	1.41E-03	N/A	1.820E+00 C	N/A	N/A	No	BSL
	72-43-5	Methoxychlor	2.35E-03	2.35E-03	mg/kg	39SS07	1/6	7.78E-04 - 3.30E-01	2.35E-03	N/A	3.911E+01 N	N/A	N/A	No	BSL
	121-14-2	2,4-Dinitrotoluene	2.33E-01	2.33E-01	mg/kg	39SB06A	1/23	1.40E-01 - 4.50E-01	2.33E-01	N/A	9.390E-01 C	N/A	N/A	No	BSL
	55-63-0	Nitroglycerin	1.80E-01 J	1.98E+01	mg/kg	39SB06A	2/7	3.31E-01 - 3.68E-01	1.98E+01	N/A	4.562E+01 C	N/A	N/A	No	BSL
	117-81-7	bis(2-Ethylhexyl) phthalate	1.60E-01 J	1.60E-01 J	mg/kg	39MW7A	1/16	3.95E-01 - 6.20E-01	1.60E-01	N/A	4.562E+01 C	N/A	N/A	No	BSL
	84-66-2	Diethyl phthalate	5.90E-02 J	5.90E-02 J	mg/kg	39SB1A	1/16	2.40E-01 - 4.50E-01	5.90E-02	N/A	6.257E+03 N	N/A	N/A	No	BSL
	84-74-2	Di-n-butyl phthalate	5.23E-01	5.23E-01	mg/kg	39SB1A	1/16	6.10E-02 - 4.50E-01	5.23E-01	N/A	7.821E+02 N	N/A	N/A	No	BSL

(1) Maximum concentration used for screening.
(2) N/A - Refer to supporting information for background discussion.
Background values derived from site-specific statistical analysis. See text for supporting information.
(3) Screening toxicity values from USEPA Region 3 RBC Table (April 2004). See text for derivation of Nutrient RDAs.
(4) Rationale Codes Selection Reason:
Infrequent Detection but Associated Historically (HIST)
No Toxicity Information Available (NTX)
Above Screening Levels (ASL)
Group A Carcinogen (GAC)
Break Down Product (BDP)
Elevated Detected Concentration (EDC)

Deletion Reason:
Below Screening and/or ARAR/TBC Level (BSL)

Definitions:
N/A = Not Applicable or Not Available
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
K = Estimated Value, Biased High
L = Estimated Value, Biased Low
C = Carcinogenic
N = Non-Carcinogenic
RDA = Recommended Daily Allowance

Table E-4
Summary of Screening of Non-Detected Chemicals
Future - Total Soil

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Total Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Above Screening Criteria? (Y/N)
Total Soil (0 - 10 ft.)	99-35-4	1,3,5-Trinitrobenzene			mg/kg		0/10	1.00E-01 - 4.88E-01	4.88E-01	N/A	2.346E+02 N	N/A	N/A	No
	99-65-0	1,3-Dinitrobenzene			mg/kg		0/10	1.00E-01 - 4.96E-01	4.96E-01	N/A	7.821E-01 N	N/A	N/A	No
	118-96-7	2,4,6-Trinitrotoluene			mg/kg		0/10	2.00E-01 - 4.56E-01	4.56E-01	N/A	3.900E+00 N	N/A	N/A	No
	35572-78-2	2-amino-4,6-Dinitrotoluene			mg/kg		0/7	2.00E-01 - 2.00E-01	2.00E-01	N/A	1.600E+00 N	N/A	N/A	No
	88-72-2	2-Nitrotoluene			mg/kg		0/7	4.00E-01 - 4.00E-01	4.00E-01	N/A	2.800E+00 C	N/A	N/A	No
	99-08-1	3-Nitrotoluene			mg/kg		0/7	4.00E-01 - 4.00E-01	4.00E-01	N/A	1.564E+02 N	N/A	N/A	No
	19406-51-0	4-amino-2,6-Dinitrotoluene			mg/kg		0/7	2.00E-01 - 2.00E-01	2.00E-01	N/A	1.600E+00 N	N/A	N/A	No
	99-99-0	4-Nitrotoluene			mg/kg		0/7	4.00E-01 - 4.00E-01	4.00E-01	N/A	3.800E+00 C	N/A	N/A	No
	121-82-4	Cyclonite			mg/kg		0/10	2.00E-01 - 5.87E-01	5.87E-01	N/A	5.807E+00 C	N/A	N/A	No
	2691-41-0	HMX			mg/kg		0/10	2.00E-01 - 6.66E-01	6.66E-01	N/A	3.911E+02 N	N/A	N/A	No
	78-11-5	Pentaerythritol tetranitrate			mg/kg		0/7	3.31E-01 - 3.68E-01	3.68E-01	N/A	N/A	N/A	N/A	No
	479-45-8	Tetryl			mg/kg		0/10	2.00E-01 - 7.31E-01	7.31E-01	N/A	7.821E+01 N	N/A	N/A	No
	93-76-5	2,4,5-T			mg/kg		0/3	1.10E-01 - 1.22E-01	1.22E-01	N/A	7.821E+01 N	N/A	N/A	No
	93-72-1	2,4,5-TP (Silvex)			mg/kg		0/3	1.10E-01 - 1.22E-01	1.22E-01	N/A	6.257E+01 N	N/A	N/A	No
	94-75-7	2,4-D			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	N/A	7.821E+01 N	N/A	N/A	No
	94-82-6	2,4-DB			mg/kg		0/3	1.10E+00 - 1.22E+00	1.22E+00	N/A	6.257E+01 N	N/A	N/A	No
	72-55-9	4,4'-DDE			mg/kg		0/6	7.36E-04 - 3.10E-01	3.10E-01	N/A	1.879E+00 C	N/A	N/A	No
	50-29-3	4,4'-DDT			mg/kg		0/5	7.36E-04 - 3.10E-01	3.10E-01	N/A	1.879E+00 C	N/A	N/A	No
	309-00-2	Aldrin			mg/kg		0/6	7.36E-04 - 3.30E-01	3.30E-01	N/A	3.760E-02 C	N/A	N/A	Yes
	319-84-6	alpha-BHC			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	N/A	1.014E-01 C	N/A	N/A	Yes
	319-85-7	beta-BHC			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	N/A	3.548E-01 C	N/A	N/A	No
	75-99-0	Dalapon			mg/kg		0/3	1.10E+00 - 1.22E+00	1.22E+00	N/A	2.346E+02 N	N/A	N/A	No
	319-86-8	delta-BHC			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	N/A	4.910E-01 C	N/A	N/A	No
	1918-00-9	Dicamba			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	N/A	2.346E+02 N	N/A	N/A	No
	120-36-5	Dichloroprop			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	N/A	N/A	N/A	N/A	No
	60-57-1	Dieldrin			mg/kg		0/6	7.36E-04 - 3.10E-01	3.10E-01	N/A	3.990E-02 C	N/A	N/A	Yes
	959-98-8	Endosulfan I			mg/kg		0/6	7.36E-04 - 6.20E-01	6.20E-01	N/A	4.690E+01 N	N/A	N/A	No
	33213-65-9	Endosulfan II			mg/kg		0/6	7.36E-04 - 6.20E-01	6.20E-01	N/A	4.690E+01 N	N/A	N/A	No
	1031-07-8	Endosulfan sulfate			mg/kg		0/6	7.36E-04 - 6.20E-01	6.20E-01	N/A	4.690E+01 N	N/A	N/A	No
	58-89-9	gamma-BHC (Lindane)			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	N/A	4.913E-01 C	N/A	N/A	No
	76-44-8	Heptachlor			mg/kg		0/6	7.36E-04 - 1.30E-01	1.30E-01	N/A	1.419E-01 C	N/A	N/A	No
	1024-57-3	Heptachlor epoxide			mg/kg		0/6	7.36E-04 - 3.30E-01	3.30E-01	N/A	7.020E-02 C	N/A	N/A	Yes
	94-74-6	MCPA			mg/kg		0/3	1.10E+02 - 1.22E+02	1.22E+02	N/A	3.911E+00 N	N/A	N/A	Yes
	93-65-2	MCPP			mg/kg		0/3	1.10E+02 - 1.22E+02	1.22E+02	N/A	7.821E+00 N	N/A	N/A	Yes
	8001-35-2	Toxaphene			mg/kg		0/6	3.68E-02 - 2.60E+00	2.60E+00	N/A	5.807E-01 C	N/A	N/A	Yes
	12674-11-2	Aroclor 1016			mg/kg		0/10	3.68E-02 - 1.40E+00	1.40E+00	N/A	5.475E+00 C	50	TSCA	No
	11104-28-2	Aroclor 1221			mg/kg		0/10	7.36E-02 - 1.40E+00	1.40E+00	N/A	3.194E-01 C	50	TSCA	Yes
	11141-16-5	Aroclor 1232			mg/kg		0/10	3.68E-02 - 1.40E+00	1.40E+00	N/A	3.194E-01 C	50	TSCA	Yes
	53469-21-9	Aroclor 1242			mg/kg		0/10	3.68E-02 - 1.40E+00	1.40E+00	N/A	3.194E-01 C	50	TSCA	Yes
	12672-29-6	Aroclor 1248			mg/kg		0/10	3.68E-02 - 2.00E+00	2.00E+00	N/A	3.194E-01 C	50	TSCA	Yes
	11097-69-1	Aroclor 1254			mg/kg		0/10	3.68E-02 - 2.30E+00	2.30E+00	N/A	1.560E-01 N	50	TSCA	Yes
	11096-82-5	Aroclor 1260			mg/kg		0/10	3.68E-02 - 2.60E+00	2.60E+00	N/A	3.194E-01 C	50	TSCA	Yes

Table E-4
Summary of Screening of Non-Detected Chemicals
Future - Total Soil

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Total Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Above Screening Criteria? (Y/N)
	120-82-1	1,2,4-Trichlorobenzene			mg/kg		0/16	4.00E-02 - 4.50E-01	4.50E-01	N/A	7.821E+01 N	N/A	N/A	No
	95-50-1	1,2-Dichlorobenzene			mg/kg		0/16	1.10E-01 - 4.50E-01	4.50E-01	N/A	7.039E+02 N	N/A	N/A	No
	122-66-7	1,2-Diphenylhydrazine			mg/kg		0/16	1.40E-01 - 4.50E-01	4.50E-01	N/A	7.984E-01 C	N/A	N/A	No
	541-73-1	1,3-Dichlorobenzene			mg/kg		0/16	1.30E-01 - 4.50E-01	4.50E-01	N/A	2.300E+02 N	N/A	N/A	No
	106-46-7	1,4-Dichlorobenzene			mg/kg		0/16	9.80E-02 - 4.50E-01	4.50E-01	N/A	2.661E+01 C	N/A	N/A	No
	95-95-4	2,4,5-Trichlorophenol			mg/kg		0/16	1.00E-01 - 1.10E+00	1.10E+00	N/A	7.821E+02 N	N/A	N/A	No
	88-06-2	2,4,6-Trichlorophenol			mg/kg		0/16	1.70E-01 - 4.50E-01	4.50E-01	N/A	5.807E+01 C	N/A	N/A	No
	120-83-2	2,4-Dichlorophenol			mg/kg		0/16	1.80E-01 - 4.50E-01	4.50E-01	N/A	2.346E+01 N	N/A	N/A	No
	105-67-9	2,4-Dimethylphenol			mg/kg		0/16	3.85E-01 - 6.90E-01	6.90E-01	N/A	1.564E+02 N	N/A	N/A	No
	51-28-5	2,4-Dinitrophenol			mg/kg		0/16	1.20E+00 - 2.20E+00	2.20E+00	N/A	1.564E+01 N	N/A	N/A	No
	606-20-2	2,6-Dinitrotoluene			mg/kg		0/23	8.50E-02 - 4.50E-01	4.50E-01	N/A	9.390E-01 C	N/A	N/A	No
	91-58-7	2-Chloronaphthalene			mg/kg		0/16	3.60E-02 - 4.50E-01	4.50E-01	N/A	6.257E+02 N	N/A	N/A	No
	95-57-8	2-Chlorophenol			mg/kg		0/16	6.00E-02 - 4.50E-01	4.50E-01	N/A	3.911E+01 N	N/A	N/A	No
	91-57-6	2-Methylnaphthalene			mg/kg		0/16	4.90E-02 - 4.50E-01	4.50E-01	N/A	3.100E+01 N	N/A	N/A	No
	88-74-4	2-Nitroaniline			mg/kg		0/16	6.20E-02 - 2.20E+00	2.20E+00	N/A	2.300E+01 N	N/A	N/A	No
	88-75-5	2-Nitrophenol			mg/kg		0/16	1.40E-01 - 4.50E-01	4.50E-01	N/A	N/A	N/A	N/A	No
	88-85-7	2-sec-butyl-4,6-dinitrophenol			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	N/A	7.821E+00 N	N/A	N/A	No
	NA	3&4-Methylphenol			mg/kg		0/12	3.95E-01 - 4.50E-01	4.50E-01	N/A	N/A	N/A	N/A	No
	91-94-1	3,3'-Dichlorobenzidine			mg/kg		0/16	7.65E-01 - 6.30E+00	6.30E+00	N/A	1.419E+00 C	N/A	N/A	Yes
	99-09-2	3-Nitroaniline			mg/kg		0/16	4.50E-01 - 2.20E+00	2.20E+00	N/A	2.300E+01 N	N/A	N/A	No
	534-52-1	4,6-Dinitro-o-cresol			mg/kg		0/16	5.50E-01 - 2.20E+00	2.20E+00	N/A	7.800E-01 N	N/A	N/A	Yes
	100-01-6	4-Nitroaniline			mg/kg		0/16	4.10E-01 - 2.20E+00	2.20E+00	N/A	2.300E+01 N	N/A	N/A	No
	100-02-7	4-Nitrophenol			mg/kg		0/16	1.40E+00 - 2.20E+00	2.20E+00	N/A	6.257E+01 N	N/A	N/A	No
	83-32-9	Acenaphthene			mg/kg		0/16	2.00E-02 - 2.20E-01	2.20E-01	N/A	4.693E+02 N	N/A	N/A	No
	208-96-8	Acenaphthylene			mg/kg		0/16	3.30E-02 - 4.30E-01	4.30E-01	N/A	2.350E+02 N	N/A	N/A	No
	120-12-7	Anthracene			mg/kg		0/16	2.00E-03 - 3.30E-02	3.30E-02	N/A	2.346E+03 N	N/A	N/A	No
	92-87-5	Benzidine			mg/kg		0/3	8.50E-01 - 8.50E-01	8.50E-01	N/A	2.800E-03 C	N/A	N/A	Yes
	56-55-3	Benzo(a)anthracene			mg/kg		0/16	2.00E-03 - 1.70E-01	1.70E-01	N/A	8.750E-01 C	N/A	N/A	No
	50-32-8	Benzo(a)pyrene			mg/kg		0/16	2.00E-03 - 2.50E-01	2.50E-01	N/A	8.750E-02 C	N/A	N/A	Yes
	205-99-2	Benzo(b)fluoranthene			mg/kg		0/16	3.90E-03 - 2.10E-01	2.10E-01	N/A	8.750E-01 C	N/A	N/A	No
	191-24-2	Benzo(g,h,i)perylene			mg/kg		0/16	3.90E-03 - 2.50E-01	2.50E-01	N/A	2.350E+02 N	N/A	N/A	No
	207-08-9	Benzo(k)fluoranthene			mg/kg		0/16	2.00E-03 - 6.60E-02	6.60E-02	N/A	8.750E+00 C	N/A	N/A	No
	65-85-0	Benzoic Acid			mg/kg		0/16	1.95E+00 - 6.10E+00	6.10E+00	N/A	3.129E+04 N	N/A	N/A	No
	100-51-6	Benzyl alcohol			mg/kg		0/16	1.90E-01 - 8.80E-01	8.80E-01	N/A	2.346E+03 N	N/A	N/A	No
	111-91-1	bis(2-Chloroethoxy)methane			mg/kg		0/16	5.90E-02 - 4.50E-01	4.50E-01	N/A	N/A	N/A	N/A	No
	111-44-4	bis(2-Chloroethyl)ether			mg/kg		0/16	3.30E-02 - 4.50E-01	4.50E-01	N/A	5.807E-01 C	N/A	N/A	No
	108-60-1	bis(2-Chloroisopropyl)ether			mg/kg		0/16	2.00E-01 - 4.50E-01	4.50E-01	N/A	9.125E+00 C	N/A	N/A	No
	85-68-7	Butyl benzyl phthalate			mg/kg		0/16	1.70E-01 - 4.50E-01	4.50E-01	N/A	1.564E+03 N	N/A	N/A	No
	86-74-8	Carbazole			mg/kg		0/13	3.85E-01 - 4.50E-01	4.50E-01	N/A	3.194E+01 C	N/A	N/A	No
	218-01-9	Chrysene			mg/kg		0/16	2.00E-03 - 1.20E-01	1.20E-01	N/A	8.750E+01 C	N/A	N/A	No
	53-70-3	Dibenz(a,h)anthracene			mg/kg		0/16	3.90E-03 - 2.10E-01	2.10E-01	N/A	8.750E-02 C	N/A	N/A	Yes
	132-64-9	Dibenzofuran			mg/kg		0/16	3.50E-02 - 4.50E-01	4.50E-01	N/A	3.129E+01 N	N/A	N/A	No

Table E-4
Summary of Screening of Non-Detected Chemicals
Future - Total Soil

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Total Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Above Screening Criteria? (Y/N)
	131-11-3	Dimethylphthalate			mg/kg		0/16	1.70E-01 - 4.50E-01	4.50E-01	N/A	7.821E+04 N	N/A	N/A	No
	117-84-0	Di-n-octyl phthalate			mg/kg		0/16	1.90E-01 - 4.50E-01	4.50E-01	N/A	3.100E+02 N	N/A	N/A	No
	206-44-0	Fluoranthene			mg/kg		0/16	3.90E-03 - 6.80E-02	6.80E-02	N/A	3.129E+02 N	N/A	N/A	No
	86-73-7	Fluorene			mg/kg		0/16	3.90E-03 - 4.30E-02	4.30E-02	N/A	3.129E+02 N	N/A	N/A	No
	118-74-1	Hexachlorobenzene			mg/kg		0/16	3.30E-02 - 4.50E-01	4.50E-01	N/A	3.992E-01 C	N/A	N/A	Yes
	87-68-3	Hexachlorobutadiene			mg/kg		0/16	2.30E-01 - 4.50E-01	4.50E-01	N/A	1.560E+00 N	N/A	N/A	No
	77-47-4	Hexachlorocyclopentadiene			mg/kg		0/16	3.85E-01 - 6.20E+00	6.20E+00	N/A	4.693E+01 N	N/A	N/A	No
	67-72-1	Hexachloroethane			mg/kg		0/16	1.50E-01 - 4.50E-01	4.50E-01	N/A	7.800E+00 N	N/A	N/A	No
	193-39-5	Indeno(1,2,3-cd)pyrene			mg/kg		0/16	2.00E-03 - 2.90E-01	2.90E-01	N/A	8.750E-01 C	N/A	N/A	No
	78-59-1	Isophorone			mg/kg		0/16	3.30E-02 - 4.50E-01	4.50E-01	N/A	6.723E+02 C	N/A	N/A	No
	91-20-3	Naphthalene			mg/kg		0/16	2.00E-02 - 2.20E-01	2.20E-01	N/A	1.564E+02 N	N/A	N/A	No
	98-95-3	Nitrobenzene			mg/kg		0/23	4.50E-02 - 4.50E-01	4.50E-01	N/A	3.911E+00 N	N/A	N/A	No
	62-75-9	N-Nitrosodimethylamine			mg/kg		0/3	1.40E-01 - 1.40E-01	1.40E-01	N/A	1.250E-02 C	N/A	N/A	Yes
	621-64-7	n-Nitroso-di-n-propylamine			mg/kg		0/16	2.00E-01 - 4.50E-01	4.50E-01	N/A	9.120E-02 C	N/A	N/A	Yes
	86-30-6	n-Nitrosodiphenylamine			mg/kg		0/16	1.90E-01 - 4.50E-01	4.50E-01	N/A	1.304E+02 C	N/A	N/A	No
	95-48-7	o-Cresol			mg/kg		0/16	2.90E-02 - 4.50E-01	4.50E-01	N/A	3.911E+02 N	N/A	N/A	No
	106-47-8	p-Chloroaniline			mg/kg		0/16	7.65E-01 - 8.80E-01	8.80E-01	N/A	3.129E+01 N	N/A	N/A	No
	59-50-7	p-Chloro-m-cresol			mg/kg		0/16	9.50E-02 - 8.80E-01	8.80E-01	N/A	N/A	N/A	N/A	No
	106-44-5	p-Cresol			mg/kg		0/4	2.40E-01 - 3.85E-01	3.85E-01	N/A	3.911E+01 N	N/A	N/A	No
	87-86-5	Pentachlorophenol			mg/kg		0/16	1.30E+00 - 2.20E+00	2.20E+00	N/A	5.323E+00 C	N/A	N/A	No
	85-01-8	Phenanthrene			mg/kg		0/16	2.00E-03 - 3.30E-02	3.30E-02	N/A	2.350E+02 N	N/A	N/A	No
	108-95-2	Phenol			mg/kg		0/16	1.10E-01 - 4.50E-01	4.50E-01	N/A	2.300E+03 N	N/A	N/A	No
	129-00-0	Pyrene			mg/kg		0/16	1.00E-03 - 3.30E-02	3.30E-02	N/A	2.346E+02 N	N/A	N/A	No
	71-55-6	1,1,1-Trichloroethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	2.190E+03 N	N/A	N/A	No
	79-34-5	1,1,2,2-Tetrachloroethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	3.194E+00 C	N/A	N/A	No
	79-00-5	1,1,2-Trichloroethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.121E+01 C	N/A	N/A	No
	75-34-3	1,1-Dichloroethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.821E+02 N	N/A	N/A	No
	75-35-4	1,1-Dichloroethene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	3.900E+02 N	N/A	N/A	No
	107-06-2	1,2-Dichloroethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.019E+00 C	N/A	N/A	No
	78-87-5	1,2-Dichloropropane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	9.393E+00 C	N/A	N/A	No
	78-93-3	2-Butanone			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	4.693E+03 N	N/A	N/A	No
	591-78-6	2-Hexanone			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	3.129E+02 N	N/A	N/A	No
	101-55-3	4-Bromophenyl phenylether			mg/kg		0/16	3.30E-02 - 4.50E-01	4.50E-01	N/A	N/A	N/A	N/A	No
	7005-72-3	4-Chlorophenyl phenylether			mg/kg		0/16	3.30E-02 - 4.50E-01	4.50E-01	N/A	N/A	N/A	N/A	No
	108-10-1	4-Methyl-2-pentanone			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	N/A	N/A	N/A	No
	67-64-1	Acetone			mg/kg		0/6	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.000E+03 N	N/A	N/A	No
	71-43-2	Benzene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.161E+01 C	N/A	N/A	No
	75-27-4	Bromodichloromethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.030E+01 C	N/A	N/A	No
	74-83-9	Bromomethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.095E+01 N	N/A	N/A	No
	75-15-0	Carbon disulfide			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.821E+02 N	N/A	N/A	No
	56-23-5	Carbon tetrachloride			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	4.913E+00 C	N/A	N/A	No
	108-90-7	Chlorobenzene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.564E+02 N	N/A	N/A	No

Table E-4
Summary of Screening of Non-Detected Chemicals
Future - Total Soil

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Total Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3) (N/C)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	Above Screening Criteria? (Y/N)
	75-00-3	Chloroethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	2.203E+02 C	N/A	N/A	No
	74-87-3	Chloromethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	4.913E+01 C	N/A	N/A	No
	156-59-2	cis-1,2-Dichloroethene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.821E+01 N	N/A	N/A	No
	10061-01-5	cis-1,3-Dichloro-1-propene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	6.400E+00 C	N/A	N/A	No
	124-48-1	Dibromochloromethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.604E+00 C	N/A	N/A	No
	100-41-4	Ethylbenzene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.821E+02 N	N/A	N/A	No
	75-09-2	Methylene chloride			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	8.516E+01 C	N/A	N/A	No
	95-47-6	o-Xylene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.564E+04 N	N/A	N/A	No
	130-312	p&m-Xylene			mg/kg		0/7	9.80E-03 - 1.20E-02	1.20E-02	N/A	N/A	N/A	N/A	No
	100-42-5	Styrene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.564E+03 N	N/A	N/A	No
	127-18-4	Tetrachloroethene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.228E+01 C	N/A	N/A	No
	108-88-3	Toluene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.564E+03 N	N/A	N/A	No
	156-60-5	trans-1,2-Dichloroethene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.564E+02 N	N/A	N/A	No
	10061-02-6	trans-1,3-Dichloropropene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	6.390E+00 C	N/A	N/A	No
	75-25-2	Tribromomethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	8.085E+01 C	N/A	N/A	No
	79-01-6	Trichloroethene			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	1.600E+00 C	N/A	N/A	No
	67-66-3	Chloroform			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.800E+01 N	N/A	N/A	No
	75-01-4	Vinyl Chloride			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	9.000E-02 C	N/A	N/A	No
	124-48-1	Dibromochloromethane			mg/kg		0/7	4.90E-03 - 5.80E-03	5.80E-03	N/A	7.6039 C	N/A	N/A	No

(1) Maximum concentration used for screening.
(2) N/A - Refer to supporting information for background discussion.
Background values derived from site-specific statistical analysis. See text for supporting information.
(3) Screening toxicity values from USEPA Region 3 RBC Table (April 2004). See text for derivation of Nutrient RDAs.

Definitions: N/A = Not Applicable or Not Available
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic
RDA = Recommended Daily Allowance
TSCA = Toxic Substances Control Act

Table E-5
Exposure Point Concentration Summary
Surface Soil - SWMU 39

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Surface Soil	TCDD TE (RME)	mg/kg	5.71E-06	---	2.07E-05	2.07E-05	mg/kg	Max	Test(3)
(0 - 2 ft.)	Aluminum	mg/kg	2.22E+04	2.58E+04 (T)	3.74E+04	2.58E+04	mg/kg	95%UCL-T	Test(2)
	Arsenic	mg/kg	3.31E+00	5.43E+00 (T)	7.26E+00	5.43E+00	mg/kg	95%UCL-T	Test(2)
	Chromium	mg/kg	3.83E+01	4.68E+01 (T)	9.51E+01	4.68E+01	mg/kg	95%UCL-T	Test(2)
	Copper	mg/kg	8.14E+01	1.18E+02 (NP)	3.75E+02	1.18E+02	mg/kg	95%UCL-BST	Test(1)
	Iron	mg/kg	3.09E+04	3.52E+04 (T)	5.28E+04	3.52E+04	mg/kg	95%UCL-T	Test(2)
	Lead	mg/kg	1.52E+03	1.28E+04 (T)	1.65E+04	1.28E+04	mg/kg	95%UCL-T	Test(2)
	Manganese	mg/kg	5.19E+02	8.12E+02 (T)	1.38E+03	8.12E+02	mg/kg	95%UCL-T	Test(2)
	Thallium	mg/kg	2.55E+00	4.28E+00 (NP)	2.27E+01	4.28E+00	mg/kg	95%UCL-BST	Test(1)
	Vanadium	mg/kg	5.57E+01	6.32E+01 (N)	9.27E+01	6.32E+01	mg/kg	95%UCL-N	Test(4)

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N), 95% UCL based on bootstrap statistic (95% UCL-Bst).

N/A - Not Applicable; Not Available

Distributions: Normal (N); Lognormal/Transformed (T); Undefined/Nonparametric (NP).

Test(1) The data were determined to be neither normally or lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50); the bootstrap statistic was used.

Test(2) The data were determined to be lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50).

Test(3) The 95% UCL was not calculated due to limited number of samples (n<=5); therefore, the maximum detect was used as the EPC.

Test(4) The data were determined to be normally distributed using Shapiro-Wilks Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50).

Test(5) The 95% UCL exceeds the maximum detected concentration; therefore, the maximum detect was used as the EPC.

Table E-6
Exposure Point Concentration Summary
Total Soil - SWMU 39

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Total Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic	Rationale
Total Soil (0 - 10 ft.)	TCDD TE (RME)	mg/kg	4.57E-06	3.31E-05 (T)	2.07E-05	2.07E-05	mg/kg	Max	Test(3)
	Aluminum	mg/kg	2.26E+04	2.52E+04 (T)	3.74E+04	2.52E+04	mg/kg	95%UCL-T	Test(2)
	Arsenic	mg/kg	3.07E+00	4.33E+00 (T)	7.26E+00	4.33E+00	mg/kg	95%UCL-T	Test(2)
	Chromium	mg/kg	3.74E+01	4.26E+01 (T)	9.51E+01	4.26E+01	mg/kg	95%UCL-T	Test(2)
	Copper	mg/kg	6.37E+01	8.93E+01 (NP)	3.75E+02	8.93E+01	mg/kg	95%UCL-BST	Test(1)
	Iron	mg/kg	3.13E+04	3.42E+04 (T)	5.28E+04	3.42E+04	mg/kg	95%UCL-T	Test(2)
	Lead	mg/kg	1.06E+03	1.71E+03 (NP)	1.65E+04	1.71E+03	mg/kg	95%UCL-BST	Test(1)
	Manganese	mg/kg	4.67E+02	6.19E+02 (T)	1.38E+03	6.19E+02	mg/kg	95%UCL-T	Test(2)
	Thallium	mg/kg	1.92E+00	3.10E+00 (NP)	2.27E+01	3.10E+00	mg/kg	95%UCL-BST	Test(1)
	Vanadium	mg/kg	5.77E+01	6.31E+01 (N)	9.27E+01	6.31E+01	mg/kg	95%UCL-N	Test(4)

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N), 95% UCL based on bootstrap statistic (95% UCL-Bst).

N/A - Not Applicable; Not Available

Distributions: Normal (N); Lognormal/Transformed (T); Undefined/Nonparametric (NP).

Test(1) The data were determined to be neither normally or lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50); the bootstrap statistic was used.

Test(2) The data were determined to be lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50).

Test(3) The 95% UCL was not calculated due to limited number of samples (n<=5); therefore, the maximum detect was used as the EPC.

Test(4) The data were determined to be normally distributed using Shapiro-Wilks Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50).

Test(5) The 95% UCL exceeds the maximum detected concentration; therefore, the maximum detect was used as the EPC.

Table E-7
Values Used for Daily Intake Calculations- Current and Future Exposures to Surface Soil

Scenario Timeframe:	Current and Future
Medium:	Surface Soil
Exposure Medium:	Surface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Maintenance Worker	Adult	SWMU 39	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				IR-S	Ingestion Rate of Soil	100	mg/day	USEPA, 2001	Potential (Lifetime) Average Daily Dose
				EF	Exposure Frequency	50	days/year	(1)	$[(L)ADD_{pot}]$ (mg/kg-day) =
				ED	Exposure Duration	25	years	USEPA, 2001	
				CF1	Conversion Factor 1	$1/10^6$	kg/mg	---	$\frac{CS \times IR\text{-}S \times EF \times ED \times CF1}{BW \times AT \times CF2}$
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	25	years	USEPA, 2001	
				CF2	Conversion Factor 2	365	days/year	---	
Dermal Absorption	Maintenance Worker	Adult	SWMU 39	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2-day	USEPA, 1997, 2001	Internal (Lifetime) Average Daily Dose
				DABS	Dermal Absorption Factor (Solid)	(2)	--	USEPA, 1995	$[(L)ADD_{int}]$ (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	3,300 (3)	cm^2	USEPA, 1997	
				EF	Exposure Frequency	50	days/year	(1)	$\frac{CS \times SSAF \times DABS \times SA \times EF \times ED \times CF1}{BW \times AT \times CF2}$
				ED	Exposure Duration	25	years	USEPA, 2001	
				CF1	Conversion Factor 1	$1/10^6$	kg/mg	---	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	25	years	USEPA, 2001	
				CF2	Conversion Factor 2	365	days/year	---	

(1) Best professional judgement. Based on site maintenance/inspection activities conducted 1day/week and assuming 2 weeks on vacation.

(2) Dermal absorption factors are presented in **Section 6.2.3** of the text.

(3) Value derived from data presented in USEPA (1997), averaging across gender and age. It is assumed that head, hands, and forearms are exposed to surface soil.

USEPA, 1991: Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER 9285.6-03.

USEPA, 1995: Assessing Dermal Exposure from Soil Hazardous Waste Management Division. Office of Superfund Programs, Region III, Philadelphia, PA.

USEPA, 1997: Exposure Factors Handbook, Volume I. EPA/600/P-95/002Fa.

USEPA, 2001: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Peer Review Draft. OSWER 9355.4-24.

Table E-8
Values Used for Daily Intake Calculations- Future Exposures to Total Soil

Scenario Timeframe:	Future
Medium:	Total Soil
Exposure Medium:	Total Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Maintenance Worker	Adult	SWMU 39	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				IR-S	Ingestion Rate of Soil	100	mg/day	USEPA, 2001	Potential (Lifetime) Average Daily Dose
				EF	Exposure Frequency	50	days/year	(1)	$[(L)ADD_{pot}]$ (mg/kg-day) =
				ED	Exposure Duration	25	years	USEPA, 2001	
				CF1	Conversion Factor 1	$1/10^6$	kg/mg	---	$\frac{CS \times IR\text{-}S \times EF \times ED \times CF1}{BW \times AT \times CF2}$
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	25	years	USEPA, 2001	
				CF2	Conversion Factor 2	365	days/year	---	
	Excavation Worker	Adult	SWMU 39	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				IR-S	Ingestion Rate of Soil	330	mg/day	USEPA, 2001	Potential (Lifetime) Average Daily Dose
				EF	Exposure Frequency	250	days/year	USEPA, 2001	$[(L)ADD_{pot}]$ (mg/kg-day) =
				ED	Exposure Duration	1	years	USEPA, 2001	
				CF1	Conversion Factor 1	$1/10^6$	kg/mg	---	$\frac{CS \times IR\text{-}S \times EF \times ED \times CF1}{BW \times AT \times CF2}$
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	1	years	USEPA, 2001	
				CF2	Conversion Factor 2	365	days/year	---	
	Resident	Adult	SWMU 39	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				IR-S	Ingestion Rate of Soil	100	mg/day	USEPA, 1991	Potential (Lifetime) Average Daily Dose
				EF	Exposure Frequency	350	days/year	USEPA, 1991	$[(L)ADD_{pot}]$ (mg/kg-day) =
				ED	Exposure Duration	30	years	USEPA, 1991	
				CF1	Conversion Factor 1	$1/10^6$	kg/mg	---	$\frac{CS \times IR\text{-}S \times EF \times ED \times CF1}{BW \times AT \times CF2}$
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	30	years	USEPA, 1991	
				CF2	Conversion Factor 2	365	days/year	---	
		Child	SWMU 39	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				IR-S	Ingestion Rate of Soil	200	mg/day	USEPA, 1991	Potential (Lifetime) Average Daily Dose
				EF	Exposure Frequency	350	days/year	USEPA, 1991	$[(L)ADD_{pot}]$ (mg/kg-day) =
				ED	Exposure Duration	6	years	USEPA, 1991	
				CF1	Conversion Factor 1	$1/10^6$	kg/mg	---	$\frac{CS \times IR\text{-}S \times EF \times ED \times CF1}{BW \times AT \times CF2}$
				BW	Body Weight	15	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	6	years	USEPA, 1991	
				CF2	Conversion Factor 2	365	days/year	---	
Dermal Absorption	Maintenance Worker	Adult	SWMU 39	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2-day	USEPA, 1997, 2001	Internal (Lifetime) Average Daily Dose
				DABS	Dermal Absorption Factor (Solid)	(2)	--	USEPA, 1995	$[(L)ADD_{int}]$ (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	3,300 (3)	cm^2	USEPA, 1997	
				EF	Exposure Frequency	50	days/year	(1)	$\frac{CS \times SSAF \times DABS \times SA \times EF \times ED \times CF1}{BW \times AT \times CF2}$
				ED	Exposure Duration	25	years	USEPA, 2001	
				CF1	Conversion Factor 1	$1/10^6$	kg/mg	---	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	25	years	USEPA, 2001	
				CF2	Conversion Factor 2	365	days/year	---	

Table E-8
Values Used for Daily Intake Calculations- Future Exposures to Total Soil

Scenario Timeframe:	Future
Medium:	Total Soil
Exposure Medium:	Total Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal Absorption (con't)	Excavation Worker	Adult	SWMU 39	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				SSAF	Soil to Skin Adherence Factor	0.3	mg/cm^2-day	USEPA, 2001	Internal (Lifetime) Average Daily Dose
				DABS	Dermal Absorption Factor (Solid)	(2)	--	USEPA, 1995	$[(L)ADD_{int}]$ (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	3,300 (3)	cm^2	USEPA, 1997	
				EF	Exposure Frequency	250	days/year	USEPA, 2001	$\frac{CS \times SSAF \times DABS \times SA \times EF \times ED \times CF1}{BW \times AT \times CF2}$
				ED	Exposure Duration	1	years	USEPA, 2001	
				CF1	Conversion Factor 1	$1/10^6$	kg/mg	---	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	1	years	USEPA, 2001	
				CF2	Conversion Factor 2	365	days/year	---	
	Resident	Adult	SWMU 39	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm^2-day	USEPA, 1997, 2004	Internal (Lifetime) Average Daily Dose
				DABS	Dermal Absorption Factor (Solid)	(2)	--	USEPA, 1995	$[(L)ADD_{int}]$ (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	5,700 (4)	cm^2	USEPA, 1997	
				EF	Exposure Frequency	350	days/year	USEPA, 1991	$\frac{CS \times SSAF \times DABS \times SA \times EF \times ED \times CF1}{BW \times AT \times CF2}$
				ED	Exposure Duration	30	years	USEPA, 1991	
				CF1	Conversion Factor 1	$1/10^6$	kg/mg	---	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	30	years	USEPA, 1991	
				CF2	Conversion Factor 2	365	days/year	---	
		Child	SWMU 39	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2-day	USEPA, 1997, 2004	Internal (Lifetime) Average Daily Dose
				DABS	Dermal Absorption Factor (Solid)	(2)	--	USEPA, 1995	$[(L)ADD_{int}]$ (mg/kg-day) =
				SA	Skin Surface Area Available for Contact	2,800 (5)	cm^2	USEPA, 1997	
				EF	Exposure Frequency	350	days/year	USEPA, 1991	$\frac{CS \times SSAF \times DABS \times SA \times EF \times ED \times CF1}{BW \times AT \times CF2}$
				ED	Exposure Duration	6	years	USEPA, 1991	
				CF1	Conversion Factor 1	$1/10^6$	kg/mg	---	
				BW	Body Weight	15	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	6	years	USEPA, 1991	
				CF2	Conversion Factor 2	365	days/year	---	

(1) Best professional judgement. Based on site maintenance/inspection activities conducted 1day/week and assuming 2 weeks on vacation.
(2) Dermal absorption factors are presented in Section 6.2.3 of the text.
(3) Value derived from data presented in USEPA (1997), averaging across gender and age. It is assumed that head, hands, and forearms are exposed to soil.
(4) Value derived from data presented in USEPA (1997), averaging across gender and age. It is assumed that head, hands, forearms, and lower legs are exposed to soil.
(5) Value derived from data presented in USEPA (1997), averaging across gender and age. It is assumed that head, hands, forearms, lower legs, and feet are exposed to soil.

USEPA, 1991: Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER 9285.6-03.
USEPA, 1995: Assessing Dermal Exposure from Soil. Hazardous Waste Management Division. Office of Superfund Programs, Region III, Philadelphia, PA.
USEPA, 1997: Exposure Factors Handbook, Volume I. EPA/600/P-95/002Fa.
USEPA, 2001: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Peer Review Draft. OSWER 9355.4-24.
USEPA, 2004: Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final.

Table E-9
Values Used for Daily Intake Calculations- Current/Future Exposures to Surface Soil- Air

Scenario Timeframe:	Current and Futore
Medium:	Surface Soil
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Maintenance Worker	Adult	Particulates	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				PEF	Particulate Emission Factor	Site-Specific PEF	m^3/kg	Site-Specific PEF	
				IN	Inhalation Rate	2.5	m^3/h	(1)	Potential (Lifetime) Average Daily Dose
				EF	Exposure Frequency	50	days/year	(2)	$[(L)ADD_{pot}]$ (mg/kg-day) =
				ED	Exposure Duration	25	years	USEPA, 2001	
				ET	Exposure Time	8	hr/day	USEPA, 1991	$\frac{CS \times (1/PEF) \times IN \times EF \times ED \times ET}{BW \times AT \times CF1}$
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	25	years	USEPA, 2001	
				CF1	Conversion Factor 1	365	days/year	---	

(1) The hourly inhalation rate was derived by dividing the adult's daily 20 m^3/day USEPA (1991) inhalation rate by 8 hours per day.
(2) Best professional judgement. Based on site maintenance/inspection activities conducted 1day/week and assuming 2 weeks on vacation.

USEPA, 1991: Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER 9285.6-03.
USEPA, 2001: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Peer Review Draft. OSWER 9355.4-24.

Table E-10
Values Used for Daily Intake Calculations- Future Exposures to Total Soil- Air

Scenario Timeframe:	Future
Medium:	Total Soil
Exposure Medium:	Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Maintenance Worker	Adult	Particulates	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				PEF	Particulate Emission Factor	Site-Specific PEF	m^3/kg	Site-Specific PEF	
				IN	Inhalation Rate	2.5	m^3/h	(1)	Potential (Lifetime) Average Daily Dose
				EF	Exposure Frequency	50	days/year	(2)	$[(L)ADD_{pot}]$ (mg/kg-day) =
				ED	Exposure Duration	25	years	USEPA, 2001	
				ET	Exposure Time	8	hr/day	USEPA, 1991	CS x (1/PEF) x IN x EF x ED x ET
				BW	Body Weight	70	kg	USEPA, 1991	BW x AT x CF1
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	25	years	USEPA, 2001	
				CF1	Conversion Factor 1	365	days/year	---	
	Excavation Worker	Adult	Particulates	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				PEF	Particulate Emission Factor	Site-Specific PEF	m^3/kg	Site-Specific PEF	
				IN	Inhalation Rate	2.5	m^3/h	(1)	Potential (Lifetime) Average Daily Dose
				EF	Exposure Frequency	250	days/year	USEPA, 2001	$[(L)ADD_{pot}]$ (mg/kg-day) =
				ED	Exposure Duration	1	years	USEPA, 2001	
				ET	Exposure Time	8	hr/day	USEPA, 1991	CS x (1/PEF) x IN x EF x ED x ET
				BW	Body Weight	70	kg	USEPA, 1991	BW x AT x CF1
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	1	years	USEPA, 2001	
				CF1	Conversion Factor 1	365	days/year	---	
	Resident	Adult	Particulates	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				PEF	Particulate Emission Factor	Site-Specific PEF	m^3/kg	Site-Specific PEF	
				IN	Inhalation Rate	0.83	m^3/h	(3)	Potential (Lifetime) Average Daily Dose
				EF	Exposure Frequency	350	days/year	USEPA, 1991	$[(L)ADD_{pot}]$ (mg/kg-day) =
				ED	Exposure Duration	30	years	USEPA, 1991	
				ET	Exposure Time	1	hr/day	(4)	CS x (1/PEF) x IN x EF x ED x ET
				BW	Body Weight	70	kg	USEPA, 1991	BW x AT x CF1
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	30	years	USEPA, 1991	
				CF1	Conversion Factor 1	365	days/year	---	
		Child	Particulates	CS	Chemical Concentration in Soil	See site-specific EPC tables	mg/kg	See site-specific EPC tables	
				PEF	Particulate Emission Factor	Site-Specific PEF	m^3/kg	Site-Specific PEF	
				IN	Inhalation Rate	1	m^3/h	(5)	Potential (Lifetime) Average Daily Dose
				EF	Exposure Frequency	350	days/year	USEPA, 1991	$[(L)ADD_{pot}]$ (mg/kg-day) =
				ED	Exposure Duration	6	years	USEPA, 1991	
				ET	Exposure Time	1	hr/day	(6)	CS x (1/PEF) x IN x EF x ED x ET
				BW	Body Weight	15	kg	USEPA, 1991	BW x AT x CF1
				AT-C	Averaging Time (Cancer)	70	years	USEPA, 1991	
				AT-N	Averaging Time (Non-Cancer)	6	years	USEPA, 1991	
				CF1	Conversion Factor 1	365	days/year	---	

(1) The maintenance worker and excavation worker hourly inhalation rate was derived by dividing the adult's daily 20 m^3/day USEPA (1991) inhalation rate by 8 hours per day.
(2) Best professional judgement. Based on site maintenance/inspection activities conducted 1day/week and assuming 2 weeks on vacation.
(3) The adult resident hourly inhalation rate was derived by dividing the adult daily 20 m^3/day USEPA (1991) inhalation rate by 24 hours per day.
(4) Exposure time is based upon the average time an adult spends outdoors, assuming 1.5 hours/day (USEPA, 1997) with the exception of the three coldest months of the year.
(5) The child resident hourly inhalation rate was based on light activities (USEPA, 1997).
(6) Exposure time is based upon the assumption that children (ages 6 years and under) would be accompanied or supervised by an adult during time spent outdoors. Therefore, the exposure time for the child is is equivalent to the adult, i.e., an average time of 1.5 hours/day (USEPA, 1997) with the exception of the coldest months of the year.

USEPA, 1991: Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER 9285.6-03.
USEPA, 2001: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Peer Review Draft. OSWER 9355.4-24.

Table E-11
Cancer Toxicity Data - Oral/Dermal

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (1)	Absorbed Cancer Slope Factor for Dermal (2)		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source	Date (3) (MM/DD/YY)
Organics								
TCDD TE	1.5E+05	$(mg/kg\text{-}day)^{-1}$	100%	1.5E+05	$(mg/kg\text{-}day)^{-1}$	B2	HEAST	1997
Inorganics								
Aluminum	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	1.5E+00	$(mg/kg\text{-}day)^{-1}$	100%	1.5E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	10/5/04:4/10/98
Chromium (III)	N/A	N/A	N/A	N/A	N/A	D	IRIS	10/5/04:9/3/98
Copper	N/A	N/A	N/A	N/A	N/A	D	IRIS	10/5/04:8/1/91
Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese	N/A	N/A	N/A	N/A	N/A	D	IRIS	10/5/04:12/1/96
Thallium	N/A	N/A	N/A	N/A	N/A	D	IRIS	10/5/04:9/1/90
Vanadium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

(1) Source: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. Section 4.2 and Exhibit 4-1.

(2) The equation for deriving the adjusted dermal cancer slope factors are presented in the text.

(3) For IRIS values, the date IRIS was searched and the date of the most recent review are provided. For HEAST values, the date of HEAST is provided.

Definitions: N/A = Not Available
IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables

EPA Group:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

Table E-12
Non-Cancer Toxicity Data - Oral/Dermal

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral to Dermal Efficiency for Dermal (1)	Absorbed RfD for Dermal (2)		Primary Target Organ(s)	Combined Uncertainty/ Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Dates of RfD (3): (MM/DD/YY)
Organics										
TCDD TE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Inorganics										
Aluminum	Chronic	1E+00	mg/kg-day	27%	2.7E-01	mg/kg-day	Neurological Toxicity	100	PPRTV	10/5/04:7/26/01
Arsenic	Chronic	3E-04	mg/kg-day	100%	3.0E-04	mg/kg-day	Skin, Vascular Effects	3	IRIS	10/5/04:2/1/93
Chromium (III)	Chronic	1.5E+00	mg/kg-day	1.3%	2.0E-02	mg/kg-day	NOAEL	1,000	IRIS	10/5/04:9/3/98
Copper	Chronic	4E-02	mg/kg-day	100%	4.0E-02	mg/kg-day	GI Tract	N/A	HEAST	1997
Iron	Chronic	3E-01	mg/kg-day	100%	3.0E-01	mg/kg-day	Blood, Liver, GI Irritation	1	EPA, 2004; VDEQ, 2004; NCEA	4/14/04:4/25/04
Lead	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese (non-food)	Chronic	2.0E-02	mg/kg-day	4%	8.0E-04	mg/kg-day	CNS	1	IRIS	10/5/04:5/1/96
Thallium	Chronic	7E-05	mg/kg-day	100%	7.0E-05	mg/kg-day	Blood, Liver, Hair	3,000	EPA, 2004; VDEQ, 2004	4/14/04:4/25/04
Vanadium	Chronic	1E-03	mg/kg-day	2.6%	2.6E-05	mg/kg-day	Kidney	100	EPA, 2004; VDEQ, 2004; NCEA	4/14/04:4/25/04

(1) Source: Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. Section 4.2 and Exhibit 4-1.

(2) The equation used to derive the adjusted dermal RfD is presented in the text.

(3) For IRIS values, the date IRIS was searched and the date of the most recent review are provided. For NCEA values, the date of the article provided by NCEA is provided. For PPRTV values, the date the PPRTV database was searched and the date of the most recent review are provided.

Definitions:
N/A = Not Available
IRIS = Integrated Risk Information System
NCEA = National Center for Environmental Assessment
PPRTV = Provisional Peer-Reviewed Toxicity Values.
EPA, 2004 = EPA Region III April 14, 2004 RBC table.
VDEQ, 2004 = Virginia Department of Environmental Quality, Voluntary Remediation Program, Table 4.1, Non-Cancer Toxicity Data, April 25, 2004.

Table E-13
Cancer Toxicity Data - Inhalation

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk: Inhalation CSF	
	Value	Units	Value	Units		Source	Date (1) (MM/DD/YY)
Organics							
TCDD TE	3.30E-11	$(ug/m^3)^{-1}$	1.50E+05	$(mg/kg\text{-}day)^{-1}$	B2	HEAST	1997
Inorganics							
Aluminum	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	4.3E-03	$(ug/m^3)^{-1}$	1.5E+01	$(mg/kg\text{-}day)^{-1}$	A	IRIS	10/5/04:4/10/98
Chromium (III)	N/A	N/A	N/A	N/A	D	IRIS	10/5/04:9/3/98
Copper	N/A	N/A	N/A	N/A	D	IRIS	10/5/04:8/1/91
Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese	N/A	N/A	N/A	N/A	D	IRIS	10/5/04:12/1/96
Thallium	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vanadium	N/A	N/A	N/A	N/A	N/A	N/A	N/A

(1) For IRIS values, the date IRIS was searched and the date of the most recent review are provided.
For HEAST values, the date of HEAST is provided.

Definitions: N/A = Not Available
IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables

EPA Group:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

Table E-14
Non-Cancer Toxicity Data - Inhalation

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD (1)		Primary Target Organ (s)	Combined Uncertainty/ Modifying Factors	RfC:Target Organ(s)	
		Value	Units	Value	Units			Source(s) (2)	Dates of RfD: (MM/DD/YY)
Organics									
TCDD TE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Inorganics									
Aluminum	Chronic	5.0E-03	mg/m^3	1.4E-03	mg/kg-day	Neurological/Psychomotor and Cognitive Impairment	300	PPRTV	10/5/04:7/26/01
Arsenic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chromium (III) (3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Copper	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese	Chronic	5.0E-05	mg/m^3	1.43E-05	mg/kg-day	CNS	1,000	IRIS	10/5/04:12/1/93
Thallium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vanadium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

(1) The adjusted inhalation RfD was derived from the RfC value assuming a 70 kg adult inhales 20 m^3/day as follows: RfD = RfC * (20 m^3/day / 70 kg).

(2) For NCEA values, the date of the article provided by NCEA is provided.

(3) No inhalation RfC is available for chromium III.

Definitions: N/A = Not Available
NCEA = National Center for Environmental Assessment
PPRTV = Provisional Peer-Reviewed Toxicity Values
EPA, 2004 = EPA Region III April 14, 2004 RBC table.

TABLE E-15a
RAGS D ADULT LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Calculations of Blood Lead Concentrations - Surface Soil – Maintenance Worker

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	1,520	mg/kg	Average Detected Value	800	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 5/19/03
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Located in Appendix E, Table E-15b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Exposure point concentration was based on the arithmetic mean of lead concentrations in surface soil; See Appendix E
What was the point of exposure and location?	Surface Soil – SWMU 39
Where are the output values located in the risk assessment report?	Located in Appendix E, Table E-15b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix <Y>.	GSD = 2.2 as the midrange value of updated GSD values (2.1 to 2.3) from NHANES III (USEPA, 2002b)
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix <Y>	PbB_0 = 1.6 ug/dL as the midrange level of updated Pb_L values (1.5 to 1.7 ug/dL) from NHANES III (USEPA, 2002b)
Was the default exposure frequency (EF; 219 days/year) used?	Yes. Default value was used as a conservative estimate for intermittent maintenance activities (50 days/year)
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Discussion of parameters in Section 6.3.2 and Appendix E

3. Final Result

Medium	Result	Comment/RBRG [1]
Surface Soil	Input value of 1,520 ppm in soil results in 8.6% of receptors above a geometric mean blood lead =3.8 ug/dL. This is above the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead.	To be calculated for Corrective Measures Study (CMS).

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

Table E-15b

Calculations of Blood Lead Concentrations (PbBs)

Radford Army Ammunition Plant - SWMU 39 - Surface Soil

Maintenance Worker

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	PbB Equation[1] 2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1 GSDi = Hom	Using Equation 1 GSDi = Het	Using Equation 2 GSDi = Hom	Using Equation 2 GSDi = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	1520	1520	1520	1520
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.6	1.6	1.6	1.6
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**			**ug/dL**	**3.8**	**3.8**	**3.8**	**3.8**
$PbB_{fetal,\ 0.95}$	**95th percentile PbB among fetuses of adult workers**			**ug/dL**	**12.5**	**12.5**	**12.5**	**12.5**
PbB_t	**Target PbB level of concern (e.g., 10 ug/dL)**			**ug/dL**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**			**%**	**8.6%**	**8.6%**	**8.6%**	**8.6%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,\ 0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,\ 0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

6-41

TABLE E-16a
RAGS D ADULT LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Calculations of Blood Lead Concentrations - Total Soil – Maintenance Worker

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	1,060	mg/kg	Average Detected Value	800	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 5/19/03
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Located in Appendix E, Table E-16b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Exposure point concentration was based on the arithmetic mean of lead concentrations in total soil; See Appendix E
What was the point of exposure and location?	Total Soil – SWMU 39
Where are the output values located in the risk assessment report?	Located in Appendix E, Table E-16b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix <Y>.	GSD = 2.2 as the midrange value of updated GSD values (2.1 to 2.3) from NHANES III (USEPA, 2002b)
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix <Y>	PbB_0 = 1.6 ug/dL as the midrange level of updated PbB values (1.5 to 1.7 ug/dL) from NHANES III (USEPA, 2002b)
Was the default exposure frequency (EF; 219 days/year) used?	Yes. Default value was used as a conservative estimate for intermittent maintenance activities (50 days/year)
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Discussion of parameters in Section 6.3.2 and Appendix E

3. Final Result

Medium	Result	Comment/RBRG [1]
Total Soil	Input value of 1,060 ppm in soil results in 5.4% of receptors above a geometric mean blood lead = 3.1 ug/dL. This is above the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead.	To be calculated for Corrective Measures Study (CMS).

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

Table E-16b

Calculations of Blood Lead Concentrations (PbBs)

Radford Army Ammunition Plant - SWMU 39 - Total Soil

Maintenance Worker

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario Using Equation 1 GSDi = Hom	Using Equation 1 GSDi = Het	Using Equation 2 GSDi = Hom	Using Equation 2 GSDi = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	1,060	1,060	1,060	1,060
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.6	1.6	1.6	1.6
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**			**ug/dL**	**3.1**	**3.1**	**3.1**	**3.1**
$PbB_{fetal,0.95}$	**95th percentile PbB among fetuses of adult workers**			**ug/dL**	**10.3**	**10.3**	**10.3**	**10.3**
PbB_t	**Target PbB level of concern (e.g., 10 ug/dL)**			**ug/dL**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**			**%**	**5.4%**	**5.4%**	**5.4%**	**5.4%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE E-17a
RAGS D ADULT LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Calculations of Blood Lead Concentrations - Total Soil – Excavation Worker

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	1,060	mg/kg	Average Detected Value	800	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 5/19/03
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Located in Appendix E, Table E-17b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Exposure point concentration was based on the arithmetic mean of lead concentrations in total soil; See Appendix E
What was the point of exposure and location?	Total Soil – SWMU 39
Where are the output values located in the risk assessment report?	Located in Appendix E, Table E-17b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix <Y>.	GSD = 2.2 as the midrange value of updated GSD values (2.1 to 2.3) from NHANES III (USEPA, 2002b)
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix <Y>	PbB_0 = 1.6 ug/dL as the midrange level of updated PbB_0 values (1.5 to 1.7 ug/dL) from NHANES III (USEPA, 2002b)
Was the default exposure frequency (EF; 219 days/year) used?	EF = 250 days/year based on full-time exposure to soil during excavation (USEPA, 2004e)
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Discussion of parameters in Section 6.3.2 and Appendix E

3. Final Result

Medium	Result	Comment/RBRG [1]
Total Soil	Input value of 1,060 ppm in soil results in 16.1% of receptors above a geometric mean blood lead = 5.1 ug/dL. This is above the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead.	To be calculated for Corrective Measures Study (CMS).

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

Table E-17b

Calculations of Blood Lead Concentrations (PbBs)
Radford Army Ammunition Plant - SWMU 39 - Total Soil
Excavation Worker

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1 GSDi = Hom	Using Equation 1 GSDi = Het	Using Equation 2 GSDi = Hom	Using Equation 2 GSDi = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	1,060	1,060	1,060	1,060
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.6	1.6	1.6	1.6
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	0.100	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.100	0.100
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	250	250	250	250
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**			**ug/dL**	**5.1**	**5.1**	**5.1**	**5.1**
$PbB_{fetal,0.95}$	**95th percentile PbB among fetuses of adult workers**			**ug/dL**	**16.7**	**16.7**	**16.7**	**16.7**
PbB_t	**Target PbB level of concern (e.g., 10 ug/dL)**			**ug/dL**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**			**%**	**16.1%**	**16.1%**	**16.1%**	**16.1%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE E-18
RAGS D IEUBK LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Child (Age 0 – 84 Months), Exposure to Total Soil

1. Lead Screening Questions

Medium	Lead Concentration Used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	1,060	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level
Water	15	ug/L	Assumed Action Level	15	ug/L	Recommended Drinking Water Action Level

2. Lead Model Questions

Question	Response for Residential Lead Model
What lead model (version and date) was used?	Lead Model for Windows, Version 1.0 Build 261
Where are the input values located in the risk assessment report?	Located in Appendix E, IEUBKwin OUTPUT (Attached)
What range of media concentrations were used for the model?	Range of site concentrations: 10.1 – 16,500 mg/kg
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Arithmetic Mean Concentration; Data are Located in Appendix E
Was soil sample taken from top 2 cm? If not, why?	No – Future scenario based on assumption that soil would be disturbed. Surface and subsurface data sets were combined to represent total soil.
Was soil sample sieved? What size screen was used? If not sieved, provide rationale.	No -- Soil samples were collected for multiple analyses.
What was the point of exposure/location?	Total soil – SWMU 39
Where are the output values located in the risk assessment report?	IEUBKwin OUTPUT (Attached)
Was the model run using default values only?	No – Assumed site-specific arithmetic mean concentration of lead in soil and concentration of lead in drinking water at action level.
Was the default soil bioavailability used?	Yes -- Default is 30%
Was the default soil ingestion rate used?	Yes -- Default values for 7 age groups are 85, 135, 135, 100, 090, and 85 mg/day
If non-default values were used, where is the rationale for the values located in the risk assessment report?	Located in Appendix E

3. Final Result

Medium	Result	Comment/PRG [1]
Total Soil	Input value of 1,060 ppm in total soil results in 53.7% of children above a blood lead level of 10 ug/dL. Geometric mean blood lead = 10.44 ug/dL. This is above the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children exceeding 10 ug/dL blood lead.	To be calculated for Corrective Measures Study (CMS).

1. Attach the IEUBK text output file and graph upon which the PRG was based as an appendix. For additional information, see www.epa.gov/superfund/programs/lead

LEAD MODEL FOR WINDOWS Version 1.0

Model Version: 1.0 Build 261
User Name: Shaw Environmental, Inc.
Date: 10/8/2004
Site Name: Radford Army Ammunition Plant
Operable Unit: SWMU 39 - Total Soil
Run Mode: Site Risk Assessment

Soil/Dust Data
Total Soil - Arithmetic mean = 1,060 mg/kg
Water Data
Assumed action level = 15 ug/L

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 15.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 752.000 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	1060.000	752.000
1-2	1060.000	752.000
2-3	1060.000	752.000
3-4	1060.000	752.000
4-5	1060.000	752.000
5-6	1060.000	752.000
6-7	1060.000	752.000

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

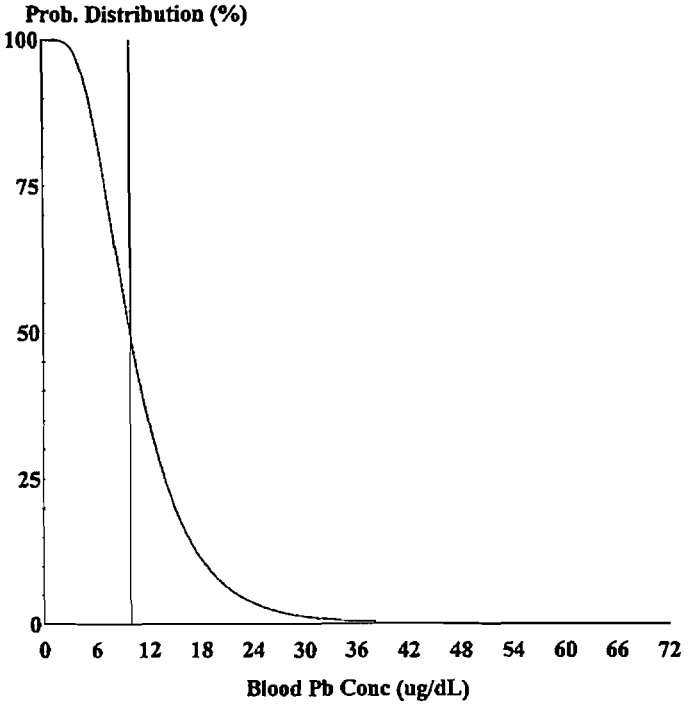
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.159	0.000	1.171
1-2	0.034	2.161	0.000	2.804
2-3	0.062	2.508	0.000	3.014
3-4	0.067	2.489	0.000	3.171
4-5	0.067	2.557	0.000	3.510
5-6	0.093	2.766	0.000	3.795
6-7	0.093	3.095	0.000	3.913

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	17.731	21.081	11.0
1-2	26.969	31.969	12.9
2-3	27.879	33.463	12.2
3-4	28.774	34.501	11.8
4-5	22.733	28.866	10.0
5-6	20.979	27.633	8.7
6-7	20.084	27.186	7.8



Cutoff = 10.000 ug/dl
Geo Mean = 10.444
GSD = 1.600
% Above = 53.685

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table E-19
Calculation of Chemical Cancer Risks
Reasonable Maximum Exposure
Current/Future - Maintenance Worker - Surface Soil

Scenario Timeframe: Current/Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
							Intake/Exposure Concentration		CSF/Unit Risk		
					Value	Units	Value	Units	Value	Units	Cancer Risk
Surface Soil	Surface Soil	SWMU 39	Ingestion	**Organics**							
				TCDD TE	2.07E-05	mg/kg	1.4E-12	mg/kg-day	1.5E+05	$(mg/kg-day)^{-1}$	2.2E-07
				Inorganics							
				Aluminum	2.58E+04	mg/kg	1.8E-03	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Arsenic	5.43E+00	mg/kg	3.8E-07	mg/kg-day	1.5E+00	$(mg/kg-day)^{-1}$	5.7E-07
				Chromium	4.68E+01	mg/kg	3.3E-06	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Copper	1.18E+02	mg/kg	8.2E-06	mg/kg-day	N/A	$(mg/kg-day)^{-2}$	---
				Iron	3.52E+04	mg/kg	2.5E-03	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Lead	1.28E+04	mg/kg	8.9E-04	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Manganese	8.12E+02	mg/kg	5.7E-05	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Thallium	4.28E+00	mg/kg	3.0E-07	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Vanadium	6.32E+01	mg/kg	4.4E-06	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
			Exp. Route Total								7.9E-07
			Dermal Absorption	**Organics**							
				TCDD TE	2.07E-05	mg/kg	2.9E-13	mg/kg-day	1.5E+05	$(mg/kg-day)^{-1}$	4.3E-08
				Inorganics							
				Aluminum	2.58E+04	mg/kg	1.2E-04	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Arsenic	5.43E+00	mg/kg	7.5E-08	mg/kg-day	1.5E+00	$(mg/kg-day)^{-1}$	1.1E-07
				Chromium	4.68E+01	mg/kg	2.2E-07	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Copper	1.18E+02	mg/kg	5.4E-07	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Iron	3.52E+04	mg/kg	1.6E-04	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Lead	1.28E+04	mg/kg	5.9E-05	mg/kg-day	N/A	$(mg/kg-day)^{-2}$	---
				Manganese	8.12E+02	mg/kg	3.7E-06	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Thallium	4.28E+00	mg/kg	2.0E-08	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Vanadium	6.32E+01	mg/kg	2.9E-07	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
			Exp. Route Total								1.6E-07
		Exposure Point Total									9.4E-07
	Exposure Media Total										9.4E-07
	Air	Particulates	Inhalation	**Organics**							
				TCDD TE	2.07E-05	mg/kg	4.8E-16	mg/kg-day	1.5E+05	$(mg/kg-day)^{-1}$	7.2E-11
				Inorganics							
				Aluminum	2.58E+04	mg/kg	5.9E-07	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Arsenic	5.43E+00	mg/kg	1.3E-10	mg/kg-day	1.5E+01	$(mg/kg-day)^{-1}$	1.9E-09
				Chromium	4.68E+01	mg/kg	1.1E-09	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Copper	1.18E+02	mg/kg	2.7E-09	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Iron	3.52E+04	mg/kg	8.1E-07	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Lead	1.28E+04	mg/kg	3.0E-07	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Manganese	8.12E+02	mg/kg	8.1E+02	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Thallium	4.28E+00	mg/kg	9.9E-11	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Vanadium	6.32E+01	mg/kg	1.5E-09	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
			Exp. Route Total								2.0E-09
		Exposure Point Total									2.0E-09
	Exposure Media Total										2.0E-09
Soil Total											9.4E-07
										Total of Receptor Risks Across All Media	9.4E-07

N/A = Not Applicable.

Table E-20
Calculation of Chemical Cancer Risks
Reasonable Maximum Exposure
Future - Maintenance Worker - Total Soil

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
							Intake/Exposure Concentration		CSF/Unit Risk		
					Value	Units	Value	Units	Value	Units	Cancer Risk
Total Soil	Total Soil	SWMU 39	**Ingestion**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	1.4E-12	mg/kg-day	1.5E+05	$(mg/kg\text{-}day)^{-1}$	2.2E-07
				Inorganics							
				Aluminum	2.52E+04	mg/kg	1.8E-03	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	3.0E-07	mg/kg-day	1.5E+00	$(mg/kg\text{-}day)^{-1}$	4.5E-07
				Chromium	4.26E+01	mg/kg	3.0E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Copper	8.93E+01	mg/kg	6.2E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Iron	3.42E+04	mg/kg	2.4E-03	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Lead	1.71E+03	mg/kg	1.2E-04	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	4.3E-05	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	2.2E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	4.4E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
			Exp. Route Total								6.7E-07
			Dermal Absorption	**Organics**							
				TCDD TE	2.07E-05	mg/kg	2.9E-13	mg/kg-day	1.5E+05	$(mg/kg\text{-}day)^{-1}$	4.3E-08
				Inorganics							
				Aluminum	2.52E+04	mg/kg	1.2E-04	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	6.0E-08	mg/kg-day	1.5E+00	$(mg/kg\text{-}day)^{-1}$	9.0E-08
				Chromium	4.26E+01	mg/kg	2.0E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Copper	8.93E+01	mg/kg	4.1E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Iron	3.42E+04	mg/kg	1.6E-04	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Lead	1.71E+03	mg/kg	7.9E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	2.9E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	1.4E-08	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	2.9E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
			Exp. Route Total								1.3E-07
		Exposure Point Total									8.0E-07
	Exposure Media Total										8.0E-07
	Air	Particulates	**Inhalation**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	4.8E-16	mg/kg-day	1.5E+05	$(mg/kg\text{-}day)^{-1}$	7.2E-11
				Inorganics							
				Aluminum	2.52E+04	mg/kg	5.8E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	1.0E-10	mg/kg-day	1.5E+01	$(mg/kg\text{-}day)^{-1}$	1.5E-09
				Chromium	4.26E+01	mg/kg	9.8E-10	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Copper	8.93E+01	mg/kg	2.1E-09	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Iron	3.42E+04	mg/kg	7.9E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Lead	1.71E+03	mg/kg	3.9E-08	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	1.4E-08	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	7.1E-11	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	1.5E-09	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
			Exp. Route Total								1.6E-09
		Exposure Point Total									1.6E-09
	Exposure Media Total										1.6E-09
Soil Total											8.1E-07
										Total of Receptor Risks Across All Media	8.1E-07

N/A = Not Applicable.

Table E-21
Calculation of Chemical Cancer Risks
Reasonable Maximum Exposure
Future - Excavation Worker - Total Soil

Scenario Timeframe: Future
Receptor Population: Excavation Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
							Intake/Exposure Concentration		CSF/Unit Risk		
					Value	Units	Value	Units	Value	Units	Cancer Risk
Total Soil	Total Soil	SWMU 39	**Ingestion**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	9.5E-13	mg/kg-day	1.5E+05	$(mg/kg\text{-}day)^{-1}$	1.4E-07
				Inorganics							
				Aluminum	2.52E+04	mg/kg	1.2E-03	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	2.0E-07	mg/kg-day	1.5E+00	$(mg/kg\text{-}day)^{-1}$	3.0E-07
				Chromium	4.26E+01	mg/kg	2.0E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Copper	8.93E+01	mg/kg	4.1E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Iron	3.42E+04	mg/kg	1.6E-03	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Lead	1.71E+03	mg/kg	7.9E-05	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	2.9E-05	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	1.4E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	2.9E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
			Exp. Route Total								4.4E-07
			Dermal Absorption	**Organics**							
				TCDD TE	2.07E-05	mg/kg	8.6E-14	mg/kg-day	1.5E+05	$(mg/kg\text{-}day)^{-1}$	1.3E-08
				Inorganics							
				Aluminum	2.52E+04	mg/kg	3.5E-05	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	1.8E-08	mg/kg-day	1.5E+00	$(mg/kg\text{-}day)^{-1}$	2.7E-08
				Chromium	4.26E+01	mg/kg	5.9E-08	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Copper	8.93E+01	mg/kg	1.2E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Iron	3.42E+04	mg/kg	4.7E-05	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Lead	1.71E+03	mg/kg	2.4E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	8.6E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	4.3E-09	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	8.7E-08	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
			Exp. Route Total								4.0E-08
		Exposure Point Total									4.8E-07
	Exposure Media Total										4.8E-07
	Air	Particulates	**Inhalation**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	9.5E-17	mg/kg-day	1.5E+05	$(mg/kg\text{-}day)^{-1}$	1.4E-11
				Inorganics							
				Aluminum	2.52E+04	mg/kg	1.2E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	2.0E-11	mg/kg-day	1.5E+01	$(mg/kg\text{-}day)^{-1}$	3.0E-10
				Chromium	4.26E+01	mg/kg	2.0E-10	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Copper	8.93E+01	mg/kg	4.1E-10	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Iron	3.42E+04	mg/kg	1.6E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Lead	1.71E+03	mg/kg	7.9E-09	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	2.9E-09	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	1.4E-11	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	2.9E-10	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
			Exp. Route Total								3.2E-10
		Exposure Point Total									3.2E-10
	Exposure Media Total										3.2E-10
Soil Total											4.8E-07
										Total of Receptor Risks Across All Media	4.8E-07

N/A = Not Applicable.

Table E-22
Calculation of Chemical Cancer Risks
Reasonable Maximum Exposure
Future - Adult Resident - Total Soil

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
							Intake/Exposure Concentration		CSF/Unit Risk		
					Value	Units	Value	Units	Value	Units	Cancer Risk
Total Soil	Total Soil	SWMU 39	**Ingestion**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	1.2E-11	mg/kg-day	1.5E+05	$(mg/kg\text{-}day)^{-1}$	1.8E-06
				Inorganics							
				Aluminum	2.52E+04	mg/kg	1.5E-02	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	2.5E-06	mg/kg-day	1.5E+00	$(mg/kg\text{-}day)^{-1}$	3.8E-06
				Chromium	4.26E+01	mg/kg	2.5E-05	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Copper	8.93E+01	mg/kg	5.2E-05	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Iron	3.42E+04	mg/kg	2.0E-02	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Lead	1.71E+03	mg/kg	1.0E-03	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	3.6E-04	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	1.8E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	3.7E-05	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
			Exp. Route Total								5.6E-06
			Dermal Absorption	**Organics**							
				TCDD TE	2.07E-05	mg/kg	1.5E-12	mg/kg-day	1.5E+05	$(mg/kg\text{-}day)^{-1}$	2.2E-07
				Inorganics							
				Aluminum	2.52E+04	mg/kg	5.9E-04	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	3.0E-07	mg/kg-day	1.5E+00	$(mg/kg\text{-}day)^{-1}$	4.6E-07
				Chromium	4.26E+01	mg/kg	1.0E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Copper	8.93E+01	mg/kg	2.1E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Iron	3.42E+04	mg/kg	8.0E-04	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Lead	1.71E+03	mg/kg	4.0E-05	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	1.4E-05	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	7.3E-08	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	1.5E-06	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
			Exp. Route Total								6.7E-07
		Exposure Point Total									6.3E-06
	Exposure Media Total										6.3E-06
	Air	Particulates	**Inhalation**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	1.7E-16	mg/kg-day	1.5E+05	$(mg/kg\text{-}day)^{-1}$	2.5E-11
				Inorganics							
				Aluminum	2.52E+04	mg/kg	2.0E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	3.5E-11	mg/kg-day	1.5E+01	$(mg/kg\text{-}day)^{-1}$	5.3E-10
				Chromium	4.26E+01	mg/kg	3.4E-10	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Copper	8.93E+01	mg/kg	7.2E-10	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Iron	3.42E+04	mg/kg	2.7E-07	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Lead	1.71E+03	mg/kg	1.4E-08	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	5.0E-09	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	2.5E-11	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	5.1E-10	mg/kg-day	N/A	$(mg/kg\text{-}day)^{-1}$	---
			Exp. Route Total								5.5E-10
		Exposure Point Total									5.5E-10
	Exposure Media Total										5.5E-10
Soil Total											6.3E-06
										Total of Receptor Risks Across All Media	6.3E-06

N/A = Not Applicable.

Table E-23
Calculation of Chemical Cancer Risks
Reasonable Maximum Exposure
Future - Child Resident - Total Soil

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations				
							Intake/Exposure Concentration		CSF/Unit Risk		
					Value	Units	Value	Units	Value	Units	Cancer Risk
Total Soil	Total Soil	SWMU 39	Ingestion	**Organics**							
				TCDD TE	2.07E-05	mg/kg	2.3E-11	mg/kg-day	1.5E+05	$(mg/kg-day)^{-1}$	3.4E-06
				Inorganics							
				Aluminum	2.52E+04	mg/kg	2.8E-02	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	4.7E-06	mg/kg-day	1.5E+00	$(mg/kg-day)^{-1}$	7.1E-06
				Chromium	4.26E+01	mg/kg	4.7E-05	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Copper	8.93E+01	mg/kg	9.8E-05	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Iron	3.42E+04	mg/kg	3.7E-02	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Lead	1.71E+03	mg/kg	1.9E-03	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	6.8E-04	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	3.4E-06	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	6.9E-05	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
			Exp. Route Total								1.1E-05
			Dermal Absorption	**Organics**							
				TCDD TE	2.07E-05	mg/kg	1.9E-12	mg/kg-day	1.5E+05	$(mg/kg-day)^{-1}$	2.9E-07
				Inorganics							
				Aluminum	2.52E+04	mg/kg	7.7E-04	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	4.0E-07	mg/kg-day	1.5E+00	$(mg/kg-day)^{-1}$	6.0E-07
				Chromium	4.26E+01	mg/kg	1.3E-06	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Copper	8.93E+01	mg/kg	2.7E-06	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Iron	3.42E+04	mg/kg	1.0E-03	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Lead	1.71E+03	mg/kg	5.2E-05	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	1.9E-05	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	9.5E-08	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	1.9E-06	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
			Exp. Route Total								8.8E-07
		Exposure Point Total									1.1E-05
	Exposure Media Total										1.1E-05
	Air	Particulates	Inhalation	**Organics**							
				TCDD TE	2.07E-05	mg/kg	1.9E-16	mg/kg-day	1.5E+05	$(mg/kg-day)^{-1}$	2.8E-11
				Inorganics							
				Aluminum	2.52E+04	mg/kg	2.3E-07	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Arsenic	4.33E+00	mg/kg	3.9E-11	mg/kg-day	1.5E+01	$(mg/kg-day)^{-1}$	5.9E-10
				Chromium	4.26E+01	mg/kg	3.8E-10	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Copper	8.93E+01	mg/kg	8.1E-10	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Iron	3.42E+04	mg/kg	3.1E-07	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Lead	1.71E+03	mg/kg	1.5E-08	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Manganese	6.19E+02	mg/kg	5.6E-09	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Thallium	3.10E+00	mg/kg	2.8E-11	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
				Vanadium	6.31E+01	mg/kg	5.7E-10	mg/kg-day	N/A	$(mg/kg-day)^{-1}$	---
			Exp. Route Total								6.2E-10
		Exposure Point Total									6.2E-10
	Exposure Media Total										6.2E-10
Soil Total											1.1E-05
										Total of Receptor Risks Across All Media	1.1E-05

N/A = Not Applicable.

Table E-24
Calculation of Non-cancer Hazards
Reasonable Maximum Exposure
Current/Future - Maintenance Worker - Surface Soil

Scenario Timeframe: Current/Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
							Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
					Value	Units	Value	Units	Value	Units	
Surface Soil	Surface Soil	SWMU 39	**Ingestion**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	4.1E-12	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.58E+04	mg/kg	5.0E-03	mg/kg-day	1.0E+00	mg/kg-day	5.0E-03
				Arsenic	5.43E+00	mg/kg	1.1E-06	mg/kg-day	3.0E-04	mg/kg-day	3.5E-03
				Chromium	4.68E+01	mg/kg	9.2E-06	mg/kg-day	1.5E+00	mg/kg-day	6.1E-06
				Copper	1.18E+02	mg/kg	2.3E-05	mg/kg-day	4.0E-02	mg/kg-day	5.8E-04
				Iron	3.52E+04	mg/kg	6.9E-03	mg/kg-day	3.0E-01	mg/kg-day	2.3E-02
				Lead	1.28E+04	mg/kg	2.5E-03	mg/kg-day	N/A	mg/kg-day	---
				Manganese	8.12E+02	mg/kg	1.6E-04	mg/kg-day	2.0E-02	mg/kg-day	7.9E-03
				Thallium	4.28E+00	mg/kg	8.4E-07	mg/kg-day	7.0E-05	mg/kg-day	1.2E-02
				Vanadium	6.32E+01	mg/kg	1.2E-05	mg/kg-day	1.0E-03	mg/kg-day	1.2E-02
			Exp. Route Total								6.4E-02
			Dermal Absorption	**Organics**							
				TCDD TE	2.07E-05	mg/kg	8.0E-13	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.58E+04	mg/kg	3.3E-04	mg/kg-day	2.7E-01	mg/kg-day	1.2E-03
				Arsenic	5.43E+00	mg/kg	2.1E-07	mg/kg-day	3.0E-04	mg/kg-day	7.0E-04
				Chromium	4.68E+01	mg/kg	6.0E-07	mg/kg-day	2.0E-02	mg/kg-day	3.1E-05
				Copper	1.18E+02	mg/kg	1.5E-06	mg/kg-day	4.0E-02	mg/kg-day	3.8E-05
				Iron	3.52E+04	mg/kg	4.5E-04	mg/kg-day	3.0E-01	mg/kg-day	1.5E-03
				Lead	1.28E+04	mg/kg	1.7E-04	mg/kg-day	N/A	mg/kg-day	---
				Manganese	8.12E+02	mg/kg	1.0E-05	mg/kg-day	8.0E-04	mg/kg-day	1.3E-02
				Thallium	4.28E+00	mg/kg	5.5E-08	mg/kg-day	7.0E-05	mg/kg-day	7.9E-04
				Vanadium	6.32E+01	mg/kg	8.2E-07	mg/kg-day	2.6E-05	mg/kg-day	3.1E-02
			Exp. Route Total								4.9E-02
		Exposure Point Total									1.1E-01
	Exposure Media Total										1.1E-01
	Air	Particulates	**Inhalation**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	1.3E-15	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.58E+04	mg/kg	1.7E-06	mg/kg-day	1.4E-03	mg/kg-day	1.2E-03
				Arsenic	5.43E+00	mg/kg	3.5E-10	mg/kg-day	N/A	mg/kg-day	---
				Chromium	4.68E+01	mg/kg	3.0E-09	mg/kg-day	N/A	mg/kg-day	---
				Copper	1.18E+02	mg/kg	7.6E-09	mg/kg-day	N/A	mg/kg-day	---
				Iron	3.52E+04	mg/kg	2.3E-06	mg/kg-day	N/A	mg/kg-day	---
				Lead	1.28E+04	mg/kg	8.3E-07	mg/kg-day	N/A	mg/kg-day	---
				Manganese	8.12E+02	mg/kg	5.2E-08	mg/kg-day	1.4E-05	mg/kg-day	3.7E-03
				Thallium	4.28E+00	mg/kg	2.8E-10	mg/kg-day	N/A	mg/kg-day	---
				Vanadium	6.32E+01	mg/kg	4.1E-09	mg/kg-day	N/A	mg/kg-day	---
			Exp. Route Total								4.9E-03
		Exposure Point Total									4.9E-03
	Exposure Media Total										4.9E-03
Soil Total											1.2E-01
										Total of Receptor Hazards Across All Media	1.2E-01

N/A = Not Applicable.

Table E-25
Calculation of Non-cancer Hazards
Reasonable Maximum Exposure
Future - Maintenance Worker - Total Soil

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
							Intake/Exposure Concentration		RfD/RfC		Hazard
					Value	Units	Value	Units	Value	Units	Quotient
Total Soil	Total Soil	SWMU 39	Ingestion	**Organics**							
				TCDD TE	2.07E-05	mg/kg	4.1E-12	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	4.9E-03	mg/kg-day	1.0E+00	mg/kg-day	4.9E-03
				Arsenic	4.33E+00	mg/kg	8.5E-07	mg/kg-day	3.0E-04	mg/kg-day	2.8E-03
				Chromium	4.26E+01	mg/kg	8.3E-06	mg/kg-day	1.5E+00	mg/kg-day	5.6E-06
				Copper	8.93E+01	mg/kg	1.7E-05	mg/kg-day	4.0E-02	mg/kg-day	4.4E-04
				Iron	3.42E+04	mg/kg	6.7E-03	mg/kg-day	3.0E-01	mg/kg-day	2.2E-02
				Lead	1.71E+03	mg/kg	3.3E-04	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	1.2E-04	mg/kg-day	2.0E-02	mg/kg-day	6.1E-03
				Thallium	3.10E+00	mg/kg	6.1E-07	mg/kg-day	7.0E-05	mg/kg-day	8.7E-03
				Vanadium	6.31E+01	mg/kg	1.2E-05	mg/kg-day	1.0E-03	mg/kg-day	1.2E-02
			Exp. Route Total								5.8E-02
			Dermal Absorption	**Organics**							
				TCDD TE	2.07E-05	mg/kg	8.0E-13	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	3.3E-04	mg/kg-day	2.7E-01	mg/kg-day	1.2E-03
				Arsenic	4.33E+00	mg/kg	1.7E-07	mg/kg-day	3.0E-04	mg/kg-day	5.6E-04
				Chromium	4.26E+01	mg/kg	5.5E-07	mg/kg-day	2.0E-02	mg/kg-day	2.8E-05
				Copper	8.93E+01	mg/kg	1.2E-06	mg/kg-day	4.0E-02	mg/kg-day	2.9E-05
				Iron	3.42E+04	mg/kg	4.4E-04	mg/kg-day	3.0E-01	mg/kg-day	1.5E-03
				Lead	1.71E+03	mg/kg	2.2E-05	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	8.0E-06	mg/kg-day	8.0E-04	mg/kg-day	1.0E-02
				Thallium	3.10E+00	mg/kg	4.0E-08	mg/kg-day	7.0E-05	mg/kg-day	5.7E-04
				Vanadium	6.31E+01	mg/kg	8.1E-07	mg/kg-day	2.6E-05	mg/kg-day	3.1E-02
			Exp. Route Total								4.5E-02
		Exposure Point Total									1.0E-01
	Exposure Media Total										1.0E-01
	Air	Particulates	Inhalation	**Organics**							
				TCDD TE	2.07E-05	mg/kg	1.3E-15	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	1.6E-06	mg/kg-day	1.4E-03	mg/kg-day	1.2E-03
				Arsenic	4.33E+00	mg/kg	2.8E-10	mg/kg-day	N/A	mg/kg-day	---
				Chromium	4.26E+01	mg/kg	2.7E-09	mg/kg-day	N/A	mg/kg-day	---
				Copper	8.93E+01	mg/kg	5.8E-09	mg/kg-day	N/A	mg/kg-day	---
				Iron	3.42E+04	mg/kg	2.2E-06	mg/kg-day	N/A	mg/kg-day	---
				Lead	1.71E+03	mg/kg	1.1E-07	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	4.0E-08	mg/kg-day	1.4E-05	mg/kg-day	2.8E-03
				Thallium	3.10E+00	mg/kg	2.0E-10	mg/kg-day	N/A	mg/kg-day	---
				Vanadium	6.31E+01	mg/kg	4.1E-09	mg/kg-day	N/A	mg/kg-day	---
			Exp. Route Total								4.0E-03
		Exposure Point Total									4.0E-03
	Exposure Media Total										4.0E-03
Soil Total											1.1E-01
										Total of Receptor Hazards Across All Media	1.1E-01

N/A = Not Applicable.

Table E-26
Calculation of Non-cancer Hazards
Reasonable Maximum Exposure
Future - Excavation Worker - Total Soil

Scenario Timeframe: Future
Receptor Population: Excavation Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
							Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
					Value	Units	Value	Units	Value	Units	
Total Soil	Total Soil	SWMU 39	**Ingestion**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	6.7E-11	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	8.1E-02	mg/kg-day	1.0E+00	mg/kg-day	8.1E-02
				Arsenic	4.33E+00	mg/kg	1.4E-05	mg/kg-day	3.0E-04	mg/kg-day	4.7E-02
				Chromium	4.26E+01	mg/kg	1.4E-04	mg/kg-day	1.5E+00	mg/kg-day	9.2E-05
				Copper	8.93E+01	mg/kg	2.9E-04	mg/kg-day	4.0E-02	mg/kg-day	7.2E-03
				Iron	3.42E+04	mg/kg	1.1E-01	mg/kg-day	3.0E-01	mg/kg-day	3.7E-01
				Lead	1.71E+03	mg/kg	5.5E-03	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	2.0E-03	mg/kg-day	2.0E-02	mg/kg-day	1.0E-01
				Thallium	3.10E+00	mg/kg	1.0E-05	mg/kg-day	7.0E-05	mg/kg-day	1.4E-01
				Vanadium	6.31E+01	mg/kg	2.0E-04	mg/kg-day	1.0E-03	mg/kg-day	2.0E-01
			Exp. Route Total								9.5E-01
			Dermal Absorption	**Organics**							
				TCDD TE	2.07E-05	mg/kg	6.0E-12	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	2.4E-03	mg/kg-day	2.7E-01	mg/kg-day	9.0E-03
				Arsenic	4.33E+00	mg/kg	1.3E-06	mg/kg-day	3.0E-04	mg/kg-day	4.2E-03
				Chromium	4.26E+01	mg/kg	4.1E-06	mg/kg-day	2.0E-02	mg/kg-day	2.1E-04
				Copper	8.93E+01	mg/kg	8.7E-06	mg/kg-day	4.0E-02	mg/kg-day	2.2E-04
				Iron	3.42E+04	mg/kg	3.3E-03	mg/kg-day	3.0E-01	mg/kg-day	1.1E-02
				Lead	1.71E+03	mg/kg	1.7E-04	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	6.0E-05	mg/kg-day	8.0E-04	mg/kg-day	7.5E-02
				Thallium	3.10E+00	mg/kg	3.0E-07	mg/kg-day	7.0E-05	mg/kg-day	4.3E-03
				Vanadium	6.31E+01	mg/kg	6.1E-06	mg/kg-day	2.6E-05	mg/kg-day	2.4E-01
			Exp. Route Total								3.4E-01
		Exposure Point Total									1.3E+00
	Exposure Media Total										1.3E+00
	Air	Particulates	**Inhalation**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	6.7E-15	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	8.1E-06	mg/kg-day	1.4E-03	mg/kg-day	5.8E-03
				Arsenic	4.33E+00	mg/kg	1.4E-09	mg/kg-day	N/A	mg/kg-day	---
				Chromium	4.26E+01	mg/kg	1.4E-08	mg/kg-day	N/A	mg/kg-day	---
				Copper	8.93E+01	mg/kg	2.9E-08	mg/kg-day	N/A	mg/kg-day	---
				Iron	3.42E+04	mg/kg	1.1E-05	mg/kg-day	N/A	mg/kg-day	---
				Lead	1.71E+03	mg/kg	5.5E-07	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	2.0E-07	mg/kg-day	1.4E-05	mg/kg-day	1.4E-02
				Thallium	3.10E+00	mg/kg	1.0E-09	mg/kg-day	N/A	mg/kg-day	---
				Vanadium	6.31E+01	mg/kg	2.0E-08	mg/kg-day	N/A	mg/kg-day	---
			Exp. Route Total								2.0E-02
		Exposure Point Total									2.0E-02
	Exposure Media Total										2.0E-02
Soil Total											1.3E+00
										Total of Receptor Hazards Across All Media	1.3E+00

N/A = Not Applicable.

Table E-27
Calculation of Non-cancer Hazards
Reasonable Maximum Exposure
Future - Adult Resident - Total Soil

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
							Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
					Value	Units	Value	Units	Value	Units	
Total Soil	Total Soil	SWMU 39	**Ingestion**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	2.8E-11	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	3.5E-02	mg/kg-day	1.0E+00	mg/kg-day	3.5E-02
				Arsenic	4.33E+00	mg/kg	5.9E-06	mg/kg-day	3.0E-04	mg/kg-day	2.0E-02
				Chromium	4.26E+01	mg/kg	5.8E-05	mg/kg-day	1.5E+00	mg/kg-day	3.9E-05
				Copper	8.93E+01	mg/kg	1.2E-04	mg/kg-day	4.0E-02	mg/kg-day	3.1E-03
				Iron	3.42E+04	mg/kg	4.7E-02	mg/kg-day	3.0E-01	mg/kg-day	1.6E-01
				Lead	1.71E+03	mg/kg	2.3E-03	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	8.5E-04	mg/kg-day	2.0E-02	mg/kg-day	4.2E-02
				Thallium	3.10E+00	mg/kg	4.2E-06	mg/kg-day	7.0E-05	mg/kg-day	6.1E-02
				Vanadium	6.31E+01	mg/kg	8.6E-05	mg/kg-day	1.0E-03	mg/kg-day	8.6E-02
			Exp. Route Total								4.0E-01
			Dermal Absorption	**Organics**							
				TCDD TE	2.07E-05	mg/kg	3.4E-12	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	1.4E-03	mg/kg-day	2.7E-01	mg/kg-day	5.1E-03
				Arsenic	4.33E+00	mg/kg	7.1E-07	mg/kg-day	3.0E-04	mg/kg-day	2.4E-03
				Chromium	4.26E+01	mg/kg	2.3E-06	mg/kg-day	2.0E-02	mg/kg-day	1.2E-04
				Copper	8.93E+01	mg/kg	4.9E-06	mg/kg-day	4.0E-02	mg/kg-day	1.2E-04
				Iron	3.42E+04	mg/kg	1.9E-03	mg/kg-day	3.0E-01	mg/kg-day	6.2E-03
				Lead	1.71E+03	mg/kg	9.3E-05	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	3.4E-05	mg/kg-day	8.0E-04	mg/kg-day	4.2E-02
				Thallium	3.10E+00	mg/kg	1.7E-07	mg/kg-day	7.0E-05	mg/kg-day	2.4E-03
				Vanadium	6.31E+01	mg/kg	3.4E-06	mg/kg-day	2.6E-05	mg/kg-day	1.3E-01
			Exp. Route Total								1.9E-01
		Exposure Point Total									5.9E-01
	Exposure Media Total										5.9E-01
	Air	Particulates	**Inhalation**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	3.9E-16	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	4.7E-07	mg/kg-day	1.4E-03	mg/kg-day	3.4E-04
				Arsenic	4.33E+00	mg/kg	8.1E-11	mg/kg-day	N/A	mg/kg-day	---
				Chromium	4.26E+01	mg/kg	8.0E-10	mg/kg-day	N/A	mg/kg-day	---
				Copper	8.93E+01	mg/kg	1.7E-09	mg/kg-day	N/A	mg/kg-day	---
				Iron	3.42E+04	mg/kg	6.4E-07	mg/kg-day	N/A	mg/kg-day	---
				Lead	1.71E+03	mg/kg	3.2E-08	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	1.2E-08	mg/kg-day	1.4E-05	mg/kg-day	8.1E-04
				Thallium	3.10E+00	mg/kg	5.8E-11	mg/kg-day	N/A	mg/kg-day	---
				Vanadium	6.31E+01	mg/kg	1.2E-09	mg/kg-day	N/A	mg/kg-day	---
			Exp. Route Total								1.1E-03
		Exposure Point Total									1.1E-03
	Exposure Media Total										1.1E-03
Soil Total											6.0E-01
										Total of Receptor Hazards Across All Media	6.0E-01

N/A = Not Applicable.

Table E-28
Calculation of Non-cancer Hazards
Reasonable Maximum Exposure
Future - Child Resident - Total Soil

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Non-Cancer Hazard Calculations				
							Intake/Exposure Concentration		RfD/RfC		Hazard
					Value	Units	Value	Units	Value	Units	Quotient
Total Soil	Total Soil	SWMU 39	**Ingestion**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	2.6E-10	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	3.2E-01	mg/kg-day	1.0E+00	mg/kg-day	3.2E-01
				Arsenic	4.33E+00	mg/kg	5.5E-05	mg/kg-day	3.0E-04	mg/kg-day	1.8E-01
				Chromium	4.26E+01	mg/kg	5.4E-04	mg/kg-day	1.5E+00	mg/kg-day	3.6E-04
				Copper	8.93E+01	mg/kg	1.1E-03	mg/kg-day	4.0E-02	mg/kg-day	2.9E-02
				Iron	3.42E+04	mg/kg	4.4E-01	mg/kg-day	3.0E-01	mg/kg-day	1.5E+00
				Lead	1.71E+03	mg/kg	2.2E-02	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	7.9E-03	mg/kg-day	2.0E-02	mg/kg-day	4.0E-01
				Thallium	3.10E+00	mg/kg	4.0E-05	mg/kg-day	7.0E-05	mg/kg-day	5.7E-01
				Vanadium	6.31E+01	mg/kg	8.1E-04	mg/kg-day	1.0E-03	mg/kg-day	8.1E-01
			Exp. Route Total								3.8E+00
			Dermal Absorption	**Organics**							
				TCDD TE	2.07E-05	mg/kg	2.2E-11	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	9.0E-03	mg/kg-day	2.7E-01	mg/kg-day	3.3E-02
				Arsenic	4.33E+00	mg/kg	4.7E-06	mg/kg-day	3.0E-04	mg/kg-day	1.6E-02
				Chromium	4.26E+01	mg/kg	1.5E-05	mg/kg-day	2.0E-02	mg/kg-day	7.8E-04
				Copper	8.93E+01	mg/kg	3.2E-05	mg/kg-day	4.0E-02	mg/kg-day	8.0E-04
				Iron	3.42E+04	mg/kg	1.2E-02	mg/kg-day	3.0E-01	mg/kg-day	4.1E-02
				Lead	1.71E+03	mg/kg	6.1E-04	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	2.2E-04	mg/kg-day	8.0E-04	mg/kg-day	2.8E-01
				Thallium	3.10E+00	mg/kg	1.1E-06	mg/kg-day	7.0E-05	mg/kg-day	1.6E-02
				Vanadium	6.31E+01	mg/kg	2.3E-05	mg/kg-day	2.6E-05	mg/kg-day	8.7E-01
			Exp. Route Total								1.3E+00
		Exposure Point Total									5.0E+00
	Exposure Media Total										5.0E+00
	Air	Particulates	**Inhalation**	**Organics**							
				TCDD TE	2.07E-05	mg/kg	2.2E-15	mg/kg-day	N/A	mg/kg-day	---
				Inorganics							
				Aluminum	2.52E+04	mg/kg	2.7E-06	mg/kg-day	1.4E-03	mg/kg-day	1.9E-03
				Arsenic	4.33E+00	mg/kg	4.6E-10	mg/kg-day	N/A	mg/kg-day	---
				Chromium	4.26E+01	mg/kg	4.5E-09	mg/kg-day	N/A	mg/kg-day	---
				Copper	8.93E+01	mg/kg	9.4E-09	mg/kg-day	N/A	mg/kg-day	---
				Iron	3.42E+04	mg/kg	3.6E-06	mg/kg-day	N/A	mg/kg-day	---
				Lead	1.71E+03	mg/kg	1.8E-07	mg/kg-day	N/A	mg/kg-day	---
				Manganese	6.19E+02	mg/kg	6.5E-08	mg/kg-day	1.4E-05	mg/kg-day	4.6E-03
				Thallium	3.10E+00	mg/kg	3.3E-10	mg/kg-day	N/A	mg/kg-day	---
				Vanadium	6.31E+01	mg/kg	6.7E-09	mg/kg-day	N/A	mg/kg-day	---
			Exp. Route Total								6.5E-03
		Exposure Point Total									6.5E-03
	Exposure Media Total										6.5E-03
Soil Total											5.0E+00
									Total of Receptor Hazards Across All Media		5.0E+00

N/A = Not Applicable.

Table E-29
Summary of Exposure Risks and Hazards for COPCs
Reasonable Maximum Exposure
Current - Maintenance Worker

Scenario Timeframe: Current
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	SWMU 39	TCDD TE	2.2E-07		4.3E-08		2.6E-07	N/A	---		---	---
			Aluminum	---		---		---	Neurological Toxicity	5.0E-03		1.2E-03	6.3E-03
			Arsenic	5.7E-07		1.1E-07		6.8E-07	Skin, Vascular Effects	3.5E-03		7.0E-04	4.2E-03
			Chromium[a]	---		---		---	NOAEL	6.1E-06		3.1E-05	3.7E-05
			Copper	---		---		---	GI Tract	5.8E-04		3.8E-05	6.2E-04
			Iron	---		---		---	Blood, Liver, GI Irritation	2.3E-02		1.5E-03	2.4E-02
			Lead	---		---		---	N/A	---		---	---
			Manganese	---		---		---	CNS	7.9E-03		1.3E-02	2.1E-02
			Thallium	---		---		---	Blood, Liver, Hair	1.2E-02		7.9E-04	1.3E-02
			Vanadium	---		---		---	Kidney	1.2E-02		3.1E-02	4.4E-02
			Chemical Total	7.9E-07		1.6E-07		9.4E-07		0.064		0.049	0.11
			Radionuclide Total										
		Exposure Point Total						9.4E-07					0.11
	Exposure Media Total							9.4E-07					0.11
	Air (Particulates)	SWMU 39	TCDD TE		7.2E-11			7.2E-11	N/A		---		---
			Aluminum		---			---	Neurological/Psychomotor and Cognitive Impairment		1.2E-03		1.2E-03
			Arsenic		1.9E-09			1.9E-09	N/A		---		---
			Chromium		---			---	N/A		---		---
			Copper		---			---	N/A		---		---
			Iron		---			---	N/A		---		---
			Lead		---			---	N/A		---		---
			Manganese		---			---	CNS		3.7E-03		3.7E-03
			Thallium		---			---	N/A		---		---
			Vanadium		---			---	N/A		---		---
			Chemical Total		2.0E-09			2.0E-09			0.0049		0.0049
			Radionuclide Total										
		Exposure Point Total						2.0E-09					0.0049
	Exposure Media Total							2.0E-09					0.0049
Surface Soil Total								9.4E-07					0.12
Receptor Total								9.4E-07					0.12

Total Risk Across All Media = 9.4E-07

Total Hazard Across All Media = 0.12

(a) The RfD is based on NOAEL; no target organ is identified.

N/A = Not Available
CNS = Central Nervous System
GI = Gastrointestinal
NOAEL = No Observed Adverse Effect Level

Total Neurological Toxicity HI Across All Media =	0.0063
Total Skin HI Across All Media =	0.0042
Total Vascular Effects HI Across All Media =	0.0042
Total NOAEL HI Across All Media =	0.000037
Total GI Tract HI Across All Media =	0.00062
Total Blood HI Aeross All Media =	0.037
Total Liver HI Across All Media =	0.037
Total CNS HI Across All Media =	0.025
Total GI Irritation HI Across All Media =	0.024
Total Hair HI Across All Media =	0.013
Total Kidney HI Across All Media =	0.044
Total Neurological/Psychomotor and Cognitive Impairment HI Across All Media =	0.0012

Table E-30
Summary of Exposure Risks and Hazards for COPCs
Reasonable Maximum Exposure
Future - Maintenance Worker

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	SWMU 39	TCDD TE	2.2E-07		4.3E-08		2.6E-07	N/A	---		---	---
			Aluminum	---		---		---	Neurological Toxicity	5.0E-03		1.2E-03	6.3E-03
			Arsenic	5.7E-07		1.1E-07		6.8E-07	Skin, Vascular Effects	3.5E-03		7.0E-04	4.2E-03
			Chromium[a]	---		---		---	NOAEL	6.1E-06		3.1E-05	3.7E-05
			Copper	---		---		---	GI Tract	5.8E-04		3.8E-05	6.2E-04
			Iron	---		---		---	Blood, Liver, GI Irritation	2.3E-02		1.5E-03	2.4E-02
			Lead	---		---		---	N/A	---		---	---
			Manganese	---		---		---	CNS	7.9E-03		1.3E-02	2.1E-02
			Thallium	---		---		---	Blood, Liver, Hair	1.2E-02		7.9E-04	1.3E-02
			Vanadium	---		---		---	Kidney	1.2E-02		3.1E-02	4.4E-02
			Chemical Total	7.9E-07		1.6E-07		9.4E-07		0.064		0.049	0.11
			Radionuclide Total										
		Exposure Point Total						9.4E-07					0.11
	Exposure Media Total							9.4E-07					0.11
	Air (Particulates)	SWMU 39	TCDD TE		7.2E-11			7.2E-11	N/A		---		---
			Aluminum		---			---	Neurological/Psychomotor and Cognitive Impairment		1.2E-03		1.2E-03
			Arsenic		1.9E-09			1.9E-09	N/A		---		---
			Chromium		---			---	N/A		---		---
			Copper		---			---	N/A		---		---
			Iron		---			---	N/A		---		---
			Lead		---			---	N/A		---		---
			Manganese		---			---	CNS		3.7E-03		3.7E-03
			Thallium		---			---	N/A		---		---
			Vanadium		---			---	N/A		---		---
			Chemical Total		2.0E-09			2.0E-09			0.0049		0.0049
			Radionuclide Total										
		Exposure Point Total						2.0E-09					0.0049
	Exposure Media Total							2.0E-09					0.0049
Surface Soil Total								9.4E-07					0.12

Table E-30
Summary of Exposure Risks and Hazards for COPCs
Reasonable Maximum Exposure
Future - Maintenance Worker

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Total Soil	Total Soil	SWMU 39	TCDD TE	2.2E-07		4.3E-08		2.6E-07	N/A	---		---	---
			Aluminum	---		---		---	Neurological Toxicity	4.9E-03		1.2E-03	6.1E-03
			Arsenic	4.5E-07		9.0E-08		5.4E-07	Skin, Vascular Effects	2.8E-03		5.6E-04	3.4E-03
			Chromium[a]	---		---		---	NOAEL	5.6E-06		2.8E-05	3.4E-05
			Copper	---		---		---	GI Tract	4.4E-04		2.9E-05	4.7E-04
			Iron	---		---		---	Blood, Liver, GI Irritation	2.2E-02		1.5E-03	2.4E-02
			Lead	---		---		---	N/A	---		---	---
			Manganese	---		---		---	CNS	6.1E-03		1.0E-02	1.6E-02
			Thallium	---		---		---	Blood, Liver, Hair	8.7E-03		5.7E-04	9.2E-03
			Vanadium	---		---		---	Kidney	1.2E-02		3.1E-02	4.4E-02
			Chemical Total	6.7E-07		1.3E-07		8.0E-07		0.058		0.045	0.10
			Radionuclide Total										
		Exposure Point Total						8.0E-07					0.10
	Exposure Media Total							8.0E-07					0.10
	Air (Particulates)	SWMU 39	TCDD TE		7.2E-11			7.2E-11	N/A		---		---
			Aluminum		---			---	Neurological/Psychomotor and Cognitive Impairment		1.2E-03		1.2E-03
			Arsenic		1.5E-09			1.5E-09	N/A		---		---
			Chromium		---			---	N/A		---		---
			Copper		---			---	N/A		---		---
			Iron		---			---	N/A		---		---
			Lead		---			---	N/A		---		---
			Manganese		---			---	CNS		2.8E-03		2.8E-03
			Thallium		---			---	N/A		---		---
			Vanadium		---			---	N/A		---		---
			Chemical Total		1.6E-09			1.6E-09			0.0040		0.0040
			Radionuclide Total										
		Exposure Point Total						1.6E-09					0.0040
	Exposure Media Total							1.6E-09					0.0040
Total Soil Total								8.1E-07					0.11
Receptor Total[b]								8.1E-07					0.12

Total Risk Across All Media[b] = 9.4E-07

Total Hazard Across All Media[b] = 0.12

(a) The RfD is based on NOAEL; no target organ is identified.
(b) Since surface soil represents the more highly contaminated portion of soil, total risk and hazard estimates are conservatively based on this soil data grouping.

CNS = Central Nervous System
GI = Gastrointestinal.
NOAEL = No Observed Adverse Effect Level.
N/A = Not Available.

Total Neurological Toxicity HI Across All Media =	0.0063
Total Skin HI Across All Media =	0.0042
Total Vascular Effects HI Across All Media =	0.0042
Total NOAEL HI Across All Media =	0.000037
Total GI Tract HI Across All Media =	0.00062
Total Blood HI Across All Media =	0.037
Total Liver HI Across All Media =	0.037
Total CNS HI Across All Media =	0.025
Total GI Irritation HI Across All Media =	0.024
Total Hair HI Across All Media =	0.013
Total Kidney HI Across All Media =	0.044
Total Neurological/Psychomotor and Cognitive Impairment HI Across All Media =	0012

Table E-31
Summary of Exposure Risks and Hazards for COPCs
Reasonable Maximum Exposure
Future - Excavation Worker

Scenario Timeframe: Future
Receptor Population: Excavation Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Total Soil	Total Soil	SWMU 39	TCDD TE	1.4E-07		1.3E-08		1.6E-07	N/A	---		---	---
			Aluminum	---		---		---	Neurological Toxicity	8.1E-02		9.0E-03	9.0E-02
			Arsenic	3.0E-07		2.7E-08		3.3E-07	Skin, Vascular Effects	4.7E-02		4.2E-03	5.1E-02
			Chromium[a]	---		---		---	NOAEL	9.2E-05		2.1E-04	3.0E-04
			Copper	---		---		---	GI Tract	7.2E-03		2.2E-04	7.4E-03
			Iron	---		---		---	Blood, Liver, GI Irritation	3.7E-01		1.1E-02	3.8E-01
			Lead	---		---		---	N/A	---		---	---
			Manganese	---		---		---	CNS	1.0E-01		7.5E-02	1.7E-01
			Thallium	---		---		---	Blood, Liver, Hair	1.4E-01		4.3E-03	1.5E-01
			Vanadium	---		---		---	Kidney	2.0E-01		2.4E-01	4.4E-01
			Chemical Total	4.4E-07		4.0E-08		4.8E-07		0.95		0.34	1.3
			Radionuclide Total										
		Exposure Point Total						4.8E-07					1.3
	Exposure Media Total							4.8E-07					1.3
	Air (Particulates)	SWMU 39	TCDD TE		1.4E-11			1.4E-11	N/A		---		---
			Aluminum		---			---	Neurological/Psychomotor and Cognitive Impairment		5.8E-03		5.8E-03
			Arsenic		3.0E-10			3.0E-10	N/A		---		---
			Chromium[a]		---			---	N/A		---		---
			Copper		---			---	N/A		---		---
			Iron		---			---	N/A		---		---
			Lead		---			---	N/A		---		---
			Manganese		---			---	CNS		1.4E-02		1.4E-02
			Thallium		---			---	N/A		---		---
			Vanadium		---			---	N/A		---		---
			Chemical Total		3.2E-10			3.2E-10			0.020		0.020
			Radionuclide Total										
		Exposure Point Total						3.2E-10					0.020
	Exposure Media Total							3.2E-10					0.020
Surface Soil Total								4.8E-07					1.3
Receptor Total								4.8E-07					1.3

Total Risk Across All Media = 4.8E-07

Total Hazard Across All Media = 1.3

(a) The RfD is based on NOAEL; no target organ is identified.

CNS = Central Nervous Sy stem
GI = Gastrointestinal
NOAEL = No Observed Adverse Effect Level
N/A = Not Available

Total Neurological Toxicity HI Across All Media =	0.090
Total Skin HI Across All Media =	0.051
Total Vascular Effects HI Across All Media =	0.051
Total NOAEL HI Across All Media =	0.00030
Total GI Tract HI Across All Media =	0.0074
Total Blood HI Across All Media =	0.53
Total Liver HI Across All Media =	0.53
Total CNS HI Across All Media =	0.19
Total GI Irritation HI Across All Media =	0.38
Total Hair HI Across All Media =	0.15
Total Kidney HI Across All Media =	0.44
Total Neurological/Psychomotor and Cognitive Impairment HI Across All Media =	0.0058

467

Table E-32
Summary of Exposure Risks and Hazards for COPCs
Reasonable Maximum Exposure
Future - Adult Resident

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Total Soil	Total Soil	SWMU 39	TCDD TE	1.8E-06		2.2E-07		2.0E-06	N/A	---		---	---
			Aluminum	---		---			Neurological Toxicity	3.5E-02		5.1E-03	4.0E-02
			Arsenic	3.8E-06		4.6E-07		4.3E-06	Skin, Vascular Effects	2.0E-02		2.4E-03	2.2E-02
			Chromium[a]	---		---		---	NOAEL	3.9E-05		1.2E-04	1.6E-04
			Copper	---		---		---	GI Tract	3.1E-03		1.2E-04	3.2E-03
			Iron	---		---		---	Blood, Liver, GI Irritation	1.6E-01		6.2E-03	1.6E-01
			Lead	---		---		---	N/A	---		---	---
			Manganese	---		---		---	CNS	4.2E-02		4.2E-02	8.5E-02
			Thallium	---		---		---	Blood, Liver, Hair	6.1E-02		2.4E-03	6.3E-02
			Vanadium	---		---		---	Kidney	8.6E-02		1.3E-01	2.2E-01
			Chemical Total	5.6E-06		6.7E-07		6.3E-06		0.40		0.19	0.59
			Radionuclide Total										
		Exposure Point Total						6.3E-06					0.59
	Exposure Media Total							6.3E-06					0.59
	Air (Particulates)	SWMU 39	TCDD TE		2.5E-11			2.5E-11	N/A		---		---
			Aluminum		---			---	Neurological/Psychomotor and Cognitive Impairment		3.4E-04		3.4E-04
			Arsenic		5.3E-10			5.3E-10	N/A		---		---
			Chromium[a]		---			---	N/A		---		---
			Copper		---			---	N/A		---		---
			Iron		---			---	N/A		---		---
			Lead		---			---	N/A		---		---
			Manganese		---			---	CNS		8.1E-04		8.1E-04
			Thallium		---			---	N/A		---		---
			Vanadium		---			---	N/A		---		---
			Chemical Total		5.5E-10			5.5E-10			1.1E-03		1.1E-03
			Radionuclide Total										
		Exposure Point Total						5.5E-10					1.1E-03
	Exposure Media Total							5.5E-10					1.1E-03
Surface Soil Total								6.3E-06					0.60
Receptor Total								6.3E-06					0.60

Total Risk Across All Media = 6.3E-06

Total Hazard Across All Media = 0.60

(a) The RfD is based on NOAEL; no target organ is identified.

CNS = Central Nervous System
GI = Gastrointestinal
NOAEL = No Observed Adverse Effect Level
N/A = Not Available

Total Neurological Toxicity HI Across All Media =	0.040
Total Skin HI Across All Media =	0.022
Total Vascular Effects HI Across All Media =	0.022
Total NOAEL HI Across All Media =	0.00016
Total GI Tract HI Across All Media =	0.0032
Total Blood HI Across All Media =	0.23
Total Liver HI Across All Media =	0.23
Total CNS HI Across All Media =	0.086
Total GI Irritation HI Across All Media =	0.16
Total Hair HI Across All Media =	0.063
Total Kidney HI Across All Media =	0.22
Total Neurological/Psychomotor and Cognitive Impairment HI Across All Media =	0.00034

Table E-33
Summary of Exposure Risks and Hazards for COPCs
Reasonable Maximum Exposure
Future - Child Resident

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Total Soil	Total Soil	SWMU 39	TCDD TE	3.4E-06		2.9E-07		3.7E-06	N/A	---		---	---
			Aluminum	---		---		---	Neurological Toxicity	3.2E-01		3.3E-02	3.6E-01
			Arsenic	7.1E-06		6.0E-07		7.7E-06	Skin, Vascular Effects	1.8E-01		1.6E-02	2.0E-01
			Chromium[a]	---		---		---	NOAEL	3.6E-04		7.8E-04	1.1E-03
			Copper	---		---		---	GI Tract	2.9E-02		8.0E-04	2.9E-02
			Iron	---		---		---	Blood, Liver, GI Irritation	1.5E+00		4.1E-02	1.5E+00
			Lead	---		---		---	N/A	---		---	---
			Manganese	---		---		---	CNS	4.0E-01		2.8E-01	6.7E-01
			Thallium	---		---		---	Blood, Liver, Hair	5.7E-01		1.6E-02	5.8E-01
			Vanadium	---		---		---	Kidney	8.1E-01		8.7E-01	1.7E+00
			Chemical Total	1.1E-05		8.8E-07		1.1E-05		3.8		1.3	5.0
			Radionuclide Total										
		Exposure Point Total						1.1E-05					5.0
	Exposure Media Total							1.1E-05					5.0
	Air (Particulates)	SWMU 39	TCDD TE		2.8E-11			2.8E-11	N/A		---		---
			Aluminum		---			---	Neurological/Psychomotor and Cognitive Impairment		1.9E-03		1.9E-03
			Arsenic		5.9E-10			5.9E-10	N/A		---		---
			Chromium[a]		---			---	N/A		---		---
			Copper		---			---	N/A		---		---
			Iron		---			---	N/A		---		---
			Lead		---			---	N/A		---		---
			Manganese		---			---	CNS		4.6E-03		4.6E-03
			Thallium		---			---	N/A		---		---
			Vanadium		---			---	N/A		---		---
			Chemical Total		6.2E-10			6.2E-10			6.5E-03		6.5E-03
			Radionuclide Total										
		Exposure Point Total						6.2E-10					6.5E-03
	Exposure Media Total							6.2E-10					6.5E-03
Surface Soil Total								1.1E-05					5.0
Receptor Total								1.1E-05					5.0

Total Risk Across All Media = 1.1E-05

Total Hazard Across All Media = 5.0

(a) The RfD is based on NOAEL; no target organ is identified.

GI = Gastrointestinal
NOAEL = No Observed Adverse Effect Level
N/A = Not Available

Total Neurological Toxicity HI Across All Media =	0.36
Total Skin HI Across All Media =	0.20
Total Vascular Effects HI Across All Media =	0.20
Total NOAEL HI Across All Media =	0.0011
Total GI Tract HI Across All Media =	0.029
Total Blood HI Across All Media =	2.1
Total Liver HI Across All Media =	2.1
Total CNS HI Across All Media =	0.68
Total GI Irritation HI Across All Media =	1.5
Total Hair HI Across All Media =	0.58
Total Kidney HI Across All Media =	1.7
Total Neurological/Psychomotor and Cognitive Impairment HI Across All Media =	0.0019

Table E-34
Risk Assessment Summary
Reasonable Maximum Exposure
Current - Maintenance Worker

Scenario Timeframe: Current
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	SWMU 39											
			Chemical Total					<1.0E-6					<1
			Radionuclide Total										
		Exposure Point Total						<1.0E-6					<1
	Exposure Media Total							<1.0E-6					<1
	Air (Particulates)	SWMU 39											
			Chemical Total					<1.0E-6					<1
			Radionuclide Total										
		Exposure Point Total						<1.0E-6					<1
	Exposure Media Total							<1.0E-6					<1
Surface Soil Total								<1.0E-6					<1
Receptor Total								<1.0E-6					<1

Total Risk Across All Media = <1.0E-6

Total Hazard Across All Media = <1

Table E-35
Risk Assessment Summary
Reasonable Maximum Exposure
Future - Maintenance Worker

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	SWMU 39											
			Chemical Total					<1.0E-6					<1
			Radionuclide Total										
		Exposure Point Total						<1.0E-6					<1
	Exposure Media Total							<1.0E-6					<1
	Air (Particulates)	SWMU 39											
			Chemical Total					<1.0E-6					<1
			Radionuclide Total										
		Exposure Point Total						<1.0E-6					<1
	Exposure Media Total							<1.0E-6					<1
Surface Soil Total								<1.0E-6					<1
Total Soil	Total Soil	SWMU 39											
			Chemical Total					<1.0E-6					<1
			Radionuclide Total										
		Exposure Point Total						<1.0E-6					<1
	Exposure Media Total							<1.0E-6					<1
	Air (Particulates)	SWMU 39											
			Chemical Total					<1.0E-6					<1
			Radionuclide Total										
		Exposure Point Total						<1.0E-6					<1
	Exposure Media Total							<1.0E-6					<1
Total Soil Total								<1.0E-6					<1
Receptor Total[a]								<1.0E-6					<1

Total Risk Across All Media = <1.0E-6

Total Hazard Across All Media = <1

E67

Table E-36
Risk Assessment Summary
Reasonable Maximum Exposure
Future - Excavation Worker

Scenario Timeframe: Future
Receptor Population: Excavation Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Total Soil	Total Soil	SWMU 39											
			Chemical Total					<1.0E-6					1.3 (a)
			Radionuclide Total										
		Exposure Point Total						<1.0E-6					1.3 (a)
	Exposure Media Total							<1.0E-6					1.3 (a)
	Air (Particulates)	SWMU 39											
			Chemical Total					<1.0E-6					<1
			Radionuclide Total										
		Exposure Point Total						<1.0E-6					<1
	Exposure Media Total							<1.0E-6					<1
Soil Total								<1.0E-6					1.3 (a)
Receptor Total								<1.0E-6					1.3 (a)

Total Risk Across All Media = <1.0E-6

Total Hazard Across All Media = 1.3 (a)

(a) No individual chemical or target organ HI was equal to or exceeded 1.

Table E-37
Risk Assessment Summary
Reasonable Maximum Exposure
Future - Adult Resident

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Total Soil	Total Soil	SWMU 39	TCDD TE	1.8E-06		2.2E-07		2.0E-06					
			Arsenic	3.8E-06		4.6E-07		4.3E-06					
			Chemical Total	5.6E-06		6.7E-07		6.3E-06					<1
			Radionuclide Total										
		Exposure Point Total						6.3E-06					<1
	Exposure Media Total							6.3E-06					<1
	Air (Particulates)	SWMU 39											
			Chemical Total					<1.0E-6					<1
			Radionuclide Total										
		Exposure Point Total						<1.0E-6					<1
	Exposure Media Total							<1.0E-6					<1
Surface Soil Total								6.3E-06					<1
Receptor Total								6.3E-06					<1

Total Risk Across All Media = 6.3E-06

Total Hazard Across All Media = <1

Table E-38
Risk Assessment Summary
Reasonable Maximum Exposure
Future - Child Resident

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Total Soil	Total Soil	SWMU 39	TCDD TE	3.4E-06		2.9E-07		3.7E-06					
			Arsenic	7.1E-06		6.0E-07		7.7E-06					
			Iron						Blood, Liver, GI Irritation	1.5E+00		4.1E-02	1.5E+00
			Vanadium						Kidney	8.1E-01		8.7E-01	1.7E+00
			Chemical Total	1.1E-05		8.8E-07		1.1E-05		2.3		0.91	3.2
			Radionuclide Total										
		Exposure Point Total						1.1E-05					3.2
	Exposure Media Total							1.1E-05					3.2
	Air (Particulates)	SWMU 39											
			Chemical Total					<1.0E-6					<1
			Radionuclide Total										
		Exposure Point Total						<1.0E-6					<1
	Exposure Media Total							<1.0E-6					<1
Surface Soil Total								1.1E-05					3.2
Receptor Total								1.1E-05					3.2

Total Risk Across All Media = 1.1E-05

Total Hazard Across All Media = 3.2

GI = Gastrointestinal

Total Blood HI Across All Media = 1.5
Total Liver HI Across All Media = 1.5
Total GI Irritation HI Across All Media = 1.5
Total Kidney HI Across All Media = 1.7

TABLE E-39a
RAGS D ADULT LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Calculations of Blood Lead Concentrations - Surface Soil Inside Lagoon – Maintenance Worker

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	2,840	mg/kg	Average Detected Value	800	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 5/19/03
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Located in Appendix E, Table E-39b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Exposure point concentration was based on the arithmetic mean of lead concentrations in surface soil inside lagoon; See Appendix E
What was the point of exposure and location?	Surface Soil – SWMU 39
Where are the output values located in the risk assessment report?	Located in Appendix E, Table E-39b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix <Y>.	GSD = 2.2 as the midrange value of updated GSD values (2.1 to 2.3) from NHANES III (USEPA, 2002b)
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix <Y>	PbB_0 = 1.6 ug/dL as the midrange level of updated PbB_0 values (1.5 to 1.7 ug/dL) from NHANES III (USEPA, 2002b)
Was the default exposure frequency (EF; 219 days/year) used?	Yes. Default value was used as a conservative estimate for intermittent maintenance activities (50 days/year)
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Discussion of parameters in Section 6.3.2 and Appendix E

3. Final Result

Medium	Result	Comment/RBRG [1]
Surface Soil	Input value of 2,840 ppm in soil results in 19.8% of receptors above a geometric mean blood lead =5.7 ug/dL. This is above the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead.	To be calculated for the Corrective Measures Study (CMS).

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

Table E-39b
Calculations of Blood Lead Concentrations (PbBs)
Radford Army Ammunition Plant - SWMU 39 - Surface Soil Inside Lagoon
Maintenance Worker

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	PbB Equation[1] 2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1 GSDi = Hom	Using Equation 1 GSDi = Het	Using Equation 2 GSDi = Hom	Using Equation 2 GSDi = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	2,840	2,840	2,840	2,840
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.6	1.6	1.6	1.6
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}			**PbB of adult worker, geometric mean**	**ug/dL**	**5.7**	**5.7**	**5.7**	**5.7**
$PbB_{fetal,0.95}$			**95th percentile PbB among fetuses of adult workers**	**ug/dL**	**18.7**	**18.7**	**18.7**	**18.7**
PbB_t			**Target PbB level of concern (e.g., 10 ug/dL)**	**ug/dL**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$			**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**19.8%**	**19.8%**	**19.8%**	**19.8%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Inte[illegible]pproach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE E-40a
RAGS D ADULT LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Calculations of Blood Lead Concentrations - Surface Soil Outside Lagoon – Maintenance Worker

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	43	mg/kg	Average Detected Value	800	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 5/19/03
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Located in Appendix E, Table E-40b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Exposure point concentration was based on the arithmetic mean of lead concentrations in surface soil outside lagoon; See Appendix E
What was the point of exposure and location?	Surface Soil – SWMU 39
Where are the output values located in the risk assessment report?	Located in Appendix E, Table E-40b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix <Y>.	GSD = 2.2 as the midrange value of updated GSD values (2.1 to 2.3) from NHANES III (USEPA, 2002b)
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix <Y>	PbB_0 = 1.6 ug/dL as the midrange level of updated PbB_0 values (1.5 to 1.7 ug/dL) from NHANES III (USEPA, 2002b)
Was the default exposure frequency (EF; 219 days/year) used?	Yes. Default value was used as a conservative estimate for intermittent maintenance activities (50 days/year)
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Discussion of parameters in Section 6.3.2 and Appendix E

3. Final Result

Medium	Result	Comment/RBRG [1]
Surface Soil	Input value of 43 ppm in soil results in 0.8% of receptors above a geometric mean blood lead =1.7 ug/dL. This is below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead.	To be calculated for the Corrective Measures Study (CMS).

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

Table E-40b
Calculations of Blood Lead Concentrations (PbBs)
Radford Army Ammunition Plant - SWMU 39 - Surface Soil Outside Lagoon
Maintenance Worker
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1 GSDi = Hom	Using Equation 1 GSDi = Het	Using Equation 2 GSDi = Hom	Using Equation 2 GSDi = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	43	43	43	43
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.6	1.6	1.6	1.6
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**			**ug/dL**	**1.7**	**1.7**	**1.7**	**1.7**
$PbB_{fetal,\ 0.95}$	**95th percentile PbB among fetuses of adult workers**			**ug/dL**	**5.5**	**5.5**	**5.5**	**5.5**
PbB_t	**Target PbB level of concern (e.g., 10 ug/dL)**			**ug/dL**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**			**%**	**0.8%**	**0.8%**	**0.8%**	**0.8%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,\ 0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,\ 0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Int pproach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE E-41a
RAGS D ADULT LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Calculations of Blood Lead Concentrations - Total Soil Inside Lagoon – Maintenance Worker

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	1,723	mg/kg	Average Detected Value	800	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 5/19/03
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Located in Appendix E, Table E-41b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Exposure point concentration was based on the arithmetic mean of lead concentrations in total soil inside lagoon; See Appendix E
What was the point of exposure and location?	Total Soil – SWMU 39
Where are the output values located in the risk assessment report?	Located in Appendix E, Table E-41b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix <Y>.	GSD = 2.2 as the midrange value of updated GSD values (2.1 to 2.3) from NHANES III (USEPA, 2002b)
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix <Y>	PbB_0 = 1.6 ug/dL as the midrange level of updated PbB_0 values (1.5 to 1.7 ug/dL) from NHANES III (USEPA, 2002b)
Was the default exposure frequency (EF; 219 days/year) used?	Yes. Default value was used as a conservative estimate for intermittent maintenance activities (50 days/year)
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Discussion of parameters in Section 6.3.2 and Appendix E

3. Final Result

Medium	Result	Comment/RBRG [1]
Total Soil	Input value of 1,723 ppm in soil results in 10.2% of receptors above a geometric mean blood lead =4.1 ug/dL. This is above the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead.	To be calculated for the Corrective Measures Study (CMS).

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

Table E-41b
Calculations of Blood Lead Concentrations (PbBs)
Radford Army Ammunition Plant - SWMU 39 - Total Soil Inside Lagoon
Maintenance Worker

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1 GSDi = Hom	Using Equation 1 GSDi = Het	Using Equation 2 GSDi = Hom	Using Equation 2 GSDi = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	1,723	1,723	1,723	1,723
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.6	1.6	1.6	1.6
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**			**ug/dL**	**4.1**	**4.1**	**4.1**	**4.1**
$PbB_{fetal,\ 0.95}$	**95th percentile PbB among fetuses of adult workers**			**ug/dL**	**13.4**	**13.4**	**13.4**	**13.4**
PbB_t	**Target PbB level of concern (e.g., 10 ug/dL)**			**ug/dL**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**			**%**	**10.2%**	**10.2%**	**10.2%**	**10.2%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,\ 0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,\ 0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Inf pproach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE E-42a
RAGS D ADULT LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Calculations of Blood Lead Concentrations - Total Soil Outside Lagoon – Maintenance Worker

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	37	mg/kg	Average Detected Value	800	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 5/19/03
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Located in Appendix E, Table E-42b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Exposure point concentration was based on the arithmetic mean of lead concentrations in total soil outside lagoon; See Appendix E
What was the point of exposure and location?	Total Soil – SWMU 39
Where are the output values located in the risk assessment report?	Located in Appendix E, Table E-42b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix <Y>.	GSD = 2.2 as the midrange value of updated GSD values (2.1 to 2.3) from NHANES III (USEPA, 2002b)
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix <Y>	PbB_0 = 1.6 ug/dL as the midrange level of updated PbB_0 values (1.5 to 1.7 ug/dL) from NHANES III (USEPA, 2002b)
Was the default exposure frequency (EF; 219 days/year) used?	Yes. Default value was used as a conservative estimate for intermittent maintenance activities (50 days/year)
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Discussion of parameters in Section 6.3.2 and Appendix E

3. Final Result

Medium	Result	Comment/RBRG [1]
Total Soil	Input value of 37 ppm in soil results in 0.8% of receptors above a geometric mean blood lead =1.7 ug/dL. This is below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead.	To be calculated for the Corrective Measures Study (CMS).

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

Table E-42b
Calculations of Blood Lead Concentrations (PbBs)
Radford Army Ammunition Plant - SWMU 39 - Total Soil Inside Lagoon
Maintenance Worker
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1 GSDi = Hom	Using Equation 1 GSDi = Het	Using Equation 2 GSDi = Hom	Using Equation 2 GSDi = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	37	37	37	37
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.6	1.6	1.6	1.6
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219	219	219	219
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**			**ug/dL**	**1.7**	**1.7**	**1.7**	**1.7**
$PbB_{fetal,0.95}$	**95th percentile PbB among fetuses of adult workers**			**ug/dL**	**5.4**	**5.4**	**5.4**	**5.4**
PbB_t	**Target PbB level of concern (e.g., 10 ug/dL)**			**ug/dL**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**			**%**	**0.8%**	**0.8%**	**0.8%**	**0.8%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Int pproach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE E-43a
RAGS D ADULT LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Calculations of Blood Lead Concentrations - Total Soil Inside Lagoon – Excavation Worker

1. Lead Screening Questions

Medium	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	1,723	mg/kg	Average Detected Value	800	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 5/19/03
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Located in Appendix E, Table E-43b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Exposure point concentration was based on the arithmetic mean of lead concentrations in total soil; See Appendix E
What was the point of exposure and location?	Total Soil – SWMU 39
Where are the output values located in the risk assessment report?	Located in Appendix E, Table E-43b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix <Y>.	GSD = 2.2 as the midrange value of updated GSD values (2.1 to 2.3) from NHANES III (USEPA, 2002b)
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix <Y>	PbB_0 = 1.6 ug/dL as the midrange level of updated PbB_0 values (1.5 to 1.7 ug/dL) from NHANES III (USEPA, 2002b)
Was the default exposure frequency (EF; 219 days/year) used?	EF = 250 days/year based on full-time exposure to soil during excavation (USEPA, 2004e)
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Discussion of parameters in Section 6.3.2 and Appendix E

3. Final Result

Medium	Result	Comment/RBRG [1]
Total Soil	Input value of 1,723 ppm in soil results in 29.5% of receptors above a geometric mean blood lead = 7.3 ug/dL. This is above the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead.	To be calculated for the Corrective Measures Study (CMS).

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

Table E-43b
Calculations of Blood Lead Concentrations (PbBs)
Radford Army Ammunition Plant - SWMU 39 - Total Soil Inside Lagoon
Excavation Worker
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	PbB Equation[1] 2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1, GSDi = Hom	Using Equation 1, GSDi = Het	Using Equation 2, GSDi = Hom	Using Equation 2, GSDi = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	1,723	1,723	1,723	1,723
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.6	1.6	1.6	1.6
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	0.100	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.100	0.100
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	250	250	250	250
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**			**ug/dL**	**7.3**	**7.3**	**7.3**	**7.3**
$PbB_{fetal,0.95}$	**95th percentile PbB among fetuses of adult workers**			**ug/dL**	**23.9**	**23.9**	**23.9**	**23.9**
PbB_t	**Target PbB level of concern (e.g., 10 ug/dL)**			**ug/dL**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**			**%**	**29.5%**	**29.5%**	**29.5%**	**29.5%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an In' pproach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE E-44a
RAGS D ADULT LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Calculations of Blood Lead Concentrations - Total Soil Outside Lagoon – Excavation Worker

1. Lead Screening Questions

	Lead Concentration used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		
Medium	Value	Units		Value	Units	Basis for Lead Screening Level
Soil	37	mg/kg	Average Detected Value	800	mg/kg	Recommended Soil Screening Level

2. Lead Model Questions

Question	Response
What lead model was used? Provide reference and version	USEPA Adult Lead Model, Version dated 5/19/03
If the EPA Adult Lead Model (ALM) was not used provide rationale for model selected.	N/A
Where are the input values located in the risk assessment report?	Located in Appendix E, Table E-44b
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Exposure point concentration was based on the arithmetic mean of lead concentrations in total soil outside lagoon; See Appendix E
What was the point of exposure and location?	Total Soil – SWMU 39
Where are the output values located in the risk assessment report?	Located in Appendix E, Table E-44b
What GSD value was used? If this is outside the recommended range of 1.8-2.1), provide rationale in Appendix <Y>.	GSD = 2.2 as the midrange value of updated GSD values (2.1 to 2.3) from NHANES III (USEPA, 2002b)
What baseline blood lead concentration (PbB_0) value was used? If this is outside the default range of 1.7 to 2.2 provide rationale in Appendix <Y>	PbB_0 = 1.6 ug/dL as the midrange level of updated PbB_0 values (1.5 to 1.7 ug/dL) from NHANES III (USEPA, 2002b)
Was the default exposure frequency (EF; 219 days/year) used?	EF = 250 days/year based on full-time exposure to soil during excavation (USEPA, 2004e)
Was the default BKSF used (0.4 ug/dL per ug/day) used?	Yes
Was the default absorption fraction (AF; 0.12) used?	Yes
Was the default soil ingestion rate (IR; 50 mg/day) used?	Yes
If non-default values were used for any of the parameters listed above, where is the rationale for the values located in the risk assessment report?	Discussion of parameters in Section 6.3.2 and Appendix E

3. Final Result

Medium	Result	Comment/RBRG [1]
Total Soil	Input value of 37 ppm in soil results in 0.9% of receptors above a geometric mean blood lead = 1.7 ug/dL. This is below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children (fetuses of exposed women) exceeding 10 ug/dL blood lead.	To be calculated for the Corrective Measures Study (CMS).

1. Attach the ALM spreadsheet output file upon which the Risk Based Remediation Goal (RBRG) was based and description of rationale for parameters used. For additional information, see www.epa.gov/superfund/programs/lead

Table E-44b
Calculations of Blood Lead Concentrations (PbBs)
Radford Army Ammunition Plant - SWMU 39 - Total Soil Inside Lagoon
Excavation Worker
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1 GSDi = Hom	Using Equation 1 GSDi = Het	Using Equation 2 GSDi = Hom	Using Equation 2 GSDi = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	37	37	37	37
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.6	1.6	1.6	1.6
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	0.100	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.100	0.100
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	250	250	250	250
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	**PbB of adult worker, geometric mean**			**ug/dL**	**1.7**	**1.7**	**1.7**	**1.7**
$PbB_{fetal,0.95}$	**95th percentile PbB among fetuses of adult workers**			**ug/dL**	**5.7**	**5.7**	**5.7**	**5.7**
PbB_t	**Target PbB level of concern (e.g., 10 ug/dL)**			**ug/dL**	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t assuming lognormal distribution**			**%**	**0.9%**	**0.9%**	**0.9%**	**0.9%**

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Inte[illegible]proach to Assessing Risks Associated with Adult Exposures to Lead in Soil

TABLE E-45
RAGS D IEUBK LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Child (Age 0 – 84 Months), Exposure to Total Soil Inside Lagoon

1. Lead Screening Questions

Medium	Lead Concentration Used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	1,723	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level
Water	15	ug/L	Assumed Action Level	15	ug/L	Recommended Drinking Water Action Level

2. Lead Model Questions

Question	Response for Residential Lead Model
What lead model (version and date) was used?	Lead Model for Windows, Version 1.0 Build 261
Where are the input values located in the risk assessment report?	Located in Appendix E, IEUBKwin OUTPUT (Attached)
What range of media concentrations were used for the model?	Range of site concentrations: 10.1 – 16,500 mg/kg
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Arithmetic Mean Concentration; Data are Located in Appendix E
Was soil sample taken from top 2 cm? If not, why?	No – Future scenario based on assumption that soil would be disturbed. Surface and subsurface data sets were combined to represent total soil.
Was soil sample sieved? What size screen was used? If not sieved, provide rationale.	No -- Soil samples were collected for multiple analyses.
What was the point of exposure/location?	Total soil – SWMU 39
Where are the output values located in the risk assessment report?	IEUBKwin OUTPUT (Attached)
Was the model run using default values only?	No – Assumed site-specific arithmetic mean concentration of lead in soil and concentration of lead in drinking water at action level.
Was the default soil bioavailability used?	Yes -- Default is 30%
Was the default soil ingestion rate used?	Yes -- Default values for 7 age groups are 85, 135, 135, 100, 090, and 85 mg/day
If non-default values were used, where is the rationale for the values located in the risk assessment report?	Located in Appendix E

3. Final Result

Medium	Result	Comment/PRG [1]
Total Soil	Input value of 1,723 ppm in total soil results in 77.4% of children above a blood lead level of 10 ug/dL. Geometric mean blood lead = 14.24 ug/dL. This is above the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children exceeding 10 ug/dL blood lead.	To be calculated for the Corrective Measures Study (CMS).

1. Attach the IEUBK text output file and graph upon which the PRG was based as an appendix. For additional information, see www.epa.gov/superfund/programs/lead

LEAD MODEL FOR WINDOWS Version 1.0

Model Version: 1.0 Build 261
User Name: Shaw Environmental, Inc.
Date: 10/8/2004
Site Name: Radford Army Ammunition Plant
Operable Unit: SWMU 39 - Total Soil (Inside Lagoon)
Run Mode: Site Risk Assessment

Soil/Dust Data
Total Soil - Arithmetic mean = 1,723 mg/kg
Water Data
Assumed action level - 15 ug/L

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 15.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 1216.100 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	1723.000	1216.100
1-2	1723.000	1216.100
2-3	1723.000	1216.100
3-4	1723.000	1216.100
4-5	1723.000	1216.100
5-6	1723.000	1216.100
6-7	1723.000	1216.100

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

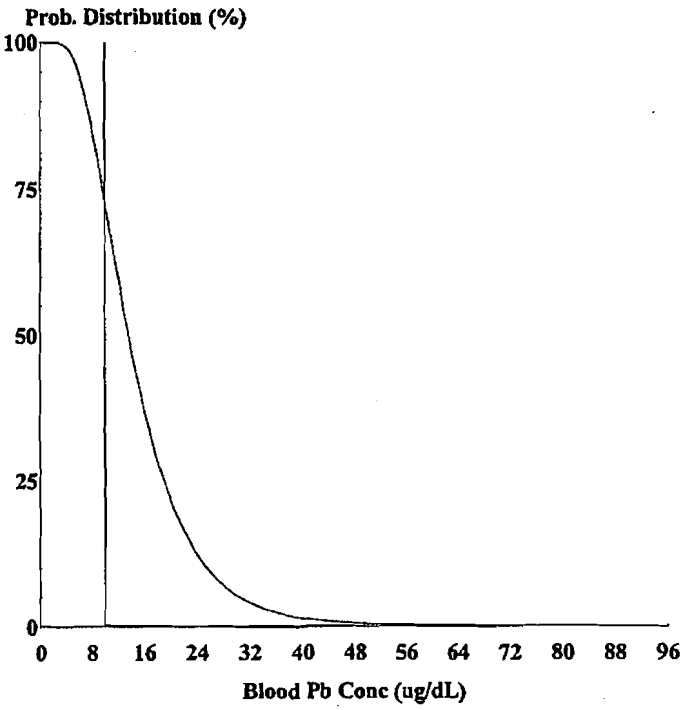
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.958	0.000	1.062
1-2	0.034	1.936	0.000	2.512
2-3	0.062	2.270	0.000	2.728
3-4	0.067	2.273	0.000	2.895
4-5	0.067	2.393	0.000	3.285
5-6	0.093	2.616	0.000	3.590
6-7	0.093	2.946	0.000	3.724

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	26.076	29.117	15.0
1-2	39.187	43.670	17.4
2-3	40.909	45.968	16.6
3-4	42.604	47.839	16.1
4-5	34.502	40.246	13.8
5-6	32.179	38.478	12.0
6-7	30.995	37.759	10.7



Cutoff = 10.000 ug/dl
Geo Mean = 14.241
GSD = 1.600
% Above = 77.406

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Site Risk Assessment

TABLE E-46
RAGS D IEUBK LEAD WORKSHEET
Radford Army Ammunition Plant – SWMU 39
Child (Age 0 – 84 Months), Exposure to Total Soil Outside Lagoon

1. Lead Screening Questions

Medium	Lead Concentration Used in Model Run		Basis for Lead Concentration Used For Model Run	Lead Screening Concentration		Basis for Lead Screening Level
	Value	Units		Value	Units	
Soil	37	mg/kg	Average Detected Value	400	mg/kg	Recommended Soil Screening Level
Water	15	ug/L	Assumed Action Level	15	ug/L	Recommended Drinking Water Action Level

2. Lead Model Questions

Question	Response for Residential Lead Model
What lead model (version and date) was used?	Lead Model for Windows, Version 1.0 Build 261
Where are the input values located in the risk assessment report?	Located in Appendix E, IEUBKwin OUTPUT (Attached)
What range of media concentrations were used for the model?	Range of site concentrations: 10.1 – 16,500 mg/kg
What statistics were used to represent the exposure concentration terms and where are the data on concentrations in the risk assessment that support use of these statistics?	Arithmetic Mean Concentration; Data are Located in Appendix E
Was soil sample taken from top 2 cm? If not, why?	No – Future scenario based on assumption that soil would be disturbed. Surface and subsurface data sets were combined to represent total soil.
Was soil sample sieved? What size screen was used? If not sieved, provide rationale.	No -- Soil samples were collected for multiple analyses.
What was the point of exposure/location?	Total soil – SWMU 39
Where are the output values located in the risk assessment report?	IEUBKwin OUTPUT (Attached)
Was the model run using default values only?	No – Assumed site-specific arithmetic mean concentration of lead in soil and concentration of lead in drinking water at action level.
Was the default soil bioavailability used?	Yes -- Default is 30%
Was the default soil ingestion rate used?	Yes -- Default values for 7 age groups are 85, 135, 135, 100, 090, and 85 mg/day
If non-default values were used, where is the rationale for the values located in the risk assessment report?	Located in Appendix E

3. Final Result

Medium	Result	Comment/PRG [1]
Total Soil	Input value of 37 ppm in total soil results in 0.32% of children above a blood lead level of 10 ug/dL. Geometric mean blood lead = 2.77 ug/dL. This is below the blood lead goal as described in the 1994 OSWER Directive of no more than 5% of children exceeding 10 ug/dL blood lead.	To be calculated for the Corrective Measures Study (CMS).

1. Attach the IEUBK text output file and graph upon which the PRG was based as an appendix. For additional information, see www.epa.gov/superfund/programs/lead

LEAD MODEL FOR WINDOWS Version 1.0

Model Version: 1.0 Build 261
User Name: Shaw Environmental, Inc.
Date: 10/8/2004
Site Name: Radford Army Ammunition Plant
Operable Unit: SWMU 39 - Total Soil (Outside Lagoon)
Run Mode: Site Risk Assessment

Soil/Dust Data
Total Soil - Arithmetic mean = 37 mg/kg
Water Data
Assumed action level - 15 ug/L

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 15.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 35.900 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	37.000	35.900
1-2	37.000	35.900
2-3	37.000	35.900
3-4	37.000	35.900
4-5	37.000	35.900
5-6	37.000	35.900
6-7	37.000	35.900

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

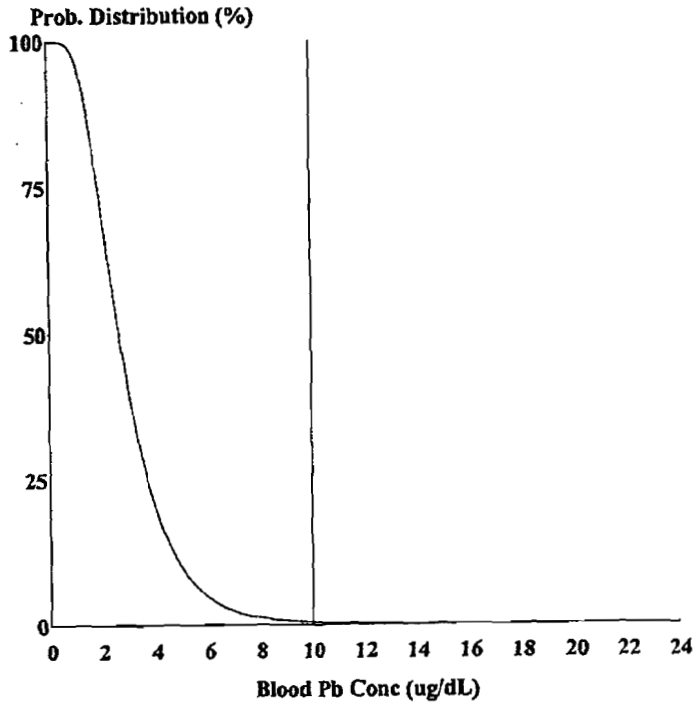
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	2.615	0.000	1.419
1-2	0.034	2.704	0.000	3.508
2-3	0.062	3.055	0.000	3.671
3-4	0.067	2.963	0.000	3.775
4-5	0.067	2.878	0.000	3.951
5-6	0.093	3.047	0.000	4.181
6-7	0.093	3.370	0.000	4.260

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	0.878	4.932	2.7
1-2	1.379	7.626	3.1
2-3	1.388	8.176	3.0
3-4	1.400	8.204	2.9
4-5	1.046	7.942	2.7
5-6	0.944	8.265	2.5
6-7	0.894	8.617	2.4



Cutoff = 10.000 ug/dl
Geo Mean = 2.774
GSD = 1.600
% Above = 0.318

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Site Risk Assessment

Appendix E-2
Statistical Comparison Results

Appendix E-2, Table 1
Statistical Summary Spreadsheet
SWMU 39 and Background

>BG?	Compound	Distribution		Sample Size		Test?	Levene's Test (F) Variances Similar?	T-Test Site > Background?	Mann Whitney Site>Background?
		On-site	Background	On-site	Background				
	Total Soil - Future Conditions								
x	Aluminum	Lognormal*	Lognormal	28	79	T-test	Yes(.054)	**Yes(.008)**	---
x	Arsenic	Lognormal	Lognormal	28	69	T-test	Yes(.336)	Yes(.024)	---
x	Barium	Lognormal	Neither	28	79	MWU	===>	===>	**Yes**
x	Beryllium	Normal	Neither	24	79	MWU	===>	===>	**Yes**
	Cadmium	Neither	Neither	28	79	MWU	===>	===>	No
x	Calcium	Neither	Lognormal	26	79	MWU	===>	===>	**Yes**
x	Chromium	Lognormal	Lognormal	28	79	T-test	No(.033)	===>	**Yes**
x	Cobalt	Lognormal	Lognormal	28	79	T-test	No(<.001)	===>	**Yes**
x	Copper	Neither	Lognormal	28	79	MWU	===>	===>	**Yes**
x	Iron	Lognormal*	Normal	28	79	MWU	===>	===>	**Yes**
x	Lead	Neither	Neither	28	79	MWU	===>	===>	**Yes**
x	Magnesium	Neither	Lognormal	28	79	MWU	===>	===>	**Yes**
	Manganese	Lognormal	Lognormal	28	79	T-test	No(.018)	===>	No
	Mercury	Neither	Neither	28	79	MWU	===>	===>	No
x	Nickel	LognormalQ	Lognormal	28	79	T-test	No(.<.001)	===>	**Yes**
x	Potassium	Normal*	Lognormal	28	79	MWU	===>	===>	**Yes**
	Thallium	Neither	Neither	28	79	MWU	===>	===>	No
x	Vanadium	Normal*	Lognormal	28	79	MWU	===>	===>	**Yes**
x	Zinc	Neither	Lognormal	28	79	MWU	===>	===>	**Yes**
	Surface Soil - Current (and Future) Conditions								
x	Aluminum	Lognormal*	Lognormal	19	28	T-test	No (0.049)	===>	**Yes**
	Arsenic	Lognormal*	Lognormal	19	24	T-test	Yes (0.167)	No (0.318)	---
x	Barium	Lognormal*	Normal	19	28	MWU	===>	===>	**Yes**
x	Beryllium	Normal	Neither	18	28	MWU	===>	===>	**Yes**
	Cadmium	LognormalQ	Neither	19	28	MWU	===>	===>	No
x	Calcium	LognormalQ	Lognormal	17	28	T-test	Yes (0.770)	**Yes (0.015)**	---
x	Chromium	Lognormal	Lognormal	19	28	T-test	Yes (0.090)	**Yes (<0.001)**	---
x	Cobalt	Lognormal	Neither	19	28	MWU	===>	===>	**Yes**
x	Copper	Neither	Normal	19	28	MWU	===>	===>	**Yes**
x	Iron	Lognormal*	Lognormal	19	28	T-test	No (0.003)	===>	**Yes**
x	Lead	LognormalQ	Neither	19	28	MWU	===>	===>	**Yes**
x	Magnesium	LognormalQ	Lognormal	19	28	T-test	No (0.001)	===>	**Yes**
	Manganese	Lognormal	Lognormal	19	28	T-test	Yes (0.403)	No (0.621)	---
	Mercury	Lognormal	Neither	19	28	MWU	===>	===>	No
x	Nickel	LognormalQ	Neither	19	28	MWU	===>	===>	**Yes**
x	Potassium	Lognormal*	Lognormal	19	28	T-test	No (<0.001)	===>	**Yes**
	Thallium	Neither	Neither	19	28	MWU	===>	===>	No
x	Vanadium	Normal*	Lognormal	19	28	MWU	===>	===>	**Yes**
x	Zinc	Neither	Lognormal	19	28	MWU	===>	===>	**Yes**

X = Site concentrations of this chemical are significantly greater than background concentrations; or chemical was detected onsite but not detected (or not analyzed for) in background samples.

M = Maximum to maximum comparison will be performed because not enough samples were available for statistical comparison.

* or Q = The designation of normal or lognormal data distributions also included data sets that were "close" to their respective categorizations, i.e., within 5 percent of being categorized as normal or lognormal, using the Shapiro-Wilk test criterion. If a data set passed both normal and lognormal distribution tests, the distribution with the best fit (i.e., distribution with the value that is closest to the critical value) is selected.

Notes

Antimony was not detected in background samples, therefore no comparisons were run.

Selenium, Silver, and Sodium were more than 80% Non-Detects (ND) in background, and Upper Tolerance Limits (UTLs) were not presented in the Facility-Wide Background Study Report (FWBSR), therefore no comparisons were run.

Cadmium had more than 80% NDs in background. However, a UTL was developed in the FWBSR, and therefore a comparison was run.

Thallium had 80% NDs in background, and in the FWBSR a UTL had been developed; therefore a comparison was run.

For arsenic in background, there were 10 samples that were B-qualified. These samples were excluded to be consistent with the data used in the risk assessment.

Duplicate samples in the SWMU 39 dataset were averaged prior to running statistical tests. Duplicate data issues had already been resolved in the background dataset.

Tests for normality were run using the Shapiro-Francia test for sample sizes > 50 and the Shapiro-Wilk test for sample sizes <= 50.

Appendix E-2, Table 2
Mann-Whitney (General) Results Spreadsheet
SWMu 39 and Background

Chemical	Distribution		Site Samples	Background Samples	Site Rank Sum (a)	$W_{.05}$		On-site Concentrations > Background
	On-site	Background	n	m	T	(b)	$W_{.95}$	Concentrations? (c)
Total Soil - Future Conditions								
Barium	Lognormal*	Neither	28	79	2380.5	1280	1744	Yes
Beryllium	Normal	Neither	24	79	1554	1037	1459	Yes
Cadmium	Neither	Neither	28	79	744	1280	1744	No
Calcium	Neither	Lognormal	26	79	1932	1156	1600	Yes
Chromium	Lognormal	Lognormal	28	79	1984.5	1280	1744	Yes
Cobalt	Lognormal	Lognormal	28	79	1791.5	1280	1744	Yes
Copper	Neither	Lognormal	28	79	2291	1280	1744	Yes
Iron	Lognormal*	Normal	28	79	1744.5	1280	1744	Yes
Lead	Neither	Neither	28	79	2171.5	1280	1744	Yes
Magnesium	Neither	Lognormal	28	79	1999.5	1280	1744	Yes
Manganese	Lognormal	Lognormal	28	79	1658.5	1280	1744	No
Mercury	Neither	Neither	28	79	1638	1280	1744	No
Nickel	LognormalQ	Lognormal	28	79	2056.5	1280	1744	Yes
Potassium	Normal*	Lognormal	28	79	2248.5	1280	1744	Yes
Thallium	Neither	Neither	28	79	1460	1280	1744	No
Vanadium	Normal*	Lognormal	28	79	1894.5	1280	1744	Yes
Zinc	Neither	Lognormal	28	79	2277.5	1280	1744	Yes
Surface Soil - Current (and Future) Conditions								
Aluminum	Lognormal*	Lognormal	19	28	699.5	380	532	Yes
Barium	Lognormal*	Normal	19	28	660	380	532	Yes
Beryllium	Normal	Neither	18	28	568	350	496	Yes
Cadmium	LognormalQ	Neither	19	28	323	380	532	No
Cobalt	Lognormal	Neither	19	28	565	380	532	Yes
Copper	Neither	Normal	19	28	722	380	532	Yes
Iron	Lognormal*	Lognormal	19	28	619.5	380	532	Yes
Lead	LognormalQ	Neither	19	28	637.5	380	532	Yes
Magnesium	LognormalQ	Lognormal	19	28	634.5	380	532	Yes
Mercury	Lognormal	Neither	19	28	478.5	380	532	No
Nickel	LognormalQ	Neither	19	28	705.5	380	532	Yes
Potassium	Lognormal*	Lognormal	19	28	700	380	532	Yes
Thallium	Neither	Neither	19	28	418	380	532	No
Vanadium	Normal*	Lognormal	19	28	631	380	532	Yes
Zinc	Neither	Lognormal	19	28	678	380	532	Yes

* or Q = The designation of normal or lognormal data distributions also included data sets that were "close" to their respective categorizations, i.e., within 5 percent of being categorized as normal or lognormal, using the Shapiro-Wilk test criterion. If a data set passed both normal and lognormal distribution tests, the distribution with the best fit (i.e., distribution with the value that is closest to the critical value) is selected.

(a) Site rank sum calculated in SPSS by Mann-Whitney test.

(b) For sample sizes <20, the $W_{.05}$ can be obtained from Quantiles of the Mann-Whitney Test Statistic tables in Conover (1980); for sample sizes >20, the $W_{.05}$ must be calculated. The $W_{.95}$ is then calculated from the $W_{.05}$.

(c) Onsite concentrations were determined to be greater than background concentrations if the site rank sum (T) exceeded the $W_{.95}$.

Appendix E-2, Table 3
Mann-Whitney Test Results Spreadsheet with Correction for Non-Detects (Ties)
SWMU 39 and Background

Chemical	Number of Nondetects	Site Samples n	Background Samples m	Site Rank Sum T	W.95	On-site Concentrations > Background Concentrations
Surface Soil - Current (and Future) Conditions						
Aluminum	2	19	28	699.5	532	Yes
Magnesium	2	19	28	634.5	532	Yes
Vanadium	2	19	28	634.5	532	Yes

Appendix E-2, Table 4
Mann-Whitney Test Results Spreadsheet with Correction for All Ties
SWMU 39 and Background

Chemical	t^3-t	Site Samples n	Background Samples m	Site Rank Sum T	W.95	On-site Concentrations > Background Concentrations
Total Soil - Future Conditions						
Barium	3240	28	79	2380.5	1744	Yes
Beryllium	1494	24	79	1554	1459	Yes
Calcium	66	26	79	1932	1600	Yes
Chromium	120	28	79	1984.5	1744	Yes
Cobalt	438	28	79	1791.5	1744	Yes
Copper	114	28	79	2291	1744	Yes
Iron	120	28	79	1744.5	1744	Yes
Lead	132	28	79	2171.5	1744	Yes
Magnesium	36	28	79	1999.5	1744	Yes
Manganese	36	28	79	1658.5	1744	No
Nickel	372	28	79	2056.5	1744	Yes
Potassium	36	28	79	2056.5	1744	Yes
Vanadium	36	28	79	1894.5	1744	Yes
Zinc	30	28	79	2277.5	1744	Yes
Surface Soil - Current (and Future) Conditions						
Barium	48	19	28	660	532	Yes
Beryllium	192	18	28	568	496	Yes
Cobalt	30	19	28	565	532	Yes
Copper	54	19	28	722	532	Yes
Iron	24	19	28	619.5	532	Yes
Lead	18	19	28	637.5	532	Yes
Mercury	2214	19	28	478.5	531	No
Nickel	114	19	28	705.5	532	Yes
Potassium	12	19	28	700	532	Yes

Appendix F
SLERA Site Reconnaissance Photographs and SLERA Risk Characterization Tables

This Appendix Contains:

Appendix F-1 SLERA Site Reconnaissance Photographs
Appendix F-2 SLERA Risk Characterization Tables

Appendix F-1
SLERA Site Reconnaissance Photographs

SWMU 39 – Southern Settling Pond Photographs

Photo F-1

Photo F-2

Photo F-3

Photo F-4

SWMU 39 – Northern Settling Pond Photographs

Photo F-5

Photo F-6

Photo F-7

Photo F-8

SWMU 39 – Northern Settling Pond Photographs, Continued

Photo F-9

Appendix F-2
SLERA Risk Characterization Tables

Table F-1
Data Used to Model Exposure[a] in the Indicator Wildlife Species

Indicator Species	Body Weight Range (average) (kg)	Average Home Range (ha) [ac]	Maximum Dietary Intake[b] (kg[dw]/day)	Average Dietary Intake[c] (kg[dw]/day)	Soil Intake[d] (%Diet) (Avg – Max) (kg[dw]/day)	Maximum Water Intake[b] (L/day)	Average Water Intake[c] (L/day)	Trophic Level	Dietary Composition
Meadow vole (*Microtus pennsylvanicus*)	0.0170-0.0524 (0.037)	0.036 [0.089]	0.010	0.0080	(2.4%) 0.00019-0.00024	0.0070	0.0051	Herbivore	Plants: 100%
Short-tailed shrew (*Blarina brevicauda*)	0.0125-0.0225 (0.015)	0.39 [0.96]	0.0030	0.0022	(10.4%) 0.00023-0.00031	0.0033	0.0023	Insectivore	Terr. Inverts: 100%
American robin (*Turdus migratorius*)	0.0635-0.103 (0.0773)	0.48 [1.2]	0.020	0.016	(4%) 0.00064-0.00080	0.013	0.011	Omnivore	Plants: 62% Terr Inverts: 38%
Red-tailed hawk (*Buteo jamaicensis*)	0.957-1.235 (1.134)	842 [2081]	0.063	0.059	(0%)	0.068	0.064	Carnivore	Mammals: 76% Birds: 24%
Red fox (*Vulpes vulpes*)	2.95-7.04 (4.53)	892 [2204]	0.34	0.24	(2.8%) 0.0067-0.0095	0.57	0.39	Carnivore	Mammals: 65% Birds: 14% Plants: 17% Terr. Inverts: 4%

[a] From USEPA (1993), except as noted.
[b] Maximum dietary and water intake based on appropriate allometric equation using maximum body weight.
[c] Average dietary and water intake based on appropriate allometric equation using average body weight.
[d] Soil ingestion rate based on estimated percent soil in diet (dry weight), and maximum or average dietary intake.

Allometric equations for mammals and birds from USEPA (1993), as follows, where FI = food ingestion (dry weight [dw]), WI = water ingestion, Wt = body weight, kg = kilogram, L = liter, and g = gram:

FI (kg/day) = 0.0687 $Wt^{0.822}$ for mammals (shrew, red fox, and mink),
FI (g/day) = 0.577 $Wt^{0.727}$ for herbivores (meadow vole),
FI (g/day) = 0.301 $Wt^{0.751}$ for non-passerine birds (red-tail hawk, great blue heron),
FI (g/day) = 0.398 $Wt^{0.850}$ for passerine birds (American robin).
WI (L/day) = 0.099 $Wt^{0.90}$ (Wt in kg) for mammals,
WI (L/day) = 0.059 $Wt^{0.67}$ (Wt in kg) for birds.

ha = hectare
ac = acre, and a hectare = 2.471 acres.

Notes:
The soil ingestion rate for the shrew set equal to the rate for the American woodcock (10.4% of diet), as both species feed predominantly on earthworms.
The soil ingestion rate for the American robin set equal to 48% of the American woodcock value (0.38 x 10.4% = 4%), based on a robin diet of 38% invertebrates (earthworms).

Table F-2
Recommended Bioaccumulation/Bioconcentration Factors or Regression Equations Utilized for the Soil-to-Plant Pathway at SWMU 39

Constituent	USEPA, 2000 [a]				Regression Equation [b]	Other BAF/BCF	Recommended Tier 1 (Maximum) BAF/BCF	Recommended Tier 2 (RME) BAF/BCF	Rationale for Recommended Tier 2 BAF/BCF
	Minimum BAF/BCF	Median BAF/BCF	90th Percentile BAF/BCF[b]	Maximum BAF/BCF					
2,3,7,8-TCDD TE (RME)	-[c]	-	-	-	Log (BCF)=-0.578(Log[Kow])+1.588	-	0.011[d]	0.0039[d]	Travis & Arms Kow Regression Eq.
Endrin Ketone	-	-	-	-	Log (BCF)=-0.578(Log[Kow])+1.588	-	0.0506[d]	0.0506[d]	Travis & Arms Kow Regression Eq.
Chromium	0.021	0.041	-	0.48	-	0.001 [f]	0.48	0.041	Median BAF from USEPA (2000)
Cobalt	0.0019	0.0075	-	0.045	-	0.054 [f]	0.054	0.0075	Median BAF from USEPA (2000).
Copper	0.0011	0.12432	0.63	7.4	ln (AGP)=0.39(ln[soil])+0.67	0.8 [f]	7.4	Regression Equation	Chemical-specific Regression Eq.
Iron	-	-	-	-	-	0.004 [f]	0.004	0.004	Value from IAEA (1994).
Lead	0.00011	0.0388	0.47	10.611	ln (AGP)=0.56(ln[soil])-1.33	0.0011 [f]	11	Regression Equation	Chemical-specific Regression Eq.
Mercury	0.0015[b]	0.65[b]	5	12[b]	ln (AGP)=0.54(ln[soil])-1.00	0.55 [e]	12	Regression Equation	Chemical-specific Regression Eq.
Nickel	0.00217	0.01786	1.4	22.2143	ln (AGP)=0.75(ln[soil])-2.22	0.18 [f]	22	Regression Equation	Chemical-specific Regression Eq.
Selenium	0.02	0.67189	3.0	77	ln (AGP)=1.1(ln[soil])-0.68	0.025 [e]	77	Regression Equation	Chemical-specific Regression Eq.
Thallium	--	--	--	--	--	0.0022 [e]	0.0022	0.0022	Value from Baes et al. (1984).
Zinc	0.00855	0.36616	1.8	34.2857	ln (APG)=0.56(ln[soil])+1.58	1.2 [e]	34	Regression Equation	Chemical-specific Regression Eq.

[a] USEPA, 2000, *Ecological Soil Screening Level Guidance*, Draft.

[b] Efroymson, R.A., et. al., 2001, *Uptake of Inorganic Chemicals from Soil by Plant Leaves: Regressions of Field Data*, Environ. Tox. Chem., 20:2561-2571 for AGP (above ground plant tissue concentration) and Travis and Arms (1988) for BCF.

[c] -- indicates that a BAF/BCF or regression equation is not available.

[d] Values estimated using Travis and Arms (1988) Kow regression equation, with the Tier 1 BCF using the lowest literature value and the Tier 2 BCF using the Kow estimated from syrres.com SMILES fragment summarized as follows:

Constituent	Tier 1 Log Kow	Tier 2 Log Kow	Tier 1 Reference
2,3,7,8-TCDD TE (RME)	6.15	6.92	Montgomery, 1996
Endrin Ketone	4.99	4.99	syrres.com

[e] Baes et al (1984); note: value from this reference used if no appropriate value available from IAEA (1994).

[f] IAEA (1994); note: value from this reference used, compared with Baes et al (1984), as IAEA (1994) is more current.

Table F-3

Recommended Bioaccumulation/Bioconcentration Factors or Regression Equations Utilized for the Soil-to-Earthworm Pathway at SWMU 39

Constituent	Sample, et. al.[a]			Regression Equation [b]	Beyer [c] BAF/BCF	Recommended Tier 1 (Maximum) BAF/BCF	Recommended Tier 2 (RME) BAF/BCF	Rationale for Tier 2 (RME) BAF/BCF
	Median BAF/BCF	90th Percentile BAF/BCF	Maximum BAF/BCF					
2,3,7,8-TCDD TE (RME)	--[d]	--	--	see footnote "b" below	--	72	72	Kow Regression Eq., using onsite TOC
Endrin Ketone	--	--	--	see footnote "b" below	--	66	66	Kow Regression Eq., using onsite TOC
Chromium	0.306	3.162	11.416	--	--	11	3.2	90th percentile value, from field studies.
Cobalt	0.122	0.291	0.321	--	--	0.32	0.29	90th percentile value, from field studies.
Copper	0.515	1.531	5.492	ln (EW)=0.24(ln[soil])+1.8	--	5.5	Regression Equation	Chemical-specific Regression Eq.
Iron	0.036	0.078	0.1	--	--	0.1	0.078	90th percentile value, from field studies.
Lead	0.266	1.522	228.261	ln (EW)=0.81(ln[soil])-0.21	--	228	Regression Equation	Chemical-specific Regression Eq.
Mercury	1.693	20.625	33	ln (EW)=0.33(ln[soil])+0.078	--	33	Regression Equation	Chemical-specific Regression Eq.
Nickel	1.059	4.73	7.802	--	--	7.8	4.7	90th percentile value, from field studies.
Selenium	0.985	1.34	13.733	ln (EW)=0.73(ln[soil])-0.075	--	14	Regression Equation	Chemical-specific Regression Eq.
Thallium	--	--	--	--	--	3.16	1.24	Geom. mean of 18 values, see Note (1).
Zinc	3.201	12.885	49.51	ln (EW)=0.33(ln[soil])+4.44	--	50	Regression Equation	Chemical-specific Regression Eq.

[a] Sample, B. E, et. al., 1998. Development and Validation of Bioaccumulation Models for Earthworms, ES/ER/TM-220.

[b] For Inorganics: Sample, B.E, et. al., 1999, Literature-Derived Bioaccumulation Models for Earthworms: Development and Validation, Environ. Toxicol. Chem., 18:2,110-2,120. (models from Table 3 of publication). EW = earthworm tissue concentration.
For Organics: Ecological Soil Screening Level (SSL) Guidance, USEPA, 2000 (Section 2.0 in Appendix 4-1, given site specific soil total organic carbon [TOC]).
Onsite TOC concentration (from one soil sample) is 0.46%.
Median Organic BAF presented, if available, from SSL (USEPA, 2000), or estimated using the following regression equation and log Kow values from http://esc.syrres.com/interkow:

$$BAF = \frac{10^{(\log Kow - 0.6)}}{foc * 10^{(0.983 * \log Kow + 0.00028)}}$$

Constituent	Log Kow	Constituent	Log Kow	Constituent	Log Kow
2,3,7,8-TCDD TE (RME)	6.92	Endrin	5.45	Endrin Ketone	4.99

[c] Beyer, W. N., 1990. Evaluating Soil Contamination, Biological Report 90(2), U.S. Department of the Interior, U.S. Fish and Wildlife Service.

[d] -- indicates that a BAF/BCF or regression equation is either not available or not recommended.

Note (1): For inorganics without BAF/BCF data, the following data (from Sample et al., 1998) were used to estimate Tier 1 and Tier 2 values:

	Max BAF/BCF	90th Percentile BAF/BCF		Max BAF/BCF	90th Percentile BAF/BCF
Aluminum	0.197	0.118	Mercury	33	20.625
Arsenic	0.925	0.523	Molybdenum	2.091	2.091
Barium	0.31	0.16	Nickel	7.802	4.73
Beryllium	1.429	1.182	Lead	228.261	1.522
Cadmium	190	40.69	Selenium	13.733	1.34
Chromium	11.416	3.162	Silver	19.5	15.338
Cobalt	0.321	0.291	Vanadium	0.088	0.088
Copper	5.492	1.531	Zinc	49.51	12.885
Iron	0.1	0.078			
Manganese	0.228	0.124	**Geometric Mean**	**3.16**	**1.24**

Table F-4
Recommended Bioaccumulation/Bioconcentration Factors Utilized for the Soil-to-Small Mammal and Bird Pathways at SWMU 39

Constituent	Sample et al., 1998 [a]						Recommended Tier 1 (Maximum) BAF/BCF	Recommended Tier 2 (90th Percentile - RME) BAF/BCF	Rationale for Recommended Tier 2 BAF/BCF
	Insectivore Median BAF/BCF	Herbivore Median BAF/BCF	Omnivore Median BAF/BCF	General [b] Median BAF/BCF	General [b] Maximum BAF/BCF	General [b] 90th percentile BAF/BCF			
2,3,7,8-TCDD TE (RME)	--[d]	1.2857	0.7783	1.07	2.2	2.2	2.2	2.2	General 90th percentile conservative for other groups' median.
Endrin Ketone	--	--	--	--	--	--	1[c]	0.5[c]	Conservative default values. See note c.
Chromium	0.0815	0.0884	0.0699	0.0846	0.8	0.3333	0.8	0.33	General 90th percentile conservative for other groups' median.
Cobalt	--	0.021	0.0158	0.0205	0.18	0.1	0.18	0.1	General 90th percentile value is upper bound.
Copper	0.7714	0.1086	0.1272	0.1963	1.398	1.045	1.4	1.1	General 90th percentile conservative for other groups' median.
Iron	--	0.0126	0.0124	0.0124	0.031	0.0171	0.031	0.017	General 90th percentile conservative for other groups' median.
Lead	0.1601	0.0522	0.0659	0.1054	2.659	0.2864	2.7	0.29	General 90th percentile conservative for other groups' median.
Mercury	1.046[e]	0.0239[e]	0.0543	0.0543	1.046	0.192	1.1	0.19	General 90th percentile value is upper bound.
Nickel	0.3643	0.0513	0.1683	0.2488	1.143	0.5891	1.1	0.59	General 90th percentile conservative for other groups' median.
Selenium	0.7241	0.0221[f]	0.2062	0.1619	1.754	1.1867	1.8	1.2	General 90th percentile conservative for other groups' median.
Thallium	--	--	0.1124	0.1124	0.123	0.1227	0.12	0.12	General 90th percentile value is upper bound.
Zinc	0.83277	0.50429	0.55772	0.7717	16.364	2.6878	16	2.7	General 90th percentile conservative for other groups' median.

[a] Sample et al., 1998, *Development and Validation of Bioaccumulation Models for Small Mammals,* ES/ER/TM-219.

[b] General = combination dataset used for insectivore, herbivore, and omnivore receptors to estimate a "general" receptor BAF/BCF value.

[c] Known bioaccumulative organics (TCDD and TCDF) have BAFs/BCFs of 1.1 and 0.13 (median) and 2.2 and 0.16 (maximum) from Sample et al. (1998). Conservative BAF/BCF default values of 1 and 0.5 were selected for other organics (Endrin, Endrin Ketone) at the site, as they are not expected to be as bioaccumulative as TCDD/TCDF.

[d] -- indicates that a BAF/BCF is not available.

[e] Only one BAF/BCF value available for exposure to mercury in soil (median is also 90th percentile value and maximum value).

[f] Mean value presented, as median value not given in Sample et al. (1998).

Notes:

(1) Bird BAF/BCF values were based on the recommended small mammal BAF/BCF values, as bird uptake values are not readily available.

Table F-5
NOAEL Toxicity Reference Values Used to Derive Wildlife Toxicity Benchmarks for Chemicals of Potential Ecological Concern at SWMU 39

COPEC	Mammalian Data				Avian Data			
	Toxicity Value	NOAEL (mg/kg/d)	Test Species	Reference	Toxicity Value	NOAEL (mg/kg/d)	Test Species	Reference
Organics								
2,3,7,8-TCDD-TE (RME)	--	1.0E-06	rat	Sample, et. al. (1996)	--	1.40E-05	ring-necked pheasant	Sample, et al. (1996)
Endrin ketone	--	0.092	mouse	Based on Endrin, Sample et. al. (1996)	--	0.3	mallard duck	Based on Endrin, Sample et. al. (1996)
Inorganics								
Chromium	--	2,737	rat	Sample, et. al. (1996)	--	1.0	black duck	Sample, et al. (1996)
Cobalt	--	1.2	rat	Terr. Tox. Database (USACHPPM, 2002)	--	1.3	chicken	Terr. Tox. Database (USACHPPM, 2002)
Copper	--	11.7	mink	Sample, et. al. (1996)	--	47	chicks	Sample, et al. (1996)
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Lead	--	8	rat	Sample, et. al. (1996)	--	3.85	American kestrel	Sample, et al. (1996)
Mercury	--	1.0	mink	Sample, et. al. (1996)	--	0.45	Japanese quail	Sample, et al. (1996)
Nickel	--	40	rat	Sample, et. al. (1996)	--	77.4	mallard duck	Sample, et al. (1996)
Selenium	--	0.2	rat	Sample, et. al. (1996)	--	0.5	mallard duck	Sample, et al. (1996)
Thallium	0.074 (LOAEL)	0.0074	rat	Sample, et. al. (1996)	23.7 (LD50)	0.237	pheasant	Hudson, et. al. (1984)
Zinc	--	160	rat	Sample, et. al. (1996)	--	14.5	hens	Sample, et al. (1996)

Notes:
NA indicates that the information is not available.

As recommended by Wentsel, et. al. (1996), Tri-Service Procedural Guidelines for Ecological Risk Assessments, the following adjustments were made to toxicity data when NOAEL or LOAEL data were not avaiable

- Subchronic LOAELs were converted to chronic NOAELs by dividing by a factor of 20.
- Chronic NOAELs were converted to chronic LOAELs by multiplying by a factor of 5.0.
- Subchronic NOAELs/LOAELs were converted to chronic NOAELs/LOAELs by dividing by a factor of 10.
- Chronic LOAELs were converted to chronic NOAELs by dividing by a factor of 10.
- LD_{50} concentrations were converted to chronic NOAELs by dividing by a factor of 100.
- LD_{50} concentrations were converted to chronic LOAELs by dividing by a factor of 20.

ATSDR, 1990, Toxicological Profile for Silver, U.S. Public Health Service
Eisler, 1987, PAH Hazards to Fish, Wildlife, and Invertebrates, A Synoptic Review.
Hudson et. al., 1984, Handbook of Toxicity of Pesticides to Wildlife.
IRIS database, USEPA, 2003.
Sample, et al., 1996, Toxicological Benchmarks for Wildlife.
Sax and Lewis, 1989, Dangerous Properties of Industrial Materials.
USACHPPM, 2002, Terrestrial Toxicity Database.

Table F-6
LOAEL Toxicity Reference Values Used to Derive Wildlife Toxicity Benchmarks for Chemicals of Potential Ecological Concern at SWMU 39

COPEC	Mammalian Data				Avian Data			
	Toxicity Value	LOAEL (mg/kg/d)	Test Species	Reference	Toxicity Value	LOAEL (mg/kg/d)	Test Species	Reference
Organics								
2,3,7,8-TCDD TE (RME)	--	1.0E-05	rat	Sample, et. al. (1996)	--	1.40E-04	ring-necked pheasant	Sample, et. al. (1996)
Endrin ketone	--	0.92	mouse	Based on Endrin, Sample et.al. (1996)	0.3 (NOAEL)	1.5	mallard duck	Based on Endrin, Sample et.al. (1996)
Inorganics								
Chromium	2,737 (NOAEL)	13,690	rat	Sample, et. al. (1996)	--	5.0	black duck	Sample, et al. (1996)
Cobalt	1.2 (NOAEL)	6.0	rat	Terr. Tox. Database (USACHPPM, 2002)	1.3 (NOAEL)	6.5	chicken	Terr. Tox. Database (USACHPPM, 2002)
Copper	--	15.1	mink	Sample, et. al. (1996)	--	62	chicks	Sample, et. al. (1996)
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Lead	--	80	rat	Sample, et. al. (1996)	--	38.5	American kestrel	Sample, et. al. (1996)
Mercury	1.0 (NOAEL)	5.0	mink	Sample, et. al. (1996)	--	0.9	Japanese quail	Sample, et. al. (1996)
Nickel	--	80	rat	Sample, et. al. (1996)	--	107	mallard duck	Sample, et. al. (1996)
Selenium	--	0.3	rat	Sample, et. al. (1996)	--	1.0	mallard duck	Sample, et. al. (1996)
Thallium	0.74 (Subchronic)	0.074	rat	Sample, et. al. (1996)	23.7 (LD_{50})	1.19	pheasant	Hudson et. al. (1984)
Zinc	--	320	rat	Sample, et. al. (1996)	--	131	hens	Sample, et. al. (1996)

Notes:
NA indicates that the information is not available.

As recommended by Wentsel, et. al. (1996), Tri-Service Procedural Guidelines for Ecological Risk Assessments, the following adjustments were made to toxicity data when NOAEL or LOAEL data were not avaiable

- Subchronic LOAELs were converted to chronic NOAELs by dividing by a factor of 20.
- Chronic NOAELs were converted to chronic LOAELs by multiplying by a factor of 5.0.
- Subchronic NOAELs/LOAELs were converted to chronic NOAELs/LOAELs by dividing by a factor of 10.
- Chronic LOAELs were converted to chronic NOAELs by dividing by a factor of 10.

ATSDR, 1990, Toxicological Profile for Silver, U.S. Public Health Service
Eisler, 1987, PAH Hazards to Fish, Wildlife, and Invertebrates, A Synoptic Review.
Hudson et. al., 1984, Handbook of Toxicity of Pesticides to Wildlife.
IRIS database, USEPA, 2003.
Sample, et al., 1996, Toxicological Benchmarks for Wildlife.
Sax and Lewis, 1989, Dangerous Properties of Industrial Materials.
USACHPPM, 2002, Terrestrial Toxicity Database.

Table F-7
Uncertainty Factors[a] for Ecological TRV[b] Extrapolations[c] at SWMU 39

Laboratory Animals (toxicity data base)		Selected Site Receptor Species	
Rat	G: Rattus F: Muridae O: Rodentia	Meadow vole	G: Microtus F: Muridae O: Rodentia
Mouse	G: Mus F: Muridae O: Rodentia	Short-tailed shrew	G: Blarina F: Soricidae O: Insectivora
Mink	G: Mustela F: Mustelidae O: Carnivora	American robin	G: Turdus F: Muscicapidae O: Passeriformes
Pheasant	G: Phasianus F: Phasianidae O: Galliformes	Red-tailed hawk	G: Buteo F: Accipitridae O: Ciconiiformes
Chick, Poultry	G: Gallus F: Phasianidae O: Galliformes	Red fox	G: Vulpes F: Canidae O: Carnivora
Black duck, Mallard	G: Anas F: Anatidae O: Anseriformes		
Japanese quail	G: Coturnix F: Phasianidae O: Galliformes		

[a] From ***Tri-Service Procedural Guidelines for Ecological Risk Assessment*** (Wentsel et al. 1996)
[b] TRV = Toxicity Reference Value
[c] Interclass extrapolations not performed; only within bird class or within mammal class.

The Uncertainty Factors Used for TRV Extrapolations are Summarized Below:

- Extrapolation between two different species = uncertainty factor of 2
- Extrapolation between two different genera (G) = uncertainty factor of 4
- Extrapolation between two different families (F) or orders (O) = uncertainty factor of 8
- Thus, for all extrapolations used in the SLERA food chain model (except for rat or mouse toxicity values extrapolated to the meadow vole), an uncertainty factor of 8 was used. For the latter, an uncertainty factor of 4 was used.

Table F-8
Tier 1 Chemicals of Potential Ecological Concern EEQs and Hazard Indices for Meadow Voles at SWMU 39

Hazard Estimate - Tier 1
Meadow Vole

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Soil Exposure Point Concentration	Units	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Plant BAF	Mammal BAF	Bird BAF	PDE Surface Water	PDE Sediment	PDE Soil	PDE Fish	PDE Aq. Invert.	PDE Terr. Invert.	PDE Plants	PDE Mammals	PDE Birds	Total PDE	Chemical-Specific Toxicity Value UF	NOAEL	Adjusted NOAEL	EEQ N	LOAEL	Adjusted LOAEL	EEQ L	Percent Contribution to EEQ N	Percent Contribution to EEQ L
							---------- unitless ----------						mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d			
2,3,7,8-TCDD TE (RME)	0.00E+00	mg/L	0.0E+00	mg/kg	2.07E-05	mg/kg	NA	NA	7.20E+01	1.10E-02	2.20E+00	2.20E+00	0.00E+00	0.00E+00	2.92E-07	NA	NA	0.00E+00	1.34E-07	0.00E+00	0.00E+00	4.26E-07	4	1.00E-06	2.50E-07	1.70E+00	1.00E-05	2.50E-06	1.70E-01	0.00%	0.00%
Endrin Ketone	0.00E+00	mg/L	0.0E+00	mg/kg	2.82E-03	mg/kg	NA	NA	6.60E+01	5.06E-02	1.00E+00	1.00E+00	0.00E+00	0.00E+00	3.98E-05	NA	NA	0.00E+00	8.39E-05	0.00E+00	0.00E+00	1.24E-04	4	9.20E-02	2.30E-02	5.38E-03	9.20E-01	2.30E-01	5.38E-04	0.00%	0.00%
Chromium	0.00E+00	mg/L	0.0E+00	mg/kg	9.51E+01	mg/kg	NA	NA	1.10E+01	4.80E-01	8.00E-01	8.00E-01	0.00E+00	0.00E+00	1.34E+00	NA	NA	0.00E+00	2.69E+01	0.00E+00	0.00E+00	2.82E+01	4	2.74E+03	6.84E+02	4.12E-02	1.37E+04	3.42E+03	8.24E-03	0.00%	0.00%
Cobalt	0.00E+00	mg/L	0.0E+00	mg/kg	2.90E+01	mg/kg	NA	NA	3.21E-01	5.40E-02	1.80E-01	1.80E-01	0.00E+00	0.00E+00	4.09E-01	NA	NA	0.00E+00	9.21E-01	0.00E+00	0.00E+00	1.33E+00	4	1.20E+00	3.00E-01	4.44E+00	6.00E+00	1.50E+00	8.87E-01	0.01%	0.01%
Copper	0.00E+00	mg/L	0.0E+00	mg/kg	3.75E+02	mg/kg	NA	NA	5.50E+00	7.40E+00	1.40E+00	1.40E+00	0.00E+00	0.00E+00	5.29E+00	NA	NA	0.00E+00	1.63E+03	0.00E+00	0.00E+00	1.64E+03	8	1.17E+01	1.46E+00	1.12E+03	1.51E+01	1.89E+00	8.68E+02	2.00%	12.40%
Iron	0.00E+00	mg/L	0.0E+00	mg/kg	5.28E+04	mg/kg	NA	NA	1.00E-01	0.004	3.10E-02	3.10E-02	0.00E+00	0.00E+00	7.45E+02	NA	NA	0.00E+00	1.24E+02	0.00E+00	0.00E+00	8.70E+02	8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0.00E+00	mg/L	0.0E+00	mg/kg	1.65E+04	mg/kg	NA	NA	2.28E+02	1.10E+01	2.70E+00	2.70E+00	0.00E+00	0.00E+00	2.33E+02	NA	NA	0.00E+00	1.07E+05	0.00E+00	0.00E+00	1.07E+05	4	8.00E+00	2.00E+00	5.35E+04	8.00E+01	2.00E+01	5.35E+03	95.35%	76.45%
Mercury	0.00E+00	mg/L	0.0E+00	mg/kg	1.02E-01	mg/kg	NA	NA	3.30E+01	1.20E+01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	1.44E-03	NA	NA	0.00E+00	7.20E-01	0.00E+00	0.00E+00	7.21E-01	8	1.00E+00	1.25E-01	5.77E+00	5.00E+00	6.25E-01	1.15E+00	0.01%	0.02%
Nickel	0.00E+00	mg/L	0.0E+00	mg/kg	3.81E+01	mg/kg	NA	NA	7.80E+00	2.20E+01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	5.38E-01	NA	NA	0.00E+00	4.93E+02	0.00E+00	0.00E+00	4.94E+02	4	4.00E+01	1.00E+01	4.94E+01	8.00E+01	2.00E+01	2.47E+01	0.09%	0.35%
Selenium	0.00E+00	mg/L	0.0E+00	mg/kg	1.20E+00	mg/kg	NA	NA	1.40E+01	7.70E+01	1.80E+00	1.80E+00	0.00E+00	0.00E+00	1.69E-02	NA	NA	0.00E+00	5.44E+01	0.00E+00	0.00E+00	5.44E+01	4	2.00E-01	5.00E-02	1.09E+03	3.30E-01	8.25E-02	6.59E+02	1.94%	9.42%
Thallium	0.00E+00	mg/L	0.0E+00	mg/kg	2.27E+01	mg/kg	NA	NA	3.16E+00	2.20E-03	1.20E-01	1.20E-01	0.00E+00	0.00E+00	3.20E-01	NA	NA	0.00E+00	2.94E-02	0.00E+00	0.00E+00	3.50E-01	4	7.40E-03	1.85E-03	1.89E+02	7.40E-02	1.85E-02	1.89E+01	0.34%	0.27%
Zinc	0.00E+00	mg/L	0.0E+00	mg/kg	3.01E+02	mg/kg	NA	NA	5.00E+01	3.40E+01	1.60E+01	1.60E+01	0.00E+00	0.00E+00	4.25E+00	NA	NA	0.00E+00	6.02E+03	0.00E+00	0.00E+00	6.02E+03	4	1.60E+02	4.00E+01	1.51E+02	3.20E+02	8.00E+01	7.53E+01	0.27%	1.08%
																						Hazard Index (Total EEQ):			5.6E+04			7.0E+03	100.00%	100.00%

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi \times Cij}{BW} \right) \right]_j \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (i) (mg/kg or mg/L)
BW = Body Weight

Notes:
Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR.
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EEQ = Ecological Effects Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
PDE = Predicted Daily Exposure
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box): [n] See text tables for equations.
If BAF/BCF regression equation produced Tier 2 value exceeding maximum Tier 1 BAF/BCF value, Tier 1 value used a default.
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Plant diet fraction =	1	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.00024	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.01	kg/d
Body weight =	0.017	kg
Home range =	0.089	acres
Water intake rate =	0.007	L/d
Site Area =	2.6	acres
Frac. home range (FHR) =	1.00E+00	unitless

Table F-9
Tier 2 Chemicals of Potential Ecological Concern EEQs and Hazard Indices for Meadow Voles at SWMU 39

Hazard Estimate - Tier 2
Meadow Vole

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Soil Exposure Point Concentration	Units	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Plant BAF	Mammal BAF	Bird BAF	PDE Surface Water	PDE Sediment	PDE Soil	PDE Fish	PDE Aq. Invert.	PDE Terr. Invert.	PDE Plants	PDE Mammals	PDE Birds	Total PDE	Chemical-Specific Toxicity Value UF	NOAEL	Adjusted NOAEL	EEQ N	LOAEL	Adjusted LOAEL	EEQ L	Percent Contribution to EEQ N	Percent Contribution to EEQ L
							---------- unitless ----------						mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d			
2,3,7,8-TCDD TE (RME)	0.00E+00	mg/L	0.0E+00	mg/kg	2.07E-05	mg/kg	NA	NA	7.20E+01	3.90E-03	2.20E+00	2.20E+00	0.00E+00	0.00E+00	1.06E-07	NA	NA	0.00E+00	1.74E-08	0.00E+00	0.00E+00	1.24E-07	4	1.00E-06	2.50E-07	4.94E-01	1.00E-05	2.50E-06	4.94E-02	0.87%	0.61%
Endrin Ketone	0.00E+00	mg/L	0.0E+00	mg/kg	2.82E-03	mg/kg	NA	NA	6.60E+01	5.06E-02	5.00E-01	5.00E-01	0.00E+00	0.00E+00	1.45E-05	NA	NA	0.00E+00	3.09E-05	0.00E+00	0.00E+00	4.53E-05	4	9.20E-02	2.30E-02	1.97E-03	9.20E-01	2.30E-01	1.97E-04	0.00%	0.00%
Chromium	0.00E+00	mg/L	0.0E+00	mg/kg	4.68E+01	mg/kg	NA	NA	3.20E+00	4.10E-02	3.30E-01	3.30E-01	0.00E+00	0.00E+00	2.40E-01	NA	NA	0.00E+00	4.15E-01	0.00E+00	0.00E+00	6.55E-01	4	2.74E+03	6.84E-02	9.57E-04	1.37E+04	3.42E+03	1.91E-04	0.00%	0.00%
Cobalt	0.00E+00	mg/L	0.0E+00	mg/kg	1.82E+01	mg/kg	NA	NA	2.90E-01	7.50E-03	1.00E-01	1.00E-01	0.00E+00	0.00E+00	9.32E-02	NA	NA	0.00E+00	2.94E-02	0.00E+00	0.00E+00	1.23E-01	4	1.20E+00	3.00E-01	4.09E-01	6.00E+00	1.50E+00	8.18E-02	0.72%	1.01%
Copper	0.00E+00	mg/L	0.0E+00	mg/kg	1.18E+02	mg/kg	NA	NA	1.61E-01	1.07E-01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	6.04E-01	NA	NA	0.00E+00	2.71E+00	0.00E+00	0.00E+00	3.32E+00	8	1.17E+01	1.46E+00	2.27E+00	1.51E+01	1.89E+00	1.76E+00	4.00%	21.65%
Iron	0.00E+00	mg/L	0.0E+00	mg/kg	3.52E+04	mg/kg	NA	NA	7.80E-02	4.00E-03	1.70E-02	1.70E-02	0.00E+00	0.00E+00	1.81E+02	NA	NA	0.00E+00	3.04E+01	0.00E+00	0.00E+00	2.11E+02	8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0.00E+00	mg/L	0.0E+00	mg/kg	1.28E+04	mg/kg	NA	NA	1.34E-01	4.12E-03	2.90E-01	2.90E-01	0.00E+00	0.00E+00	6.59E+01	NA	NA	0.00E+00	1.14E+01	0.00E+00	0.00E+00	7.74E+01	4	8.00E+00	2.00E+00	3.87E+01	8.00E+01	2.00E+01	3.87E+00	68.16%	47.66%
Mercury	0.00E+00	mg/L	0.0E+00	mg/kg	6.22E-02	mg/kg	NA	NA	6.95E+00	1.32E+00	1.90E-01	1.90E-01	0.00E+00	0.00E+00	3.19E-04	NA	NA	0.00E+00	1.77E-02	0.00E+00	0.00E+00	1.81E-02	8	1.00E+00	1.25E-01	1.45E-01	5.00E+00	6.25E-01	2.89E-02	0.25%	0.36%
Nickel	0.00E+00	mg/L	0.0E+00	mg/kg	2.40E+01	mg/kg	NA	NA	4.70E+00	4.90E-02	5.90E-01	5.90E-01	0.00E+00	0.00E+00	1.23E-01	NA	NA	0.00E+00	2.55E-01	0.00E+00	0.00E+00	3.78E-01	4	4.00E+01	1.00E+01	3.78E-02	8.00E+01	2.00E+01	1.89E-02	0.07%	0.23%
Selenium	0.00E+00	mg/L	0.0E+00	mg/kg	6.20E-01	mg/kg	NA	NA	1.06E+00	4.83E-01	1.20E+00	1.20E+00	0.00E+00	0.00E+00	3.18E-03	NA	NA	0.00E+00	6.47E-02	0.00E+00	0.00E+00	6.79E-02	4	2.00E-01	5.00E-02	1.36E+00	3.30E-01	8.25E-02	8.23E-01	2.39%	10.14%
Thallium	0.00E+00	mg/L	0.0E+00	mg/kg	4.28E+00	mg/kg	NA	NA	1.24E+00	2.20E-03	1.20E-01	1.20E-01	0.00E+00	0.00E+00	2.20E-02	NA	NA	0.00E+00	2.04E-03	0.00E+00	0.00E+00	2.40E-02	4	7.40E-03	1.85E-03	1.30E+01	7.40E-02	1.85E-02	1.30E+00	22.86%	15.99%
Zinc	0.00E+00	mg/L	0.0E+00	mg/kg	1.11E+02	mg/kg	NA	NA	3.62E+00	6.12E-01	2.70E+00	2.70E+00	0.00E+00	0.00E+00	5.69E-01	NA	NA	0.00E+00	1.47E+01	0.00E+00	0.00E+00	1.52E+01	4	1.60E+02	4.00E+01	3.81E-01	3.20E+02	8.00E+01	1.90E-01	0.67%	2.35%
																									Hazard Index (Total EEQ):					5.7E+01				8.1E+00	100.00%	100.00%

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi \, x \, Cij}{BW} \right) \right]_j \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR.
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EEQ = Ecological Effects Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
PDE = Predicted Daily Exposure
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box): n See text tables for equations.
If BAF/BCF regression equation produced Tier 2 value exceeding maximum Tier 1 BAF/BCF value, Tier 1 value used as default.
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Plant diet fraction =	1	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.00019	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.008	kg/d
Body weight =	0.037	kg
Home range =	0.089	acres
Water intake rate =	0.0051	L/d
Site Area =	2.6	acres
Frac. home range (FHR) =	1.00E+00	unitless

Table F-10
Tier 1 Chemicals of Potential Ecological Concern EEQs and Hazard Indices for Short-tailed Shrews at SWMU 39

Hazard Estimate - Tier 1
Short-tailed Shrew

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Soil Exposure Point Concentration	Units	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Plant BAF	Mammal BAF	Bird BAF	PDE Surface Water	PDE Sediment	PDE Soil	PDE Fish	PDE Aq. Invert.	PDE Terr. Invert.	PDE Plants	PDE Mammals	PDE Birds	Total PDE	Chemical-Specific Toxicity Value UF	NOAEL	Adjusted NOAEL	EEQ N	LOAEL	Adjusted LOAEL	EEQ L	Percent Contribution to EEQ N	Percent Contribution to EEQ L
							unitless						mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d			
2,3,7,8-TCDD TE (RME)	0.00E+00	mg/L	0.0E+00	mg/kg	2.07E-05	mg/kg	NA	NA	7.20E+01	1.10E-02	2.20E+00	2.20E+00	0.00E+00	0.00E+00	5.13E-07	NA	NA	3.57E-04	0.00E+00	0.00E+00	0.00E+00	3.58E-04	8	1.00E-06	1.25E-07	2.86E+03	1.00E-05	1.25E-06	2.86E+02	0.31%	0.31%
Endrin Ketone	0.00E+00	mg/L	0.0E+00	mg/kg	2.82E-03	mg/kg	NA	NA	6.60E+01	5.06E-02	1.00E+00	1.00E+00	0.00E+00	0.00E+00	6.99E-05	NA	NA	4.47E-02	0.00E+00	0.00E+00	0.00E+00	4.47E-02	8	9.20E-02	1.15E-02	3.89E+00	9.20E-01	1.15E-01	3.89E-01	0.00%	0.00%
Chromium	0.00E+00	mg/L	0.0E+00	mg/kg	9.51E+01	mg/kg	NA	NA	1.10E+01	4.80E-01	8.00E-01	8.00E-01	0.00E+00	0.00E+00	2.36E+00	NA	NA	2.51E+02	0.00E+00	0.00E+00	0.00E+00	2.53E+02	8	2.74E+03	3.42E+02	7.41E-01	1.37E+04	1.71E+03	1.48E-01	0.00%	0.00%
Cobalt	0.00E+00	mg/L	0.0E+00	mg/kg	2.90E+01	mg/kg	NA	NA	3.21E-01	5.40E-02	1.80E-01	1.80E-01	0.00E+00	0.00E+00	7.19E-01	NA	NA	2.23E+00	0.00E+00	0.00E+00	0.00E+00	2.95E+00	8	1.20E+00	1.50E-01	1.97E+01	6.00E+00	7.50E-01	3.94E+00	0.00%	0.00%
Copper	0.00E+00	mg/L	0.0E+00	mg/kg	3.75E+02	mg/kg	NA	NA	5.50E+00	7.40E+00	1.40E+00	1.40E+00	0.00E+00	0.00E+00	9.30E+00	NA	NA	4.95E+02	0.00E+00	0.00E+00	0.00E+00	5.04E+02	8	1.17E+01	1.46E+00	3.45E+02	1.51E+01	1.89E+00	2.67E+02	0.04%	0.29%
Iron	0.00E+00	mg/L	0.0E+00	mg/kg	5.28E+04	mg/kg	NA	NA	1.00E-01	0.004	3.10E-02	3.10E-02	0.00E+00	0.00E+00	1.31E+03	NA	NA	1.27E+03	0.00E+00	0.00E+00	0.00E+00	2.58E+03	8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0.00E+00	mg/L	0.0E+00	mg/kg	1.65E+04	mg/kg	NA	NA	2.28E+02	1.10E+01	2.70E+00	2.70E+00	0.00E+00	0.00E+00	4.09E+02	NA	NA	9.03E+05	0.00E+00	0.00E+00	0.00E+00	9.03E+05	8	8.00E+00	1.00E+00	9.03E+05	8.00E+01	1.00E+01	9.03E+04	97.54%	97.12%
Mercury	0.00E+00	mg/L	0.0E+00	mg/kg	1.02E-01	mg/kg	NA	NA	3.30E+01	1.20E+01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	2.53E+03	NA	NA	8.08E-01	0.00E+00	0.00E+00	0.00E+00	8.10E-01	8	1.00E+00	1.25E-01	6.48E+00	5.00E+00	6.25E-01	1.30E+00	0.00%	0.00%
Nickel	0.00E+00	mg/L	0.0E+00	mg/kg	3.81E+01	mg/kg	NA	NA	7.80E+00	2.20E+01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	9.45E-01	NA	NA	7.13E+01	0.00E+00	0.00E+00	0.00E+00	7.23E+01	8	4.00E+01	5.00E+00	1.45E+01	8.00E+01	1.00E+01	7.23E+00	0.00%	0.01%
Selenium	0.00E+00	mg/L	0.0E+00	mg/kg	1.20E+00	mg/kg	NA	NA	1.40E+01	7.70E+01	1.80E+00	1.80E+00	0.00E+00	0.00E+00	2.98E-02	NA	NA	4.03E+00	0.00E+00	0.00E+00	0.00E+00	4.06E+00	8	2.00E-01	2.50E-02	1.62E+02	3.30E-01	4.13E-02	9.85E+01	0.02%	0.11%
Thallium	0.00E+00	mg/L	0.0E+00	mg/kg	2.27E+01	mg/kg	NA	NA	3.16E+00	2.20E-03	1.20E-01	1.20E-01	0.00E+00	0.00E+00	5.63E-01	NA	NA	1.72E+01	0.00E+00	0.00E+00	0.00E+00	1.78E+01	8	7.40E-03	9.25E-04	1.92E+04	7.40E-02	9.25E-03	1.92E+03	2.08%	2.07%
Zinc	0.00E+00	mg/L	0.0E+00	mg/kg	3.01E+02	mg/kg	NA	NA	5.00E+01	3.40E+01	1.60E+01	1.60E+01	0.00E+00	0.00E+00	7.46E+00	NA	NA	3.61E+03	0.00E+00	0.00E+00	0.00E+00	3.62E+03	8	1.60E+02	2.00E+01	1.81E+02	3.20E+02	4.00E+01	9.05E+01	0.02%	0.10%
																							Hazard Index (Total EEQ):			9.3E+05			9.3E+04	100.00%	100.00%

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi \times Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
Tier 2 = EEQ using 95%-EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR.
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EEQ = Ecological Effects Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
PDE = Predicted Daily Exposure
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box): [n] See text tables for equations.
If BAF/BCF regression equation produced Tier 2 value exceeding maximum Tier 1 BAF/BCF value, Tier 1 value used a default.
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Plant diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	1	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.00031	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.003	kg/d
Body weight =	0.0125	kg
Home range =	0.96	acres
Water intake rate =	0.0033	L/d
Site Area =	2.6	acres
Frac. home range (FHR) =	1.00E+00	unitless

Table F-11
Tier 2 Chemicals of Potential Ecological Concern EEQs and Hazard Indices for Short-tailed Shrews at SWMU 39

Hazard Estimate - Tier 2
Short-tailed Shrew

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Soil Exposure Point Concentration	Units	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Plant BAF	Mammal BAF	Bird BAF	PDE Surface Water	PDE Sediment	PDE Soil	PDE Fish	PDE Aq. Invert.	PDE Terr. Invert.	PDE Plants	PDE Mammals	PDE Birds	Total PDE	Chemical-Specific Toxicity Value UF	NOAEL	Adjusted NOAEL	EEQ N	LOAEL	Adjusted LOAEL	EEQ L	Percent Contribution to EEQ N	Percent Contribution to EEQ L
							---------- unitless ----------						mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d			
2,3,7,8-TCDD TE (RME)	0.00E+00	mg/L	0.0E+00	mg/kg	2.07E-05	mg/kg	NA	NA	7.20E+01	3.90E-03	2.20E+00	2.20E+00	0.00E+00	0.00E+00	8.59E-07	NA	NA	5.91E-04	0.00E+00	0.00E+00	0.00E+00	5.92E-04	8	1.00E-06	1.25E-07	4.74E+03	1.00E-05	1.25E-06	4.74E+02	55.79%	54.47%
Endrin Ketone	0.00E+00	mg/L	0.0E+00	mg/kg	2.82E-03	mg/kg	NA	NA	6.60E+01	5.06E-02	5.00E-01	5.00E-01	0.00E+00	0.00E+00	1.17E-04	NA	NA	7.39E-02	0.00E+00	0.00E+00	0.00E+00	7.40E-02	8	9.20E-02	1.15E-02	6.44E+00	9.20E-01	1.15E-01	6.44E-01	0.08%	0.07%
Chromium	0.00E+00	mg/L	0.0E+00	mg/kg	4.68E+01	mg/kg	NA	NA	3.20E+00	4.10E-02	3.30E-01	3.30E-01	0.00E+00	0.00E+00	1.94E+00	NA	NA	5.95E+01	0.00E+00	0.00E+00	0.00E+00	6.14E+01	8	2.74E+03	3.42E+02	1.79E-01	1.37E+04	1.71E+03	3.59E-02	0.00%	0.00%
Cobalt	0.00E+00	mg/L	0.0E+00	mg/kg	1.82E+01	mg/kg	NA	NA	2.90E-01	7.50E-03	1.00E-01	1.00E-01	0.00E+00	0.00E+00	7.54E-01	NA	NA	2.09E+00	0.00E+00	0.00E+00	0.00E+00	2.84E+00	8	1.20E+00	1.50E-01	1.90E+01	6.00E+00	7.50E-01	3.79E+00	0.22%	0.44%
Copper	0.00E+00	mg/L	0.0E+00	mg/kg	1.18E+02	mg/kg	NA	NA	1.61E-01	1.07E-01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	4.89E+00	NA	NA	7.55E+00	0.00E+00	0.00E+00	0.00E+00	1.24E+01	8	1.17E+01	1.46E+00	8.50E+00	1.51E+01	1.89E+00	6.59E+00	0.10%	0.76%
Iron	0.00E+00	mg/L	0.0E+00	mg/kg	3.52E+04	mg/kg	NA	NA	7.80E-02	4.00E-03	1.70E-02	1.70E-02	0.00E+00	0.00E+00	1.46E+03	NA	NA	1.09E+03	0.00E+00	0.00E+00	0.00E+00	2.55E+03	8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0.00E+00	mg/L	0.0E+00	mg/kg	1.28E+04	mg/kg	NA	NA	1.34E-01	4.12E-03	2.90E-01	2.90E-01	0.00E+00	0.00E+00	5.33E+02	NA	NA	6.85E+02	0.00E+00	0.00E+00	0.00E+00	1.22E+03	8	8.00E+00	1.00E+00	1.22E+03	8.00E+01	1.00E+01	1.22E+02	14.35%	14.01%
Mercury	0.00E+00	mg/L	0.0E+00	mg/kg	6.22E-02	mg/kg	NA	NA	6.95E+00	1.32E+00	1.90E-01	1.90E-01	0.00E+00	0.00E+00	2.58E-03	NA	NA	1.72E-01	0.00E+00	0.00E+00	0.00E+00	1.74E-01	8	1.00E+00	1.25E-01	1.39E+00	5.00E+00	6.25E-01	2.79E-01	0.02%	0.03%
Nickel	0.00E+00	mg/L	0.0E+00	mg/kg	2.40E+01	mg/kg	NA	NA	4.70E+00	4.90E-02	5.90E-01	5.90E-01	0.00E+00	0.00E+00	9.98E-01	NA	NA	4.49E+01	0.00E+00	0.00E+00	0.00E+00	4.59E+01	8	4.00E+01	5.00E+00	9.18E+00	8.00E+01	1.00E+01	4.59E+00	0.11%	0.53%
Selenium	0.00E+00	mg/L	0.0E+00	mg/kg	6.20E-01	mg/kg	NA	NA	1.06E+00	4.83E-01	1.20E+00	1.20E+00	0.00E+00	0.00E+00	2.57E-02	NA	NA	2.60E-01	0.00E+00	0.00E+00	0.00E+00	2.86E-01	8	2.00E-01	2.50E-02	1.14E+01	3.30E-01	4.13E-02	6.93E+00	0.13%	0.80%
Thallium	0.00E+00	mg/L	0.0E+00	mg/kg	4.28E+00	mg/kg	NA	NA	1.24E+00	2.20E-03	1.20E-01	1.20E-01	0.00E+00	0.00E+00	1.78E-01	NA	NA	2.11E+00	0.00E+00	0.00E+00	0.00E+00	2.29E+00	8	7.40E-03	9.25E-04	2.47E+03	7.40E-02	9.25E-03	2.47E+02	29.10%	28.41%
Zinc	0.00E+00	mg/L	0.0E+00	mg/kg	1.11E+02	mg/kg	NA	NA	3.62E+00	6.12E-01	2.70E+00	2.70E+00	0.00E+00	0.00E+00	4.60E+00	NA	NA	1.59E+02	0.00E+00	0.00E+00	0.00E+00	1.64E+02	8	1.60E+02	2.00E+01	8.19E+00	3.20E+02	4.00E+01	4.10E+00	0.10%	0.47%
																							Hazard Index (Total EEQ):			8.5E+03			8.7E+02	100.00%	100.00%

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi \, x \, Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR.
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EEQ = Ecological Effects Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
PDE = Predicted Daily Exposure
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box): [0] See text tables for equations.
If BAF/BCF regression equation produced Tier 2 value exceeding maximum Tier 1 BAF/BCF value, Tier 1 value used as default.
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.

Species-Specific Factors

Plant diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	1	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.00023	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.0022	kg/d
Body weight =	0.015	kg
Home range =	0.96	acres
Water intake rate =	0.0023	L/d
Site Area =	2.6	acres
Frac. home range (FHR) =	2.71E+00	unitless

Table F-12
Tier 1 Chemicals of Potential Ecological Concern EEQs and Hazard Indices for American Robins at SWMU 39

Hazard Estimate - Tier 1
American Robin

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Soil Exposure Point Concentration	Units	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Plant BAF	Mammal BAF	Bird BAF	PDE Surface Water	PDE Sediment	PDE Soil	PDE Fish	PDE Aq. Invert.	PDE Terr. Invert.	PDE Plants	PDE Mammals	PDE Birds	Total PDE	Chemical-Specific Toxicity Value UF	NOAEL	Adjusted NOAEL	EEQ N	LOAEL	Adjusted LOAEL	EEQ L	Percent Contribution to EEQ N	Percent Contribution to EEQ L
							---------- unitless ----------						mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d			
2,3,7,8-TCDD TE (RME)	0.00E+00	mg/L	0.0E+00	mg/kg	2.07E-05	mg/kg	NA	NA	7.20E+01	1.10E-02	2.20E+00	2.20E+00	0.00E+00	0.00E+00	2.60E-07	NA	NA	1.78E-04	4.44E-08	0.00E+00	0.00E+00	1.78E-04	8	1.40E-05	1.75E-06	1.02E+02	1.40E-04	1.75E-05	1.02E+01	0.01%	0.01%
Endrin Ketone	0.00E+00	mg/L	0.0E+00	mg/kg	2.82E-03	mg/kg	NA	NA	6.60E+01	5.06E-02	1.00E+00	1.00E+00	0.00E+00	0.00E+00	3.55E-05	NA	NA	2.23E-02	2.79E-05	0.00E+00	0.00E+00	2.23E-02	8	3.00E-01	3.75E-02	5.96E-01	1.50E+00	1.88E-01	1.19E-01	0.00%	0.00%
Chromium	0.00E+00	mg/L	0.0E+00	mg/kg	9.51E+01	mg/kg	NA	NA	1.10E+01	4.80E-01	8.00E-01	8.00E-01	0.00E+00	0.00E+00	1.20E+00	NA	NA	1.25E+02	8.91E+00	0.00E+00	0.00E+00	1.35E+02	8	1.00E+00	1.25E-01	1.08E+03	5.00E+00	6.25E-01	2.17E+02	0.11%	0.21%
Cobalt	0.00E+00	mg/L	0.0E+00	mg/kg	2.90E+01	mg/kg	NA	NA	3.21E-01	5.40E-02	1.80E-01	1.80E-01	0.00E+00	0.00E+00	3.65E-01	NA	NA	1.11E+00	3.06E-01	0.00E+00	0.00E+00	1.79E+00	8	1.30E+00	1.63E 01	1.10E+01	6.50E+00	8.13E-01	2.20E+00	0.00%	0.00%
Copper	0.00E+00	mg/L	0.0E+00	mg/kg	3.75E+02	mg/kg	NA	NA	5.50E+00	7.40E+00	1.40E+00	1.40E+00	0.00E+00	0.00E+00	4.72E+00	NA	NA	2.47E+02	5.42E+02	0.00E+00	0.00E+00	7.93E+02	8	4.70E+01	5.88E+00	1.35E+02	6.20E+01	7.75E+00	1.02E+02	0.01%	0.10%
Iron	0.00E+00	mg/L	0.0E+00	mg/kg	5.28E+04	mg/kg	NA	NA	1.00E-01	0.004	3.10E-02	3.10E-02	0.00E+00	0.00E+00	6.65E+02	NA	NA	6.32E+02	4.12E+01	0.00E+00	0.00E+00	1.34E+03	8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0.00E+00	mg/L	0.0E+00	mg/kg	1.65E+04	mg/kg	NA	NA	2.28E+02	1.10E+01	2.70E+00	2.70E+00	0.00E+00	0.00E+00	2.08E+02	NA	NA	4.50E+05	3.54E+04	0.00E+00	0.00E+00	4.86E+05	8	3.85E+00	4.81E-01	1.01E+06	3.85E+01	4.81E+00	1.01E+05	99.60%	99.21%
Mercury	0.00E+00	mg/L	0.0E+00	mg/kg	1.02E-01	mg/kg	NA	NA	3.30E+01	1.20E+01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	1.29E-03	NA	NA	4.03E-01	2.39E-01	0.00E+00	0.00E+00	6.43E-01	8	4.50E-01	5.63E-02	1.14E+01	9.00E-01	1.13E-01	5.72E+00	0.00%	0.01%
Nickel	0.00E+00	mg/L	0.0E+00	mg/kg	3.81E+01	mg/kg	NA	NA	7.80E+00	2.20E+01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	4.80E-01	NA	NA	3.56E+01	1.64E+02	0.00E+00	0.00E+00	2.00E+02	8	7.74E+01	9.68E+00	2.06E+01	1.07E+02	1.34E+01	1.49E+01	0.00%	0.01%
Selenium	0.00E+00	mg/L	0.0E+00	mg/kg	1.20E+00	mg/kg	NA	NA	1.40E+01	7.70E+01	1.80E+00	1.80E+00	0.00E+00	0.00E+00	1.51E-02	NA	NA	2.01E+00	1.80E+01	0.00E+00	0.00E+00	2.01E+01	8	5.00E-01	6.25E-02	3.21E+02	1.00E+00	1.25E-01	1.61E+02	0.03%	0.16%
Thallium	0.00E+00	mg/L	0.0E+00	mg/kg	2.27E+01	mg/kg	NA	NA	3.16E+00	2.20E-03	1.20E-01	1.20E-01	0.00E+00	0.00E+00	2.86E-01	NA	NA	8.59E+00	9.75E-03	0.00E+00	0.00E+00	8.88E+00	8	2.37E-01	2.96E-02	3.00E+02	1.19E+00	1.49E-01	5.97E+01	0.03%	0.06%
Zinc	0.00E+00	mg/L	0.0E+00	mg/kg	3.01E+02	mg/kg	NA	NA	5.00E+01	3.40E+01	1.60E+01	1.60E+01	0.00E+00	0.00E+00	3.79E+00	NA	NA	1.80E+03	2.00E+03	0.00E+00	0.00E+00	3.80E+03	8	1.45E+01	1.81E+00	2.10E+03	1.31E+02	1.64E+01	2.32E+02	0.21%	0.23%
																							Hazard Index (Total EEQ):			1.0E+06			1.0E+05	100.00%	100.00%

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi \times Cij}{BW} \right) \right]^{1} \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR.
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EEQ = Ecological Effects Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
PDE = Predicted Daily Exposure
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box): [n] See text tables for equations.
If BAF/BCF regression equation produced Tier 2 value exceeding maximum Tier 1 BAF/BCF value, Tier 1 value used a default.
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Plant diet fraction =	0.62	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0.38	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.0008	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.02	kg/d
Body weight =	0.0635	kg
Home range =	1.2	acres
Water intake rate =	0.013	L/d
Site Area =	2.6	acres
Frac. home range (FHR) =	1.00E+00	unitless

Table F-13
Tier 2 Chemicals of Potential Ecological Concern EEQs and Hazard Indices for American Robins at SWMU 39

Hazard Estimate - Tier 2
American Robin

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Soil Exposure Point Concentration	Units	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Plant BAF	Mammal BAF	Bird BAF	PDE Surface Water	PDE Sediment	PDE Soil	PDE Fish	PDE Aq. Invert.	PDE Terr. Invert.	PDE Plants	PDE Mammals	PDE Birds	Total PDE	Chemical-Specific Toxicity Value UF	NOAEL	Adjusted NOAEL	EEQ N	LOAEL	Adjusted LOAEL	EEQ L	Percent Contribution to EEQ N	Percent Contribution to EEQ L
							---------- unitless ----------						mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d			
2,3,7,8-TCDD TE (RME)	0.00E+00	mg/L	0.0E+00	mg/kg	2.07E-05	mg/kg	NA	NA	7.20E+01	3.90E-03	2.20E+00	2.20E+00	0.00E+00	0.00E+00	3.71E-07	NA	NA	2.54E-04	2.24E-08	0.00E+00	0.00E+00	2.54E-04	8	1.40E-05	1.75E-06	1.45E+02	1.40E-04	1.75E-05	1.45E+01	9.19%	7.70%
Endrin Ketone	0.00E+00	mg/L	0.0E+00	mg/kg	2.82E-03	mg/kg	NA	NA	6.60E+01	5.06E-02	5.00E-01	5.00E-01	0.00E+00	0.00E+00	5.06E-05	NA	NA	3.17E-02	3.97E-05	0.00E+00	0.00E+00	3.18E-02	8	3.00E-01	3.75E-02	8.48E-01	1.50E+00	1.88E-01	1.70E-01	0.05%	0.09%
Chromium	0.00E+00	mg/L	0.0E+00	mg/kg	4.68E+01	mg/kg	NA	NA	3.20E+00	4.10E-02	3.30E-01	3.30E-01	0.00E+00	0.00E+00	8.39E-01	NA	NA	2.55E+01	5.33E-01	0.00E+00	0.00E+00	2.69E+01	8	1.00E+00	1.25E-01	2.15E+02	5.00E+00	6.25E-01	4.30E+01	13.61%	22.82%
Cobalt	0.00E+00	mg/L	0.0E+00	mg/kg	1.82E+01	mg/kg	NA	NA	2.90E-01	7.50E-03	1.00E-01	1.00E-01	0.00E+00	0.00E+00	3.26E-01	NA	NA	8.97E-01	3.79E-02	0.00E+00	0.00E+00	1.26E+00	8	1.30E+00	1.63E-01	7.76E+00	6.50E+00	8.13E-01	1.55E+00	0.49%	0.82%
Copper	0.00E+00	mg/L	0.0E+00	mg/kg	1.18E+02	mg/kg	NA	NA	1.61E-01	1.07E-01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	2.11E+00	NA	NA	3.24E+00	3.49E+00	0.00E+00	0.00E+00	8.84E+00	8	4.70E+01	5.88E+00	1.50E+00	6.20E+01	7.75E+00	1.14E+00	0.10%	0.61%
Iron	0.00E+00	mg/L	0.0E+00	mg/kg	3.52E+04	mg/kg	NA	NA	7.80E-02	4.00E-03	1.70E-02	1.70E-02	0.00E+00	0.00E+00	6.32E+02	NA	NA	4.68E+02	3.92E+01	0.00E+00	0.00E+00	1.14E+03	8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0.00E+00	mg/L	0.0E+00	mg/kg	1.28E+04	mg/kg	NA	NA	1.34E-01	4.12E-03	2.90E-01	2.90E-01	0.00E+00	0.00E+00	2.30E+02	NA	NA	2.94E+02	1.47E+01	0.00E+00	0.00E+00	5.39E+02	8	3.85E+00	4.81E-01	1.12E+03	3.85E+01	4.81E+00	1.12E+02	70.89%	59.43%
Mercury	0.00E+00	mg/L	0.0E+00	mg/kg	6.22E-02	mg/kg	NA	NA	6.95E+00	1.32E+00	1.90E-01	1.90E-01	0.00E+00	0.00E+00	1.12E-03	NA	NA	7.37E-02	2.28E-02	0.00E+00	0.00E+00	9.76E-02	8	4.50E-01	5.63E-02	1.74E+00	9.00E-01	1.13E-01	8.68E-01	0.11%	0.46%
Nickel	0.00E+00	mg/L	0.0E+00	mg/kg	2.40E+01	mg/kg	NA	NA	4.70E+00	4.90E-02	5.90E-01	5.90E-01	0.00E+00	0.00E+00	4.31E-01	NA	NA	1.93E+01	3.28E-01	0.00E+00	0.00E+00	2.00E+01	8	7.74E+01	9.68E+00	2.07E+00	1.07E+02	1.34E+01	1.50E+00	0.13%	0.79%
Selenium	0.00E+00	mg/L	0.0E+00	mg/kg	6.20E-01	mg/kg	NA	NA	1.06E+00	4.83E-01	1.20E+00	1.20E+00	0.00E+00	0.00E+00	1.11E-02	NA	NA	1.12E-01	8.33E-02	0.00E+00	0.00E+00	2.06E-01	8	5.00E-01	6.25E-02	3.29E+00	1.00E+00	1.25E-01	1.65E+00	0.21%	0.87%
Thallium	0.00E+00	mg/L	0.0E+00	mg/kg	4.28E+00	mg/kg	NA	NA	1.24E+00	2.20E-03	1.20E-01	1.20E-01	0.00E+00	0.00E+00	7.68E-02	NA	NA	9.04E-01	2.62E-03	0.00E+00	0.00E+00	9.84E-01	8	2.37E-01	2.96E-02	3.32E+01	1.19E+00	1.49E-01	6.61E+00	2.10%	3.51%
Zinc	0.00E+00	mg/L	0.0E+00	mg/kg	1.11E+02	mg/kg	NA	NA	3.62E+00	6.12E-01	2.70E+00	2.70E+00	0.00E+00	0.00E+00	1.99E+00	NA	NA	6.83E+01	1.89E+01	0.00E+00	0.00E+00	8.92E+01	8	1.45E+01	1.81E+00	4.92E+01	1.31E+02	1.64E+01	5.45E+00	3.11%	2.89%
																									Hazard Index (Total EEQ):				1.6E+03			1.9E+02	100.00%	100.00%

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi \times Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR.
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EEQ = Ecological Effects Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
PDE = Predicted Daily Exposure
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box): n See text tables for equations.
If BAF/BCF regression equation produced Tier 2 value exceeding maximum Tier 1 BAF/BCF value, Tier 1 value used as default.
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Plant diet fraction =	0.62	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0.38	unitless
Mammal diet fraction =	0	unitless
Bird diet fraction =	0	unitless
Soil ingestion rate =	0.00064	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.016	kg/d
Body weight =	0.0773	kg
Home range =	1.2	acres
Water intake rate =	0.011	L/d
Site Area =	2.6	acres
Frac. home range (FHR) =	2.17E+00	unitless

Table F-14
Tier 1 Chemicals of Potential Ecological Concern EEQs and Hazard Indices for Red-Tailed Hawks at SWMU 39

Hazard Estimate - Tier 1
Red-Tailed Hawk

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Soil Exposure Point Concentration	Units	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Plant BAF	Mammal BAF	Bird BAF	PDE Surface Water	PDE Sediment	PDE Soil	PDE Fish	PDE Aq. Invert.	PDE Terr. Invert.	PDE Plants	PDE Mammals	PDE Birds	Total PDE	Chemical-Specific Toxicity Value UF	NOAEL	Adjusted NOAEL	EEQ N	LOAEL	Adjusted LOAEL	EEQ L	Percent Contribution to EEQ N	Percent Contribution to EEQ L
							---------- unitless ----------						mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d			
2,3,7,8-TCDD TE (RME)	0.00E+00	mg/L	0.0E+00	mg/kg	2.07E-05	mg/kg	NA	NA	7.20E+01	1.10E-02	2.20E+00	2.20E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	2.28E-06	7.19E-07	2.99E-06	8	1.40E-05	1.75E-06	1.71E+00	1.40E-04	1.75E-05	1.71E-01	0.03%	0.03%
Endrin Ketone	0.00E+00	mg/L	0.0E+00	mg/kg	2.82E-03	mg/kg	NA	NA	6.60E+01	5.06E-02	1.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	1.41E-04	4.46E-05	1.86E-04	8	3.00E-01	3.75E-02	4.95E-03	1.50E+00	1.88E-01	9.90E-04	0.00%	0.00%
Chromium	0.00E+00	mg/L	0.0E+00	mg/kg	9.51E+01	mg/kg	NA	NA	1.10E+01	4.80E-01	8.00E-01	8.00E-01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	3.81E+00	1.20E+00	5.01E+00	8	1.00E+00	1.25E-01	4.01E+01	5.00E+00	6.25E-01	8.01E+00	0.63%	1.24%
Cobalt	0.00E+00	mg/L	0.0E+00	mg/kg	2.90E+01	mg/kg	NA	NA	3.21E-01	5.40E-02	1.80E-01	1.80E-01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	2.61E-01	8.25E-02	3.44E-01	8	1.30E+00	1.63E-01	2.11E+00	6.50E+00	8.13E-01	4.23E-01	0.03%	0.07%
Copper	0.00E+00	mg/L	0.0E+00	mg/kg	3.75E+02	mg/kg	NA	NA	5.50E+00	7.40E+00	1.40E+00	1.40E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	2.63E+01	8.29E+00	3.46E+01	8	4.70E+01	5.88E+00	5.88E+00	6.20E+01	7.75E+00	4.46E+00	0.09%	0.69%
Iron	0.00E+00	mg/L	0.0E+00	mg/kg	5.28E+04	mg/kg	NA	NA	1.00E-01	0.004	3.10E-02	3.10E-02	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	8.19E+01	2.59E+01	1.08E+02	8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0.00E+00	mg/L	0.0E+00	mg/kg	1.65E+04	mg/kg	NA	NA	2.28E+02	1.10E+01	2.70E+00	2.70E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	2.23E+03	7.04E+02	2.93E+03	8	3.85E+00	4.81E-01	6.09E+03	3.85E+01	4.81E+00	6.09E+02	96.31%	94.56%
Mercury	0.00E+00	mg/L	0.0E+00	mg/kg	1.02E-01	mg/kg	NA	NA	3.30E+01	1.20E+01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	5.61E-03	1.77E-03	7.39E-03	8	4.50E-01	5.63E-02	1.31E-01	9.00E-01	1.13E-01	6.57E-02	0.00%	0.01%
Nickel	0.00E+00	mg/L	0.0E+00	mg/kg	3.81E+01	mg/kg	NA	NA	7.80E+00	2.20E+01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	2.10E+00	6.62E-01	2.76E+00	8	7.74E+01	9.68E+00	2.85E-01	1.07E+02	1.34E+01	2.06E-01	0.00%	0.03%
Selenium	0.00E+00	mg/L	0.0E+00	mg/kg	1.20E+00	mg/kg	NA	NA	1.40E+01	7.70E+01	1.80E+00	1.80E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	1.08E-01	3.41E-02	1.42E-01	8	5.00E-01	6.25E-02	2.28E+00	1.00E+00	1.25E-01	1.14E+00	0.04%	0.18%
Thallium	0.00E+00	mg/L	0.0E+00	mg/kg	2.27E+01	mg/kg	NA	NA	3.16E+00	2.20E-03	1.20E-01	1.20E-01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	1.36E-01	4.30E-02	1.79E-01	8	2.37E-01	2.96E-02	6.05E+00	1.19E+00	1.49E-01	1.21E+00	0.10%	0.19%
Zinc	0.00E+00	mg/L	0.0E+00	mg/kg	3.01E+02	mg/kg	NA	NA	5.00E+01	3.40E+01	1.60E+01	1.60E+01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	2.41E+02	7.61E+01	3.17E+02	8	1.45E+01	1.81E+00	1.75E+02	1.31E+02	1.64E+01	1.94E+01	2.76%	3.00%
																						Hazard Index (Total EEQ):			6.3E+03			6.4E+02	100.00%	100.00%

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi \times Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR.
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EEQ = Ecological Effects Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
PDE = Predicted Daily Exposure
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box): [n] See text tables for equations.
If BAF/BCF regression equation produced Tier 2 value exceeding maximum Tier 1 BAF/BCF value, Tier 1 value used a default.
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Plant diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0	unitless
Mammal diet fraction =	0.76	unitless
Bird diet fraction =	0.24	unitless
Soil ingestion rate =	0	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.063	kg/d
Body weight =	0.957	kg
Home range =	2081	acres
Water intake rate =	0.068	L/d
Site Area =	2.6	acres
Frac. home range (FHR) =	1.00E+00	unitless

Table F-15
Tier 2 Chemicals of Potential Ecological Concern EEQs and Hazard Indices for Red-Tailed Hawks at SWMU 39

Hazard Estimate - Tier 2
Red-Tailed Hawk

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Soil Exposure Point Concentration	Units	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Plant BAF	Mammal BAF	Bird BAF	PDE Surface Water	PDE Sediment	PDE Soil	PDE Fish	PDE Aq. Invert.	PDE Terr. Invert.	PDE Plants	PDE Mammals	PDE Birds	Total PDE	Chemical-Specific Toxicity Value UF	NOAEL	Adjusted NOAEL	EEQ N	LOAEL	Adjusted LOAEL	EEQ L	Percent Contribution to EEQ N	Percent Contribution to EEQ L
							unitless						mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d			
2,3,7,8-TCDD TE (RME)	0.00E+00	mg/L	0.0E+00	mg/kg	2.07E-05	mg/kg	NA	NA	7.20E+01	3.90E-03	2.20E+00	2.20E+00	0.00E+00	0.00E+00	0.00F+00	NA	NA	0.00E+00	0.00E+00	2.25E-09	7.10E-10	2.96E-09	8	1.40E-05	1.75E-06	1.69E-03	1.40E-04	1.75E-05	1.69E-04	0.32%	0.31%
Endrin Ketone	0.00E+00	mg/L	0.0E+00	mg/kg	2.82E-03	mg/kg	NA	NA	6.60E+01	5.06E-02	5.00E-01	5.00E-01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	6.97E-08	2.20E-08	9.17E-08	8	3.00E-01	3.75E-02	2.44E-06	1.50E+00	1.88E-01	4.89E-07	0.00%	0.00%
Chromium	0.00E+00	mg/L	0.0E+00	mg/kg	4.68E+01	mg/kg	NA	NA	3.20E+00	4.10E-02	3.30E-01	3.30E-01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	7.63E-04	2.41E-04	1.00E-03	8	1.00E+00	1.25E-01	8.03E-03	5.00E+00	6.25E-01	1.61E-03	1.52%	2.91%
Cobalt	0.00E+00	mg/L	0.0E+00	mg/kg	1.82E+01	mg/kg	NA	NA	2.90E-01	7.50E-03	1.00E-01	1.00E-01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	8.97E-05	2.83E-05	1.18E-04	8	1.30E+00	1.63E-01	7.26E-04	6.50E+00	8.13E-01	1.45E-04	0.14%	0.26%
Copper	0.00E+00	mg/L	0.0E+00	mg/kg	1.18E+02	mg/kg	NA	NA	1.61E-01	1.07E-01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	6.40E-03	2.02E-03	8.42E-03	8	4.70E+01	5.88E+00	1.43E-03	6.20E+01	7.75E+00	1.09E-03	0.27%	1.97%
Iron	0.00E+00	mg/L	0.0E+00	mg/kg	3.52E+04	mg/kg	NA	NA	7.80E-02	4.00E-03	1.70E-02	1.70E-02	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	2.96E-02	9.34E-03	3.89E-02	8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0.00E+00	mg/L	0.0E+00	mg/kg	1.28E+04	mg/kg	NA	NA	1.34E-01	4.12E-03	2.90E-01	2.90E-01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	1.84E-01	5.81E-02	2.42E-01	8	3.85E+00	4.81E-01	5.03E-01	3.85E+01	4.81E+00	5.03E-02	95.33%	91.15%
Mercury	0.00E+00	mg/L	0.0E+00	mg/kg	6.22E-02	mg/kg	NA	NA	6.95E+00	1.32E+00	1.90E-01	1.90E-01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	5.84E-07	1.84E-07	7.68E-07	8	4.50E-01	5.63E-02	1.37E-05	9.00E-01	1.13E-01	6.83E-06	0.00%	0.01%
Nickel	0.00E+00	mg/L	0.0E+00	mg/kg	2.40E+01	mg/kg	NA	NA	4.70E+00	4.90E-02	5.90E-01	5.90E-01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	7.01E-04	2.21E-04	9.22E-04	8	7.74E+01	9.68E+00	9.53E-05	1.07E+02	1.34E+01	6.89E-05	0.02%	0.12%
Selenium	0.00E+00	mg/L	0.0E+00	mg/kg	6.20E-01	mg/kg	NA	NA	1.06E+00	4.83E-01	1.20E+00	1.20E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	3.68E-05	1.16E-05	4.84E-05	8	5.00E-01	6.25E-02	7.74E-04	1.00E+00	1.25E-01	3.87E-04	0.15%	0.70%
Thallium	0.00E+00	mg/L	0.0E+00	mg/kg	4.28E+00	mg/kg	NA	NA	1.24E+00	2.20E-03	1.20E-01	1.20E-01	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	2.54E-05	8.01E-06	3.34E-05	8	2.37E-01	2.96E-02	1.13E-03	1.19E+00	1.49E-01	2.24E-04	0.21%	0.41%
Zinc	0.00E+00	mg/L	0.0E+00	mg/kg	1.11E+02	mg/kg	NA	NA	3.62E+00	6.12E-01	2.70E+00	2.70E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00	1.48E-02	4.67E-03	1.95E-02	8	1.45E+01	1.81E+00	1.07E-02	1.31E+02	1.64E+01	1.19E-03	2.03%	2.15%
																							Hazard Index (Total EEQ):			5.3E-01			5.5E-02	100.00%	100.00%

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi \, x \, Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR.
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EEQ = Ecological Effects Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
PDE = Predicted Daily Exposure
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box): n See text tables for equations.
If BAF/BCF regression equation produced Tier 2 value exceeding maximum Tier 1 BAF/BCF value, Tier 1 value used as default.
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Plant diet fraction =	0	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0	unitless
Mammal diet fraction =	0.76	unitless
Bird diet fraction =	0.24	unitless
Soil ingestion rate =	0	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.059	kg/d
Body weight =	1.134	kg
Home range =	2081	acres
Water intake rate =	0.064	L/d
Site Area =	2.6	acres
Frac. home range (FHR) =	1.25E-03	unitless

Table F-16
Tier 1 Chemicals of Potential Ecological Concern EEQs and Hazard Indices for Red Foxes at SWMU 39

Hazard Estimate - Tier 1
Red Fox

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Soil Exposure Point Concentration	Units	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Plant BAF	Mammal BAF	Bird BAF	PDE Surface Water	PDE Sediment	PDE Soil	PDE Fish	PDE Aq. Invert.	PDE Terr. Invert.	PDE Plants	PDE Mammals	PDE Birds	Total PDE	Chemical-Specific Toxicity Value UF	NOAEL	Adjusted NOAEL	EEQ N	LOAEL	Adjusted LOAEL	EEQ L	Percent Contribution to EEQ N	Percent Contribution to EEQ L
							---------- unitless ----------						mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d			
2,3,7,8-TCDD TE (RME)	0.00E+00	mg/L	0.0E+00	mg/kg	2.07E-05	mg/kg	NA	NA	7.20E+01	1.10E-02	2.20E+00	2.20E+00	0.00E+00	0.00E+00	6.66E-08	NA	NA	6.86E-06	4.46E-09	3.41E-06	7.34E-07	1.11E-05	8	1.00E-06	1.25E-07	8.86E+01	1.00E-05	1.25E-06	8.86E+00	0.34%	0.33%
Endrin Ketone	0.00E+00	mg/L	0.0E+00	mg/kg	2.82E-03	mg/kg	NA	NA	6.60E+01	5.06E-02	1.00E+00	1.00E+00	0.00E+00	0.00E+00	9.08E-06	NA	NA	8.58E-04	2.80E-06	2.11E-04	4.55E-05	1.13E-03	8	9.20E-02	1.15E-02	9.80E-02	9.20E-01	1.15E-01	9.80E-03	0.00%	0.00%
Chromium	0.00E+00	mg/L	0.0E+00	mg/kg	9.51E+01	mg/kg	NA	NA	1.10E+01	4.80E-01	8.00E-01	8.00E-01	0.00E+00	0.00E+00	3.06E-01	NA	NA	4.82E+00	8.94E-01	5.70E+00	1.23E+00	1.30E+01	8	2.74E+03	3.42E+02	3.79E-02	1.37E+04	1.71E+03	7.57E-03	0.00%	0.00%
Cobalt	0.00E+00	mg/L	0.0E+00	mg/kg	2.90E+01	mg/kg	NA	NA	3.21E-01	5.40E-02	1.80E-01	1.80E-01	0.00E+00	0.00E+00	9.34E-02	NA	NA	4.29E-02	3.07E-02	3.91E-01	8.42E-02	6.42E-01	8	1.20E+00	1.50E-01	4.28E+00	6.00E+00	7.50E-01	8.56E-01	0.02%	0.03%
Copper	0.00E+00	mg/L	0.0E+00	mg/kg	3.75E+02	mg/kg	NA	NA	5.50E+00	7.40E+00	1.40E+00	1.40E+00	0.00E+00	0.00E+00	1.21E+00	NA	NA	9.51E+00	5.44E+01	3.93E+01	8.47E+00	1.13E+02	8	1.17E+01	1.46E+00	7.72E+01	1.51E+01	1.89E+00	5.98E+01	0.30%	2.21%
Iron	0.00E+00	mg/L	0.0E+00	mg/kg	5.28E+04	mg/kg	NA	NA	1.00E-01	0.004	3.10E-02	3.10E-02	0.00E+00	0.00E+00	1.70E+02	NA	NA	2.43E+01	4.14E+00	1.23E+02	2.64E+01	3.48E+02	8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0.00E+00	mg/L	0.0E+00	mg/kg	1.65E+04	mg/kg	NA	NA	2.28E+02	1.10E+01	2.70E+00	2.70E+00	0.00E+00	0.00E+00	5.31E+01	NA	NA	1.73E+04	3.56E+03	3.34E+03	7.19E+02	2.50E+04	8	8.00E+00	1.00E+00	2.50E+04	8.00E+01	1.00E+01	2.50E+03	96.16%	92.23%
Mercury	0.00E+00	mg/L	0.0E+00	mg/kg	1.02E-01	mg/kg	NA	NA	3.30E+01	1.20E+01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	3.28E-04	NA	NA	1.55E-02	2.40E-02	8.41E-03	1.81E-03	5.00E-02	8	1.00E+00	1.25E-01	4.00E-01	5.00E+00	6.25E-01	8.01E-02	0.00%	0.00%
Nickel	0.00E+00	mg/L	0.0E+00	mg/kg	3.81E+01	mg/kg	NA	NA	7.80E+00	2.20E+01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	1.23E-01	NA	NA	1.37E+00	1.64E+01	3.14E+00	6.76E-01	2.17E+01	8	4.00E+01	5.00E+00	4.35E+00	8.00E+01	1.00E+01	2.17E+00	0.02%	0.08%
Selenium	0.00E+00	mg/L	0.0E+00	mg/kg	1.20E+00	mg/kg	NA	NA	1.40E+01	7.70E+01	1.80E+00	1.80E+00	0.00E+00	0.00E+00	3.86E-03	NA	NA	7.75E-02	1.81E+00	1.62E-01	3.49E-02	2.09E+00	8	2.00E-01	2.50E-02	8.35E+01	3.30E-01	4.13E-02	5.06E+01	0.32%	1.87%
Thallium	0.00E+00	mg/L	0.0E+00	mg/kg	2.27E+01	mg/kg	NA	NA	3.16E+00	2.20E-03	1.20E-01	1.20E-01	0.00E+00	0.00E+00	7.31E-02	NA	NA	3.31E-01	9.78E-04	2.04E-01	4.40E-02	6.53E-01	8	7.40E-03	9.25E-04	7.06E+02	7.40E-02	9.25E-03	7.06E+01	2.71%	2.60%
Zinc	0.00E+00	mg/L	0.0E+00	mg/kg	3.01E+02	mg/kg	NA	NA	5.00E+01	3.40E+01	1.60E+01	1.60E+01	0.00E+00	0.00E+00	9.69E-01	NA	NA	6.94E+01	2.01E+02	3.61E+02	7.77E+01	7.09E+02	8	1.60E+02	2.00E+01	3.55E+01	3.20E+02	4.00E+01	1.77E+01	0.14%	0.65%
																						Hazard Index (Total EEQ):			2.6E+04			2.7E+03	100.00%	100.00%

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRixCij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR.
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EEQ = Ecological Effects Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
PDE = Predicted Daily Exposure
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box): n See text tables for equations.
If BAF/BCF regression equation produced Tier 2 value exceeding maximum Tier 1 BAF/BCF value, Tier 1 value used a default.
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Plant diet fraction =	0.17	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0.04	unitless
Mammal diet fract on =	0.65	unitless
Bird diet fraction =	0.14	unitless
Soil ingestion rate =	0.0095	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.34	kg/d
Body weight =	2.95	kg
Home range =	2204	acres
Water intake rate =	0.57	L/d
Site Area =	2.6	acres
Frac. home range (FHR) =	1.00E+00	unitless

Table F-17
Tier 2 Chemicals of Potential Ecological Concern EEQs and Hazard Indices for Red Foxes at SWMU 39

Hazard Estimate - Tier 2
Red Fox

Chemical	Surface Water Exposure Point Concentration	Units	Sediment Exposure Point Concentration	Units	Soil Exposure Point Concentration	Units	Fish BAF	Aq. Invert. BAF	Terr. Invert. BAF	Plant BAF	Mammal BAF	Bird BAF	PDE Surface Water	PDE Sediment	PDE Soil	PDE Fish	PDE Aq. Invert.	PDE Terr. Invert.	PDE Plants	PDE Mammals	PDE Birds	Total PDE	Chemical-Specific Toxicity Value UF	NOAEL	Adjusted NOAEL	EEQ N	LOAEL	Adjusted LOAEL	EEQ L	Percent Contribution to EEQ N	Percent Contribution to EEQ L
							---------- unitless ----------						mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d		mg/kg-d	mg/kg-d			
2,3,7,8-TCDD TE (RME)	0.00E+00	mg/L	0.0E+00	mg/kg	2.07E-05	mg/kg	NA	NA	7.20E+01	3.90E-03	2.20E+00	2.20E+00	0.00E+00	0.00E+00	3.61E-11	NA	NA	3.72E-09	8.57E-13	1.85E-09	3.98E-10	6.00E-09	8	1.00E-06	1.25E-07	4.80E-02	1.00E-05	1.25E-06	4.80E-03	15.13%	13.25%
Endrin Ketone	0.00E+00	mg/L	0.0E+00	mg/kg	2.82E-03	mg/kg	NA	NA	6.60E+01	5.06E-02	5.00E-01	5.00E-01	0.00E+00	0.00E+00	4.92E-09	NA	NA	4.65E-07	1.52E-09	5.73E-08	1.23E-08	5.41E-07	8	9.20E-02	1.15E-02	4.71E-05	9.20E-01	1.15E-01	4.71E-06	0.01%	0.01%
Chromium	0.00E+00	mg/L	0.0E+00	mg/kg	4.68E+01	mg/kg	NA	NA	3.20E+00	4.10E-02	3.30E-01	3.30E-01	0.00E+00	0.00E+00	8.16E-05	NA	NA	3.74E-04	2.04E-05	6.27E-04	1.35E-04	1.24E-03	8	2.74E+03	3.42E+02	3.62E-06	1.37E+04	1.71E+03	7.24E-07	0.00%	0.00%
Cobalt	0.00E+00	mg/L	0.0E+00	mg/kg	1.82E+01	mg/kg	NA	NA	2.90E-01	7.50E-03	1.00E-01	1.00E-01	0.00E+00	0.00E+00	3.17E-05	NA	NA	1.32E-05	1.45E-06	7.37E-05	1.59E-05	1.36E-04	8	1.20E+00	1.50E-01	9.06E-04	6.00E+00	7.50E-01	1.81E-04	0.29%	0.50%
Copper	0.00E+00	mg/L	0.0E+00	mg/kg	1.18E+02	mg/kg	NA	NA	1.61E-01	1.07E-01	1.10E+00	1.10E+00	0.00E+00	0.00E+00	2.05E-04	NA	NA	4.75E-05	1.33E-04	5.26E-03	1.13E-03	6.78E-03	8	1.17E+01	1.46E+00	4.63E-03	1.51E+01	1.89E+00	3.59E-03	1.46%	9.91%
Iron	0.00E+00	mg/L	0.0E+00	mg/kg	3.52E+04	mg/kg	NA	NA	7.80E-02	4.00E-03	1.70E-02	1.70E-02	0.00E+00	0.00E+00	6.14E-02	NA	NA	6.87E-03	1.50E-03	2.43E-02	5.24E-03	9.93E-02	8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	0.00E+00	mg/L	0.0E+00	mg/kg	1.28E+04	mg/kg	NA	NA	1.34E-01	4.12E-03	2.90E-01	2.90E-01	0.00E+00	0.00E+00	2.24E-02	NA	NA	4.31E-03	5.62E-04	1.51E-01	3.26E-02	2.11E-01	8	8.00E+00	1.00E+00	2.11E-01	8.00E+01	1.00E+01	2.11E-02	66.51%	58.25%
Mercury	0.00E+00	mg/L	0.0E+00	mg/kg	6.22E-02	mg/kg	NA	NA	6.95E+00	1.32E+00	1.90E-01	1.90E-01	0.00E+00	0.00E+00	1.08E-07	NA	NA	1.08E-06	8.72E-07	4.80E-07	1.03E-07	2.64E-06	8	1.00E+00	1.25E-01	2.12E-05	5.00E+00	6.25E-01	4.23E-06	0.01%	0.01%
Nickel	0.00E+00	mg/L	0.0E+00	mg/kg	2.40E+01	mg/kg	NA	NA	4.70E+00	4.90E-02	5.90E-01	5.90E-01	0.00E+00	0.00E+00	4.19E-05	NA	NA	2.82E-04	1.25E-05	5.76E-04	1.24E-04	1.04E-03	8	4.00E+01	5.00E+00	2.07E-04	8.00E+01	1.00E+01	1.04E-04	0.07%	0.29%
Selenium	0.00E+00	mg/L	0.0E+00	mg/kg	6.20E-01	mg/kg	NA	NA	1.06E+00	4.83E-01	1.20E+00	1.20E+00	0.00E+00	0.00E+00	1.08E-06	NA	NA	1.64E-06	3.18E-06	3.02E-05	6.51E-06	4.26E-05	8	2.00E-01	2.50E-02	1.71E-03	3.30E-01	4.13E-02	1.03E-03	0.54%	2.85%
Thallium	0.00E+00	mg/L	0.0E+00	mg/kg	4.28E+00	mg/kg	NA	NA	1.24E+00	2.20E-03	1.20E-01	1.20E-01	0.00E+00	0.00E+00	7.47E-06	NA	NA	1.33E-05	1.00E-07	2.09E-05	4.49E-06	4.62E-05	8	7.40E-03	9.25E-04	4.99E-02	7.40E-02	9.25E-03	4.99E-03	15.73%	13.77%
Zinc	0.00E+00	mg/L	0.0E+00	mg/kg	1.11E+02	mg/kg	NA	NA	3.62E+00	6.12E-01	2.70E+00	2.70E+00	0.00E+00	0.00E+00	1.93E-04	NA	NA	1.00E-03	7.20E-04	1.22E-02	2.62E-03	1.67E-02	8	1.60E+02	2.00E+01	8.35E-04	3.20E+02	4.00E+01	4.17E-04	0.26%	1.15%
																							Hazard Index (Total EEQ):			3.2E-01			3.6E-02	100.00%	100.00%

Intake Equation:

$$Ej = \left(\frac{A}{HR} \left[\sum_{i=1}^{m} \left(\frac{IRi \times Cij}{BW} \right) \right] \right)$$

Where:
Ej = Total Exposure to Chemical
A = Site Area
HR = Home Range
m = Total number of ingested media
i = counter
IRi = Consumption Rate for Medium
Cij = Chemical concentration (j) in medium (I) (mg/kg or mg/L)
BW = Body Weight

Notes:
Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.
Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR.
BAF = Bioaccumulation Factor (may be BCF if this is the only value available)
EEQ = Ecological Effects Quotient.
L = LOAEL based; N = NOAEL based
LOAEL = Lowest Observed Adverse Effect Level
NOAEL = No Observed Adverse Effect Level
NA = Not applicable/Not available
PDE = Predicted Daily Exposure
BAF (or BCF) values from appropriate text tables (BCF = bioconcentration factor)
Some BAF (or BCF) values based on media regression equations (value in box): n See text tables for equations.
If BAF/BCF regression equation produced Tier 2 value exceeding maximum Tier 1 BAF/BCF value, Tier 1 value used as default.
LOAEL and NOAEL values from appropriate toxicity summary tables in the text.
UF = Uncertainty Factor for toxicity factor extrapolation, and Adjusted LOAEL or NOAEL = LOAEL/UF or NOAEL/UF
A "0" entry in the exposure concentration column indicates this chemical not selected as a COPEC for this medium.
Receptor diet data and home range data from appropriate text table.
Exposure point concentrations (EPCs) from appropriate text tables.

Species-Specific Factors

Plant diet fraction =	0.17	unitless
Fish diet fraction =	0	unitless
Aq. Invert diet fraction =	0	unitless
Terr. Invert diet fraction =	0.04	unitless
Mammal diet fraction =	0.65	unitless
Bird diet fraction =	0.14	unitless
Soil ingestion rate =	0.0067	kg/d
Sediment ingestion rate =	0	kg/d
Food ingestion rate =	0.24	kg/d
Body weight =	4.53	kg
Home range =	2204	acres
Water intake rate =	0.39	L/d
Site Area =	2.6	acres
Frac. home range (FHR) =	1.18E-03	unitless

Table F-18
Comparison of Maximum Detection Limits for Not Detected Compounds in Surface Soil to Ecological Screening Values for SWMU 39

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Ecological Screening Toxicity Value (3)	Region III BTAG Screening Levels	Above Screening Toxicity Value? Y/N
Surface Soil (0 - 2 ft.)	99-35-4	1,3,5-Trinitrobenzene			mg/kg		0/8	1.00E-01 - 4.88E-01	4.88E-01	3.76E-01	NVA	Y
	99-65-0	1,3-Dinitrobenzene			mg/kg		0/8	1.00E-01 - 4.96E-01	4.96E-01	6.55E-01	NVA	N
	118-96-7	2,4,6-Trinitrotoluene			mg/kg		0/8	2.00E-01 - 4.56E-01	4.56E-01	7.00E-01	NVA	N
	35572-78-2	2-amino-4,6-Dinitrotoluene			mg/kg		0/5	2.00E-01 - 2.00E-01	2.00E-01	5.30E+00	NVA	N
	88-72-2	2-Nitrotoluene			mg/kg		0/5	4.00E-01 - 4.00E-01	4.00E-01	4.10E+00	NVA	N
	99-08-1	3-Nitrotoluene			mg/kg		0/5	4.00E-01 - 4.00E-01	4.00E-01	5.30E+00	NVA	N
	19406-51-0	4-amino-2,6-Dinitrotoluene			mg/kg		0/5	2.00E-01 - 2.00E-01	2.00E-01	3.60E+00	NVA	N
	99-99-0	4-Nitrotoluene			mg/kg		0/5	4.00E-01 - 4.00E-01	4.00E-01	9.40E+00	NVA	N
	121-82-4	Cyclonite			mg/kg		0/8	2.00E-01 - 5.87E-01	5.87E-01	5.80E+00	NVA	N
	2691-41-0	HMX			mg/kg		0/8	2.00E-01 - 6.66E-01	6.66E-01	4.30E+01	NVA	N
	78-11-5	Pentaerythritol tetranitrate			mg/kg		0/5	3.31E-01 - 3.68E-01	3.68E-01	1.40E+04	NVA	N
	479-45-8	Tetryl			mg/kg		0/8	2.00E-01 - 7.31E-01	7.31E-01	2.00E+00	NVA	N
	93-76-5	2,4,5-T			mg/kg		0/3	1.10E-01 - 1.22E-01	1.22E-01	5.96E-01	NVA	N
	93-72-1	2,4,5-TP (Silvex)			mg/kg		0/3	1.10E-01 - 1.22E-01	1.22E-01	1.09E-01	NVA	Y
	94-75-7	2,4-D			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	2.73E-02	NVA	Y
	94-82-6	2,4-DB			mg/kg		0/3	1.10E+00 - 1.22E+00	1.22E+00	NVA	NVA	N
	72-55-9	4,4'-DDE			mg/kg		0/6	7.36E-04 - 3.10E-01	3.10E-01	5.96E-01	1.00E-01	Y
	50-29-3	4,4'-DDT			mg/kg		0/5	7.36E-04 - 3.10E-01	3.10E-01	1.75E-02	1.00E-01	Y
	309-00-2	Aldrin			mg/kg		0/6	7.36E-04 - 3.30E-01	3.30E-01	3.32E-03	1.00E-01	Y
	319-84-6	alpha-BHC			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	9.94E-02	NVA	Y
	319-85-7	beta-BHC			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	3.98E-03	NVA	Y
	75-99-0	Dalapon			mg/kg		0/3	1.10E+00 - 1.22E+00	1.22E+00	NVA	NVA	N
	319-86-8	delta-BHC			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	9.94E+00	1.00E-01	Y
	1918-00-9	Dicamba			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	NVA	NVA	N
	120-36-5	Dichloroprop			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	NVA	NVA	N
	60-57-1	Dieldrin			mg/kg		0/6	7.36E-04 - 3.10E-01	3.10E-01	1.10E-02	1.00E-01	Y
	959-98-8	Endosulfan I			mg/kg		0/6	7.36E-04 - 6.20E-01	6.20E-01	1.19E-01	NVA	Y
	33213-65-9	Endosulfan II			mg/kg		0/6	7.36E-04 - 6.20E-01	6.20E-01	1.19E-01	NVA	Y
	1031-07-8	Endosulfan sulfate			mg/kg		0/6	7.36E-04 - 6.20E-01	6.20E-01	3.58E-02	NVA	Y

Table F-18
Comparison of Maximum Detection Limits for Not Detected Compounds in Surface Soil to Ecological Screening Values for SWMU 39

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Ecological Screening Toxicity Value (3)	Region III BTAG Screening Levels	Above Screening Toxicity Value? Y/N
	58-89-9	gamma-BHC (Lindane)			mg/kg		0/6	7.36E-04 - 2.70E-01	2.70E-01	5.00E-03	1.00E-01	Y
	76-44-8	Heptachlor			mg/kg		0/6	7.36E-04 - 1.30E-01	1.30E-01	5.98E-03	NVA	Y
	1024-57-3	Heptachlor epoxide			mg/kg		0/6	7.36E-04 - 3.30E-01	3.30E-01	1.52E-01	1.00E-01	Y
	94-74-6	MCPA			mg/kg		0/3	1.10E+02 - 1.22E+02	1.22E+02	NVA	NVA	N
	93-65-2	MCPP			mg/kg		0/3	1.10E+02 - 1.22E+02	1.22E+02	NVA	NVA	N
	8001-35-2	Toxaphene			mg/kg		0/6	3.68E-02 - 2.60E+00	2.60E+00	1.19E-01	NVA	Y
	12674-11-2	Aroclor 1016			mg/kg		0/8	3.68E-02 - 1.40E+00	1.40E+00	3.71E-01	1.00E-01	Y
	11104-28-2	Aroclor 1221			mg/kg		0/8	7.36E-02 - 1.40E+00	1.40E+00	3.71E-01	1.00E-01	Y
	11141-16-5	Aroclor 1232			mg/kg		0/8	3.68E-02 - 1.40E+00	1.40E+00	3.71E-01	1.00E-01	Y
	53469-21-9	Aroclor 1242			mg/kg		0/8	3.68E-02 - 1.40E+00	1.40E+00	3.71E-01	1.00E-01	Y
	12672-29-6	Aroclor 1248			mg/kg		0/8	3.68E-02 - 2.00E+00	2.00E+00	3.71E-01	1.00E-01	Y
	11097-69-1	Aroclor 1254			mg/kg		0/8	3.68E-02 - 2.30E+00	2.30E+00	3.71E-01	1.00E-01	Y
	11096-82-5	Aroclor 1260			mg/kg		0/8	3.68E-02 - 2.60E+00	2.60E+00	3.71E-01	1.00E-01	Y
	120-82-1	1,2,4-Trichlorobenzene			mg/kg		0/9	4.00E-02 - 4.50E-01	4.50E-01	2.00E+01	1.00E-01	Y
	95-50-1	1,2-Dichlorobenzene			mg/kg		0/9	1.10E-01 - 4.50E-01	4.50E-01	2.96E+00	1.00E-01	Y
	122-66-7	1,2-Diphenylhydrazine			mg/kg		0/9	1.40E-01 - 4.50E-01	4.50E-01	NVA	NVA	N
	541-73-1	1,3-Dichlorobenzene			mg/kg		0/9	1.30E-01 - 4.50E-01	4.50E-01	3.77E+01	NVA	N
	106-46-7	1,4-Dichlorobenzene			mg/kg		0/9	9.80E-02 - 4.50E-01	4.50E-01	2.00E+01	1.00E-01	Y
	95-95-4	2,4,5-Trichlorophenol			mg/kg		0/9	1.00E-01 - 1.10E+00	1.10E+00	9.00E+00	1.00E-01	Y
	88-06-2	2,4,6-Trichlorophenol			mg/kg		0/9	1.70E-01 - 4.50E-01	4.50E-01	4.00E+00	1.00E-01	Y
	120-83-2	2,4-Dichlorophenol			mg/kg		0/9	1.80E-01 - 4.50E-01	4.50E-01	8.75E+01	1.00E-01	Y
	105-67-9	2,4-Dimethylphenol			mg/kg		0/9	4.10E-01 - 6.90E-01	6.90E-01	1.00E-02	1.00E-01	Y
	51-28-5	2,4-Dinitrophenol			mg/kg		0/9	1.20E+00 - 2.20E+00	2.20E+00	2.00E+01	1.00E-01	Y
	606-20-2	2,6-Dinitrotoluene			mg/kg		0/14	8.50E-02 - 4.50E-01	4.50E-01	3.28E-02	NVA	Y
	91-58-7	2-Chloronaphthalene			mg/kg		0/9	3.60E-02 - 4.50E-01	4.50E-01	1.22E-02	NVA	Y
	95-57-8	2-Chlorophenol			mg/kg		0/9	6.00E-02 - 4.50E-01	4.50E-01	2.43E-01	1.00E-01	Y
	91-57-6	2-Methylnaphthalene			mg/kg		0/9	4.90E-02 - 4.50E-01	4.50E-01	3.24E+00	NVA	N
	88-74-4	2-Nitroaniline			mg/kg		0/9	6.20E-02 - 2.20E+00	2.20E+00	7.41E+01	NVA	N
	88-75-5	2-Nitrophenol			mg/kg		0/9	1.40E-01 - 4.50E-01	4.50E-01	1.60E+00	NVA	N
	88-85-7	2-sec-butyl-4,6-dinitrophenol			mg/kg		0/3	2.21E-01 - 2.45E-01	2.45E-01	2.18E-02	NVA	Y
	NA	3&4-Methylphenol			mg/kg		0/6	4.10E-01 - 4.50E-01	4.50E-01	3.49E+00	1.00E-01	Y
	91-94-1	3,3'-Dichlorobenzidine			mg/kg		0/9	8.00E-01 - 6.30E+00	6.30E+00	6.46E-01	NVA	Y
	99-09-2	3-Nitroaniline			mg/kg		0/9	4.50E-01 - 2.20E+00	2.20E+00	3.16E+00	NVA	N

Table F-18
Comparison of Maximum Detection Limits for Not Detected Compounds in Surface Soil to Ecological Screening Values for SWMU 39

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Ecological Screening Toxicity Value (3)	Region III BTAG Screening Levels	Above Screening Toxicity Value? Y/N
	534-52-1	4,6-Dinitro-o-cresol			mg/kg		0/9	5.50E-01 - 2.20E+00	2.20E+00	1.44E-01	NVA	Y
	100-01-6	4-Nitroaniline			mg/kg		0/9	4.10E-01 - 2.20E+00	2.20E+00	2.19E+01	NVA	N
	100-02-7	4-Nitrophenol			mg/kg		0/9	1.40E+00 - 2.20E+00	2.20E+00	7.00E+00	1.00E-01	Y
	83-32-9	Acenaphthene			mg/kg		0/9	2.10E-02 - 2.20E-01	2.20E-01	2.00E+01	1.00E-01	Y
	208-96-8	Acenaphthylene			mg/kg		0/9	3.30E-02 - 4.30E-01	4.30E-01	6.82E+02	1.00E-01	Y
	120-12-7	Anthracene			mg/kg		0/9	2.10E-03 - 3.30E-02	3.30E-02	1.48E+03	1.00E-01	N
	92-87-5	Benzidine			mg/kg		0/3	8.50E-01 - 8.50E-01	8.50E-01	NVA	NVA	N
	56-55-3	Benzo(a)anthracene			mg/kg		0/9	2.10E-03 - 1.70E-01	1.70E-01	5.21E+00	1.00E-01	Y
	50-32-8	Benzo(a)pyrene			mg/kg		0/9	2.10E-03 - 2.50E-01	2.50E-01	1.52E+00	1.00E-01	Y
	205-99-2	Benzo(b)fluoranthene			mg/kg		0/9	4.10E-03 - 2.10E-01	2.10E-01	5.98E+01	1.00E-01	Y
	191-24-2	Benzo(g,h,i)perylene			mg/kg		0/9	4.10E-03 - 2.50E-01	2.50E-01	1.19E+02	1.00E-01	Y
	207-08-9	Benzo(k)fluoranthene			mg/kg		0/9	2.10E-03 - 6.60E-02	6.60E-02	1.48E+02	1.00E-01	N
	65-85-0	Benzoic Acid			mg/kg		0/9	2.00E+00 - 6.10E+00	6.10E+00	7.30E+00	NVA	N
	100-51-6	Benzyl alcohol			mg/kg		0/9	1.90E-01 - 8.80E-01	8.80E-01	6.58E+01	NVA	N
	111-91-1	bis(2-Chloroethoxy)methane			mg/kg		0/9	5.90E-02 - 4.50E-01	4.50E-01	3.02E-01	NVA	Y
	111-44-4	bis(2-Chloroethyl)ether			mg/kg		0/9	3.30E-02 - 4.50E-01	4.50E-01	2.37E+01	NVA	N
	108-60-1	bis(2-Chloroisopropyl)ether			mg/kg		0/9	2.00E-01 - 4.50E-01	4.50E-01	1.99E+01	NVA	N
	117-81-7	bis(2-Ethylhexyl) phthalate			mg/kg		0/9	4.10E-01 - 6.20E-01	6.20E-01	9.26E-01	NVA	N
	85-68-7	Butyl benzyl phthalate			mg/kg		0/9	1.70E-01 - 4.50E-01	4.50E-01	2.39E-01	NVA	Y
	86-74-8	Carbazole			mg/kg		0/6	4.10E-01 - 4.50E-01	4.50E-01	NVA	NVA	N
	218-01-9	Chrysene			mg/kg		0/9	2.00E-03 - 1.20E-01	1.20E-01	4.73E+00	1.00E-01	Y
	53-70-3	Dibenz(a,h)anthracene			mg/kg		0/9	4.10E-03 - 2.10E-01	2.10E-01	1.84E+01	1.00E-01	Y
	132-64-9	Dibenzofuran			mg/kg		0/9	3.50E-02 - 4.50E-01	4.50E-01	6.10E+00	NVA	N
	131-11-3	Dimethylphthalate			mg/kg		0/9	1.70E-01 - 4.50E-01	4.50E-01	7.34E+02	NVA	N
	117-84-0	Di-n-octyl phthalate			mg/kg		0/9	1.90E-01 - 4.50E-01	4.50E-01	7.09E+02	NVA	N
	206-44-0	Fluoranthene			mg/kg		0/9	4.10E-03 - 6.80E-02	6.80E-02	1.22E+02	1.00E-01	N
	86-73-7	Fluorene			mg/kg		0/9	4.10E-03 - 4.30E-02	4.30E-02	1.22E+02	1.00E-01	N
	118-74-1	Hexachlorobenzene			mg/kg		0/9	3.30E-02 - 4.50E-01	4.50E-01	1.99E-01	NVA	Y
	87-68-3	Hexachlorobutadiene			mg/kg		0/9	2.30E-01 - 4.50E-01	4.50E-01	3.98E-02	NVA	Y
	77-47-4	Hexachlorocyclopentadiene			mg/kg		0/9	4.10E-01 - 6.20E+00	6.20E+00	1.00E+01	NVA	N
	67-72-1	Hexachloroethane			mg/kg		0/9	1.50E-01 - 4.50E-01	4.50E-01	5.96E-01	NVA	N
	193-39-5	Indeno(1,2,3-cd)pyrene			mg/kg		0/9	2.10E-03 - 2.90E-01	2.90E-01	1.09E+02	1.00E-01	Y
	78-59-1	Isophorone			mg/kg		0/9	3.30E-02 - 4.50E-01	4.50E-01	1.39E+02	NVA	N

Table F-18
Comparison of Maximum Detection Limits for Not Detected Compounds in Surface Soil to Ecological Screening Values for SWMU 39

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Ecological Screening Toxicity Value (3)	Region III BTAG Screening Levels	Above Screening Toxicity Value? Y/N
	91-20-3	Naphthalene			mg/kg		0/9	2.10E-02 - 2.20E-01	2.20E-01	9.94E-02	1.00E-01	Y
	98-95-3	Nitrobenzene			mg/kg		0/14	4.50E-02 - 4.50E-01	4.50E-01	1.31E+00	NVA	N
	62-75-9	n-Nitroso-di-methylamine			mg/kg		0/3	1.40E-01 - 1.40E-01	1.40E-01	3.21E-05	NVA	Y
	621-64-7	n-Nitroso-di-n-propylamine			mg/kg		0/9	2.00E-01 - 4.50E-01	4.50E-01	5.44E-01	NVA	N
	86-30-6	n-Nitroso-di-phenylamine			mg/kg		0/9	1.90E-01 - 4.50E-01	4.50E-01	5.45E-01	NVA	N
	95-48-7	o-Cresol			mg/kg		0/9	2.90E-02 - 4.50E-01	4.50E-01	4.04E+01	1.00E-01	Y
	106-47-8	p-Chloroaniline			mg/kg		0/9	8.00E-01 - 8.80E-01	8.80E-01	1.10E+00	NVA	N
	59-50-7	p-Chloro-m-cresol			mg/kg		0/9	9.50E-02 - 8.80E-01	8.80E-01	7.95E+00	NVA	N
	106-44-5	p-Cresol			mg/kg		0/3	2.40E-01 - 2.40E-01	2.40E-01	1.63E+02	1.00E-01	Y
	87-86-5	Pentachlorophenol			mg/kg		0/9	1.30E+00 - 2.20E+00	2.20E+00	3.00E+00	1.00E-01	Y
	85-01-8	Phenanthrene			mg/kg		0/9	2.10E-03 - 3.30E-02	3.30E-02	4.57E+01	1.00E-01	N
	108-95-2	Phenol			mg/kg		0/9	1.10E-01 - 4.50E-01	4.50E-01	3.00E+01	1.00E-01	Y
	129-00-0	Pyrene			mg/kg		0/9	1.00E-03 - 3.30E-02	3.30E-02	7.85E+01	1.00E-01	N
	71-55-6	1,1,1-Trichloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	2.98E+01	3.00E-01	N
	79-34-5	1,1,2,2-Tetrachloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	1.27E-01	3.00E-01	N
	79-00-5	1,1,2-Trichloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	2.86E+01	3.00E-01	N
	75-34-3	1,1-Dichloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	2.01E+01	3.00E-01	N
	75-35-4	1,1-Dichloroethene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	8.28E+00	NVA	N
	107-06-2	1,2-Dichloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	2.12E+01	8.70E+02	N
	78-87-5	1,2-Dichloropropane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	3.27E+01	NVA	N
	78-93-3	2-Butanone			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	8.96E+01	NVA	N
	591-78-6	2-Hexanone			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	1.26E+01	NVA	N
	101-55-3	4-Bromophenyl phenylether			mg/kg		0/9	3.30E-02 - 4.50E-01	4.50E-01	NVA	NVA	N
	7005-72-3	4-Chlorophenyl phenylether			mg/kg		0/9	3.30E-02 - 4.50E-01	4.50E-01	NVA	NVA	N
	108-10-1	4-Methyl-2-pentanone			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	4.43E+02	1.00E+02	N
	67-64-1	Acetone			mg/kg		0/4	4.90E-03 - 5.80E-03	5.80E-03	2.50E+00	NVA	N
	71-43-2	Benzene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	2.55E-01	1.00E-01	N
	75-27-4	Bromodichloromethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	5.40E-01	4.50E+02	N
	74-83-9	Bromomethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	2.35E-01	NVA	N
	75-15-0	Carbon disulfide			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	9.41E-02	NVA	N
	56-23-5	Carbon tetrachloride			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	2.98E+00	3.00E-01	N
	108-90-7	Chlorobenzene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	4.00E+01	1.00E-01	N
	75-00-3	Chloroethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	NVA	NVA	N

Table F-18
Comparison of Maximum Detection Limits for Not Detected Compounds in Surface Soil to Ecological Screening Values for SWMU 39

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Ecological Screening Toxicity Value (3)	Region III BTAG Screening Levels	Above Screening Toxicity Value? Y/N
	74-87-3	Chloromethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	1.04E+01	NVA	N
	156-59-2	cis-1,2-Dichloroethene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	7.84E-01	3.00E-01	N
	10061-01-5	cis-1,3-Dichloro-1-propene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	3.98E-01	3.00E-01	N
	124-48-1	Dibromochloromethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	2.05E+00	NVA	N
	100-41-4	Ethylbenzene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	5.16E+00	1.00E-01	N
	75-09-2	Methylene chloride			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	4.05E+00	3.00E-01	N
	95-47-6	o-Xylene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	1.00E+01	1.00E-01	N
	130-312	p&m-Xylene			mg/kg		0/5	9.80E-03 - 1.20E-02	1.20E-02	1.00E+01	1.00E-01	N
	100-42-5	Styrene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	3.00E+02	1.00E-01	N
	127-18-4	Tetrachloroethene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	9.92E+00	3.00E-01	N
	108-88-3	Toluene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	2.00E+02	1.00E-01	N
	156-60-5	trans-1,2-Dichloroethene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	7.84E-01	3.00E-01	N
	10061-02-6	trans-1,3-Dichloropropene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	3.98E-01	3.00E-01	N
	75-25-2	Tribromomethane			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	1.59E+01	1.47E+03	N
	79-01-6	Trichloroethene			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	1.24E+01	3.00E-01	N
	67-66-3	Chloroform			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	1.19E+00	3.00E-01	N
	75-01-4	Vinyl Chloride			mg/kg		0/5	4.90E-03 - 5.80E-03	5.80E-03	6.46E-01	3.00E-01	N

(1) Maximum detection limit used for screening.

(2) Screening toxicity values from USEPA SSLs (2000); Efroymson et al., PRGs (1997); and USEPA Region V EDQLs (1999); and other sources. See text for derivation.

(3) Selection Rationale

Reasons for Selection:

Above Screening Level (ASL)

Reasons for Deletion:

Below Screening Level (BSL)

No Toxicity Data (NTX)

Table F-19
Selection of Ecological Soil Screening Toxicity Values for Non-Detect Constituents at SWMU 39

Parameter	Ecological Soil Screening Levels[a] (mg/kg)	Ecological Preliminary Remediation Goals[b] (mg/kg)	Ecological Data Quality Levels[c] (mg/kg)	Other Ecological Soil Screening Levels[d] (mg/kg)	Selected Ecological Screening Toxicity Value[e] (mg/kg)
1,1,1-Trichloroethane	NVA	NVA	29.8	--	29.8
1,1,2,2-Tetrachloroethane	NVA	NVA	0.12722	--	0.12722
1,1,2-Trichloroethane	NVA	NVA	28.6	--	28.6
1,1-Dichloroethane	NVA	NVA	20.1	--	20.1
1,1-Dichloroethene	NVA	NVA	8.28	--	8.28
1,2,4-Trichlorobenzene	NVA	20(earthworm)	11.1	--	20
1,2-Dichlorobenzene	NVA	NVA	2.96	--	2.96
1,2-Dichloroethane	NVA	NVA	21.2	--	21.2
1,2-Dichloropropane	NVA	NVA	32.7	--	32.7
1,2-Diphenylhydrazine	NVA	NVA	NVA	NVA	NVA
1,3,5-Trinitrobenzene	NVA	NVA	0.37615	--	0.37615
1,3-Dichlorobenzene	NVA	NVA	37.7	--	37.7
1,3-Dinitrobenzene	NVA	NVA	0.6547	--	0.6547
1,4-Dichlorobenzene	NVA	20(earthworm)	0.54559	--	20
2,4,5-T	NVA	NVA	0.59634	--	0.59634
2,4,5-TP (Silvex)	NVA	NVA	0.1088	--	0.1088
2,4,5-Trichlorophenol	NVA	9(earthworm)	14.1	--	9
2,4,6-Trichlorophenol	NVA	4(plant)	9.94	--	4
2,4,6-Trinitrotoluene	NVA	NVA	NVA	0.7[f]	0.7
2,4-D	NVA	NVA	0.02725	--	0.02725
2,4-DB	NVA	NVA	NVA	NVA	NVA
2,4-Dichlorophenol	NVA	NVA	87.5	--	87.5
2,4-Dimethylphenol	NVA	NVA	0.01	--	0.01
2,4-Dinitrophenol	NVA	20(plant)	0.06086	--	20
2,6-Dinitrotoluene	NVA	NVA	0.03283	--	0.03283
2-amino-4,6-Dinitrotoluene	NVA	NVA	NVA	5.3	5.3
2-Butanone	NVA	NVA	89.6	--	89.6
2-Chloronaphthalene	NVA	NVA	0.01218	--	0.01218
2-Chlorophenol	NVA	NVA	0.24266	--	0.24266
2-Hexanone	NVA	NVA	12.6	--	12.6
2-Methylnaphthalene	NVA	NVA	3.24	--	3.24
2-Nitroaniline	NVA	NVA	74.1	--	74.1
2-Nitrophenol	NVA	NVA	1.6	--	1.6
2-Nitrotoluene	NVA	NVA	NVA	4.1	4.1
2-sec-butyl-4,6-dinitrophenol	NVA	NVA	0.0218	--	0.0218
3&4-Methylphenol	NVA	NVA	3.49	--	3.49
3,3'-Dichlorobenzidine	NVA	NVA	0.64636	--	0.64636
3-Nitroaniline	NVA	NVA	3.16	--	3.16
3-Nitrotoluene	NVA	NVA	NVA	5.3[f]	5.3
4,4'-DDE	NVA	NVA	0.59587	--	0.59587
4,4'-DDT	NVA	NVA	0.0175	--	0.0175
4,6-Dinitro-o-cresol	NVA	NVA	0.14408	--	0.14408
4-amino-2,6-Dinitrotoluene	NVA	NVA	NVA	3.6[f]	3.6

Table F-19
Selection of Ecological Soil Screening Toxicity Values for Non-Detect Constituents at SWMU 39

Parameter	Ecological Soil Screening Levels[a] (mg/kg)	Ecological Preliminary Remediation Goals[b] (mg/kg)	Ecological Data Quality Levels[c] (mg/kg)	Other Ecological Soil Screening Levels[d] (mg/kg)	Selected Ecological Screening Toxicity Value[e] (mg/kg)
4-Bromophenyl phenylether	NVA	NVA	NVA	NVA	NVA
4-Chlorophenyl phenylether	NVA	NVA	NVA	NVA	NVA
4-Methyl-2-pentanone	NVA	NVA	443	--	443
4-Nitroaniline	NVA	NVA	21.9	--	21.9
4-Nitrophenol	NVA	7(earthworm)	5.12	--	7
4-Nitrotoluene	NVA	NVA	NVA	9.4	9.4
Acenaphthene	NVA	20(plant)	682	--	20
Acenaphthylene	NVA	NVA	682	--	682
Acetone	NVA	NVA	2.5	--	2.5
Aldrin	NVA	NVA	0.00332	--	0.00332
alpha-BHC	NVA	NVA	0.09939	--	0.09939
Anthracene	NVA	NVA	1480	--	1480
Aroclor 1016	NVA	0.371(mammal)	0.000332	--	0.371
Aroclor 1221	NVA	0.371(mammal)	0.000332	--	0.371
Aroclor 1232	NVA	0.371(mammal)	0.000332	--	0.371
Aroclor 1242	NVA	0.371(mammal)	0.000332	--	0.371
Aroclor 1248	NVA	0.371(mammal)	0.000332	--	0.371
Aroclor 1254	NVA	0.371(mammal)	0.000332	--	0.371
Aroclor 1260	NVA	0.371(mammal)	0.000332	--	0.371
Benzene	NVA	NVA	0.25462	--	0.25462
Benzidine	NVA	NVA	NVA	--	NVA
Benzo(a)anthracene	NVA	NVA	5.21	--	5.21
Benzo(a)pyrene	NVA	NVA	1.52	--	1.52
Benzo(g,h,i)perylene	NVA	NVA	119	--	119
Benzo(k)fluoranthene	NVA	NVA	148	--	148
Benzoic acid	NVA	NVA	NVA	7.3[f]	7.3
Benzyl alcohol	NVA	NVA	65.8	--	65.8
beta-BHC	NVA	NVA	0.00398	--	0.00398
bis(2-Chloroethoxy)methane	NVA	NVA	0.30209	--	0.30209
bis(2-Chloroethyl)ether	NVA	NVA	23.7	--	23.7
bis(2-Chloroisopropyl)ether	NVA	NVA	19.9	--	19.9
bis(2-Ethylhexyl) phthalate	NVA	NVA	0.92594	--	0.92594
Bromodichloromethane	NVA	NVA	0.53978	--	0.53978
Bromomethane	NVA	NVA	0.23516	--	0.23516
Butyl benzyl phthalate	NVA	NVA	0.23889	--	0.23889
Carbazole	NVA	NVA	NVA	NVA	NVA
Carbon disulfide	NVA	NVA	0.09412	--	0.09412
Carbon tetrachloride	NVA	NVA	2.98	--	2.98
Chlorobenzene	NVA	40(earthworm)	13.1	--	40
Chloroethane	NVA	NVA	NVA	NVA	NVA
Chloromethane	NVA	NVA	10.4	--	10.4
Chrysene	NVA	NVA	4.73	--	4.73
cis-1,2-Dichloroethene	NVA	NVA	0.78373	--	0.78373
cis-1,3-Dichloro-1-propene	NVA	NVA	0.39786	--	0.39786

Table F-19
Selection of Ecological Soil Screening Toxicity Values for Non-Detect Constituents at SWMU 39

Parameter	Ecological Soil Screening Levels[a] (mg/kg)	Ecological Preliminary Remediation Goals[b] (mg/kg)	Ecological Data Quality Levels[c] (mg/kg)	Other Ecological Soil Screening Levels[d] (mg/kg)	Selected Ecological Screening Toxicity Value[e] (mg/kg)
Cyclonite (RDX)	5.8(mammal)	NVA	NVA	--	5.8
Dalapon	NVA	NVA	NVA	NVA	NVA
delta-BHC	NVA	NVA	9.94	--	9.94
Dibenz(a,h)anthracene	NVA	NVA	18.4	--	18.4
Dibenzofuran	NVA	NVA	NVA	6.1[f]	6.1
Dibromochloromethane	NVA	NVA	2.05	--	2.05
Dicamba	NVA	NVA	NVA	NVA	NVA
Dichloroprop	NVA	NVA	NVA	NVA	NVA
Dieldrin	0.011(bird)	NVA	0.00238	--	0.011
Dimethylphthalate	NVA	NVA	734	--	734
Di-n-octyl phthalate	NVA	NVA	709	--	709
Endosulfan I	NVA	NVA	0.11927	--	0.11927
Endosulfan II	NVA	NVA	0.11927	--	0.11927
Endosulfan sulfate	NVA	NVA	0.03578	--	0.03578
Ethylbenzene	NVA	NVA	5.16	--	5.16
Fluoranthene	NVA	NVA	122	--	122
Fluorene	NVA	NVA	122	--	122
gamma-BHC (Lindane)	NVA	NVA	0.005	--	0.005
Heptachlor	NVA	NVA	0.00598	--	0.00598
Heptachlor epoxide	NVA	NVA	0.15188	--	0.15188
Hexachlorobenzene	NVA	NVA	0.19878	--	0.19878
Hexachlorobutadiene	NVA	NVA	0.03976	--	0.03976
Hexachlorocyclopentadiene	NVA	10(plant)	0.75537	--	10
Hexachloroethane	NVA	NVA	0.59634	--	0.59634
HMX	NVA	NVA	NVA	43	43
Indeno(1,2,3-cd)pyrene	NVA	NVA	109	--	109
Isophorone	NVA	NVA	139	--	139
m+p-Xylenes	NVA	NVA	10	--	10
MCPA	NVA	NVA	NVA	NVA	NVA
MCPP	NVA	NVA	NVA	NVA	NVA
Methylene chloride	NVA	NVA	4.05	--	4.05
Naphthalene	NVA	NVA	0.09939	--	0.09939
Nitrobenzene	NVA	NVA	1.31	--	1.31
n-Nitroso-di-methylamine	NVA	NVA	0.0000321	--	0.0000321
n-Nitroso-di-n-propylamine	NVA	NVA	0.54368	--	0.54368
n-Nitrosodiphenylamine	NVA	NVA	0.54514	--	0.54514
o-Cresol	NVA	NVA	40.4	--	40.4
o-Xylene	NVA	NVA	10	--	10
p-Chloroaniline	NVA	NVA	1.1	--	1.1
p-Chloro-m-cresol	NVA	NVA	7.95	--	7.95
p-Cresol	NVA	NVA	163	--	163
Pentachlorophenol	NVA	3(plant)	0.11927	--	3
Pentaerythritol tetranitrate (PETN)	NVA	NVA	NVA	14,000[f]	14000

Table F-19
Selection of Ecological Soil Screening Toxicity Values for Non-Detect Constituents at SWMU 39

Parameter	Ecological Soil Screening Levels[a] (mg/kg)	Ecological Preliminary Remediation Goals[b] (mg/kg)	Ecological Data Quality Levels[c] (mg/kg)	Other Ecological Soil Screening Levels[d] (mg/kg)	Selected Ecological Screening Toxicity Value[e] (mg/kg)
Phenanthrene	NVA	NVA	45.7	--	45.7
Phenol	NVA	30(earthworm)	120	--	30
Pyrene	NVA	NVA	78.5	--	78.5
Styrene	NVA	300(plant)	4.69	--	300
Tetrachloroethene	NVA	NVA	9.92	--	9.92
Tetryl	NVA	NVA	NVA	2[f]	2
Toluene	NVA	200(plant)	5.45	--	200
Toxaphene	NVA	NVA	0.11927	--	0.11927
trans-1,2-Dichloroethene	NVA	NVA	0.78373	--	0.78373
trans-1,3-Dichloropropene	NVA	NVA	0.39786	--	0.39786
Tribromomethane	NVA	NVA	15.9	--	15.9
Trichloroethene	NVA	NVA	12.4	--	12.4
Trichloromethane (chloroform)	NVA	NVA	1.19	--	1.19
Vinyl chloride	NVA	NVA	0.64614	--	0.64614

[a] Ecological Soil Screening Level Guidance, U.S.EPA, July 2000, Draft.

[b] Preliminary Remediation Goals for Ecological Endpoints, R. A. Efroymson, et. al., August 1997.

[c] Ecological Data Quality Levels, U.S.EPA Region 5, October 1999.

[d] Los Alamos National Laboratory, 2002, Environmental Restoration Project, Environmental Screening Levels, Release 1.5, September.

[e] The following hierarchy was utilized to select the final Ecological Screening Toxicity Values for this assessment:

1. The lower value of either the Ecological Soil Screening Level Guidance or the Preliminary Remediation Goals for Ecological Endpoints.
2. Ecological Data Quality Levels, U.S.EPA Region 5

[f] Value is from Los Alamos

NVA = No Value Available

Appendix G
USEPA Guidance Documents and Remedial Goal Calculations

This Appendix Contains:

Appendix G-1 USEPA Guidance Documents
Appendix G-2 Remedial Goal Calculations

Appendix G-1
USEPA Guidance Documents

United States Environmental Protection Agency | Solid Waste and Emergency Response (5101) | EPA540-F-98-030 NTIS: PB98-963 244 August 1998

EPA

Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities

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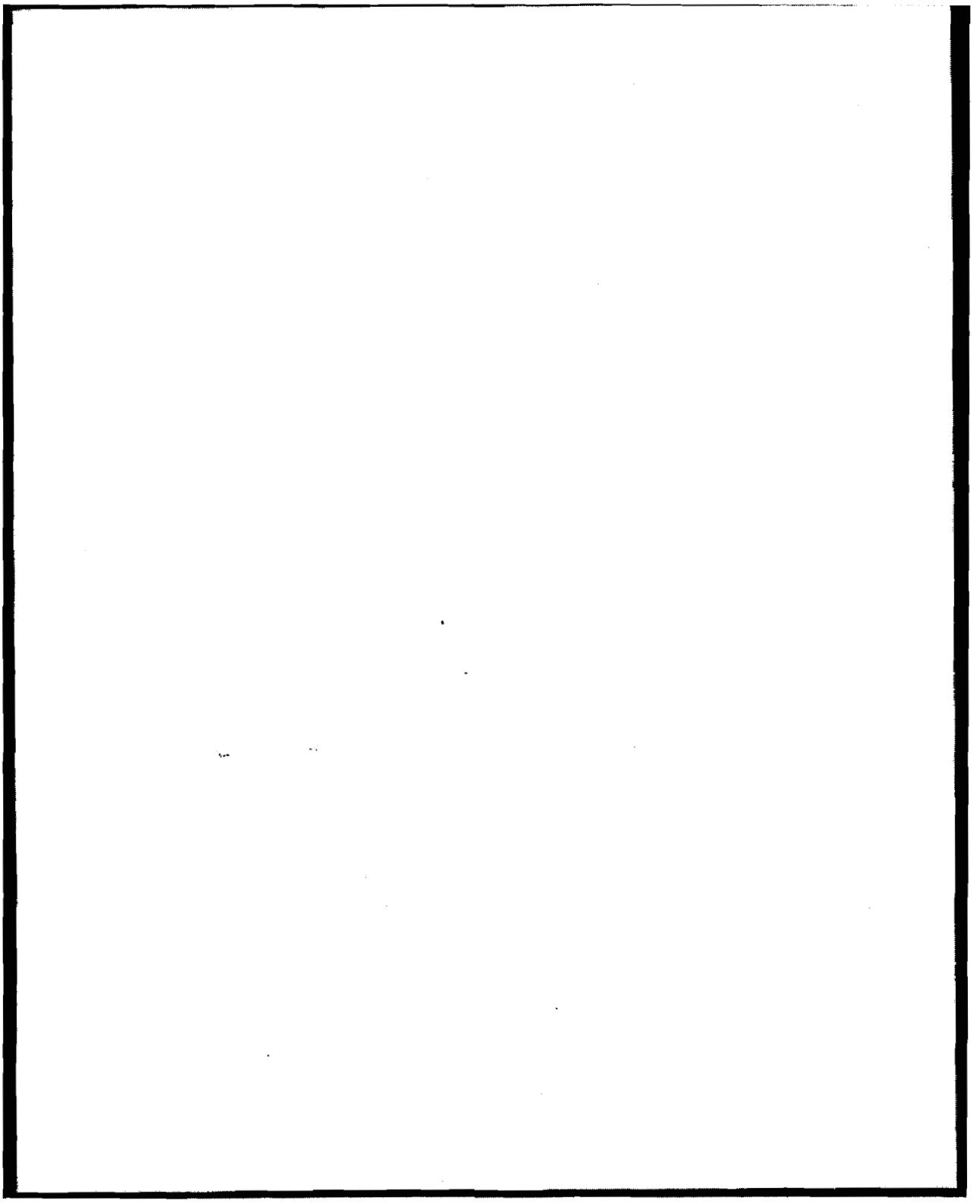

CLARIFICATION TO THE 1994 REVISED INTERIM SOIL LEAD GUIDANCE FOR CERCLA SITES AND RCRA CORRECTIVE ACTION FACILITIES

OSWER DIRECTIVE # 9200.4-27

AUGUST 1998

OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

9200.4-27
EPA/540/F-98/030
PB98-963244

AUG 27 1998

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

OSWER Directive # 9200.4-27P

MEMORANDUM

SUBJECT: Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities

FROM: Timothy Fields, Jr.
Acting Assistant Administrator

TO: Regional Administrators I-X

PURPOSE

This directive clarifies the existing 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, OSWER Directive 9355.4-12. Specifically, this directive clarifies OSWER's policy on (1) using EPA's Science Advisory Board (SAB) reviewed Integrated Exposure Uptake Biokinetic Model (IEUBK) and blood lead studies, (2) determining the geographic area to use in evaluating human exposure to lead contamination ("exposure units"), (3) addressing multimedia lead contamination and (4) determining appropriate response actions at lead sites. The purpose for clarifying the existing 1994 directive is to promote national consistency in decision-making at CERCLA and RCRA lead sites across the country.

BACKGROUND

OSWER Directive 9355.4-12, issued on July 14, 1994 established OSWER's current approach to addressing lead in soil at CERCLA and RCRA sites. The existing directive established a streamlined approach for determining protective levels for lead in soil at CERCLA sites and RCRA facilities as follows:

- It recommends a 400 ppm screening level for lead in soil at residential properties;
- It describes how to develop site-specific preliminary remediation goals (PRGs) at CERCLA sites and media cleanup standards at RCRA Corrective Action facilities for

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residential land use; and,

- It describes a strategy for management of lead contamination at CERCLA sites and RCRA Corrective Action facilities that have multiple sources of lead.

The existing interim directive provides direction regarding risk assessment and risk management approaches for addressing soil lead contaminated sites. The OSWER directive states that, "... implementation of this guidance is expected to provide more consistent decisions across the country ..." However, since that directive was released, OSWER determined that clarification of the guidance is needed. Key areas being clarified by issuance of this directive include: (1) using the IEUBK model and blood lead studies, (2) determining exposure units to be considered in evaluating risk and developing risk management strategies, (3) addressing multimedia lead contamination and (4) determining appropriate response actions at residential lead sites. The existing directive provides the following guidance on these areas:

1. The OSWER directive recommends using the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children (Pub. # 9285.7-15-1, PB93-963510) for setting site-specific residential preliminary risk-based remediation goals (PRGs) at CERCLA sites and media cleanup standards (MCSs) at RCRA corrective actions Facilities. The directive states that the IEUBK model is the best tool currently available for predicting the potential blood lead levels of children exposed to lead in the environment. OSWER's directive also recommends the evaluation of blood lead data, where available, and states that well-conducted blood lead studies provide useful information to site managers. The directive however recommends that "... blood lead data not be used alone to assess risk from lead exposure or to develop soil lead cleanup levels."

2. The directive describes OSWER's risk reduction goal as "... generally, OSWER will attempt to limit exposure to soil lead levels such that a typical (or hypothetical) child or group of similarly exposed children would have an estimated risk of no more than 5% of exceeding a 10 ug/dl blood lead level." The directive also states that "... EPA recommends that a soil lead concentration be determined so that a typical child or group of children exposed to lead at this level would have an estimated risk of no more than 5% of exceeding a blood lead of 10 ug/dl." OSWER generally defines an exposure unit as a geographic area where exposures occur to the receptor of concern during the time of interest and believes that for a child or group of similarly exposed children, this is typically the individual residence and other areas where routine exposures are occurring.

3. The directive recommends that risk managers assess the contribution of multiple environmental sources of lead to overall lead exposure (e.g., consideration of the importance of soil lead levels relative to lead from drinking water, paint, and household dust) which promotes development of risk reduction strategies that address all sources that contribute significantly to exposure.

4. The OSWER directive states that the IEUBK model is not the only factor to be considered in establishing lead cleanup goals. Rather, the IEUBK model is the primary risk assessment tool available for evaluating lead risk and the results of the model are used to guide selection of appropriate risk management strategies for each site.

Since the OSWER directive was issued in 1994, there has been a trend toward a more consistent approach to managing risk at residential lead sites, however, OSWER was interested in identifying areas requiring additional clarification to facilitate more effective implementation of the directive. As a first step in the process, meetings were held with various EPA Regions, States and local governments to discuss how the directive has been implemented nationally at lead sites since 1994. By participating in these meetings and by reviewing the decisions that are being made across the country, OSWER believed that clarification of certain aspects of the 1994 directive would be useful.

All of the documents and guidance referenced in this directive are available through the National Technical Information Service (NTIS) at 703-605-6000 or could be downloaded electronically from: http//epa.gov/superfund/oerr/ini_prod/lead/prods.htm.

OBJECTIVE

At lead contaminated residential sites, OSWER seeks assurance that the health of the most susceptible population (children and women of child bearing age) is protected and promotes a program that proactively assesses and addresses risk. OSWER believes that predictive tools should be used to evaluate the risk of lead exposure, and that cleanup actions should be designed to address both current and potential future risk.

While health studies, surveys, and monitoring can be valuable in identifying current exposures and promoting improved public health, they are not definitive tools in evaluating potential risk from exposure to environmental contaminants. In the case of lead exposure, blood lead monitoring programs can be of critical importance in identifying individuals experiencing potential negative health outcomes and directing education and intervention resources to address those risks. However, CERCLA §121(b) requires EPA to select cleanup approaches that are protective of human health and the environment and that utilize permanent solutions to the maximum extent practicable. To comply with the requirements set forth in CERCLA § 121(b), OSWER will generally require selection of cleanup programs that are proactive in mitigating risk and that do not simply rely on biological monitoring programs to determine if an exposure has already occurred.

To meet these objectives, OSWER will seek actions that limit exposure to soil lead levels such that a typical child or group of similarly exposed children would have an estimated risk of no more than 5% of exceeding a 10 ug/dl blood lead level. If lead is predicted to pose a risk to the susceptible population, OSWER recommends that actions be taken to significantly minimize or eliminate this exposure to lead.

The principles laid out in the four attached factsheets (Appendix) support OSWER's goals by encouraging appropriate assessment and response actions at CERCLA and RCRA lead sites across the country.

This clarification directive emphasizes the following key messages regarding the four areas and encourages the users of this directive, be they EPA Regions, States, or other stakeholders, to adopt these principles in assessing and managing CERCLA and RCRA lead sites across the country. The critical elements of the attached papers are as follows:

I. Using Blood Lead Studies and IEUBK Model at Lead Sites:

OSWER emphasizes the use of the IEUBK Model for estimating risks for childhood lead exposure from a number of sources, such as soils, dust, air, water, and other sources to predict blood lead levels in children 6 months to 84 (7 years) months old. The 1994 directive also recommended evaluation of available blood lead data and stated that data from a well-conducted blood lead study of children could provide useful information to site managers. In summary, OSWER's clarification policy on the appropriate use of the IEUBK and blood lead studies is that:

- OSWER recommends that the IEUBK model be used as the primary tool to generate risk-based soil cleanup levels at lead sites for current or future residential land use. If Regions propose an alternative method for generating cleanup levels, they are required to submit their approach to the national Lead Sites Consultation Group (LSCG)[1] for review and comment ;

- Response actions can be taken using IEUBK predictions alone; blood lead studies are not required; and

- Blood lead studies and surveys are useful tools at lead sites and can be used to identify key site-specific exposure pathways and to direct health professionals to individuals needing immediate assistance in minimizing lead exposure; however, OSWER recommends that blood lead studies not be used for establishing long-term remedial or non-time-critical removal cleanup levels at lead sites.

II. Determining Exposure and Remediation Units at Lead Sites

OSWER recommends that cleanup levels at lead sites be designed to reduce risk to a typical or individual child receiving exposures at the residence to meet Agency guidelines (i.e., no greater

(1) The Lead Sites Consultation Group (LSCG) is comprised of senior management representatives from the Waste Management Divisions in all 10 EPA regions along with senior representatives from the Office of Emergency and Remedial Response in EPA headquarters. The LSCG is supported by EPA's Technical Review Workgroup (TRW) for lead and the national Lead Sites Workgroup (LSW). The TRW consists of key scientific experts in lead risk assessment from various EPA Regions, labs and headquarters. The LSW is comprised of senior Regional Project Managers from various Regions and key representatives from headquarters who are experienced in addressing lead threats at Superfund sites.

than a 5% chance of exceeding a 10 ug/dl blood-lead level for a full-time child resident).

Therefore, it is recommended that risk assessments conducted at lead-contaminated residential sites use the individual residence as the primary exposure unit of concern. This does not mean that a risk assessment should be conducted for every yard, rather that the soil lead contamination data from yards and other residential media (for example, interior dust and drinking water) should be input into the IEUBK model to provide a preliminary remediation goal (PRG) for the residential setting. When applicable, potential exposure to accessible site-related lead sources outside the residential setting should also be evaluated to understand how these other potential exposures contribute to the overall risk to children, and to suggest appropriate cleanup measures for those areas.

III. Addressing Multimedia Contamination at Lead Sites

EPA generally has limited legal authority to use Superfund to address exposure from **interior lead-based paint**. As a policy matter, OSWER recommends that such exposures not be addressed through actual abatement activities. However, EPA Regions should promote addressing interior paint risks through actions by others (e.g., potentially responsible parties (PRPs), other government programs, etc.) as a component of an overall site management strategy.

Because of other competing demands on the Superfund Trust Fund, OSWER recommends that EPA Regions avoid using the Superfund Trust Fund for removing **exterior lead-based paint** and soil contaminated from lead-based paint. Superfund dollars *may* however be used in limited circumstances to remediate exterior lead-based paint in order to protect the overall site remedy (i.e., to avoid re-contamination of soils that have been remediated) but generally only after determining that other funding sources are unavailable. As with interior lead-based paint abatement, EPA Regions should promote remediation of exterior lead-based paint by others, such as PRPs, local governments or individual homeowners.

IV. Determining Appropriate Response Actions at Lead Sites

In selecting site management strategies, it is OSWER's preference to seek early risk reduction with a combination of engineering controls (actions which permanently remove or treat contaminants, or create reliable barriers to mitigate the risk of exposure) and non-engineering response actions. All potential lead sources should be identified in site assessment activities. Non-engineering response actions, such as education and health intervention programs, should be considered an integral part of early risk reduction efforts because of their potential to provide immediate health benefits. In addition, engineering controls should be implemented early at sites presenting the greatest risk to children and other susceptible subpopulations.

As a given project progresses, OSWER's goal should be to reduce the reliance on education and intervention programs to mitigate risk. The goal should be cleanup strategies that move away from reliance on long-term changes in community behavior to be protective since behavioral

changes may be difficult to maintain over time. The actual remedy selected at each CERCLA site must be determined by application of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (55 FR 8666- 8865, March 8, 1990) remedy selection criteria to site-specific circumstances. This approach also recognizes the NCP preference for permanent remedies and emphasizes selection of engineering over non-engineering remedies for long-term response actions.

This directive clarifies OSWER's policy on four key issue areas addressed in the 1994 OSWER soil lead directive in order to promote a nationally consistent decision-making process for assessing and managing risks associated with lead contaminated sites across the country. The policy presented in these specific issue areas supersedes all existing OSWER policy and directives on these subjects. No other aspects of the existing 1994 directive are affected.

IMPLEMENTATION

The principles laid out in this directive (which includes the four attached factsheets) are meant to apply to all residential lead sites currently being evaluated through the CERCLA Remedial Investigation/Feasibility Study process and all future CERCLA Sites and RCRA Corrective Action Facilities contaminated with lead. The Regions will be required to submit their rationale for deviating from the policies laid out in this directive to the Lead Sites Consultation Group. This directive does not apply to previous remedy selection decisions.

Attachments

cc: Waste Management Policy Managers (Regions I-X)
Stephen Luftig, OERR
Elizabeth Cotsworth, OSW
James Woolford, FFRRO
Barry Breen, OSRE
Larry Reed, OERR
Tom Sheckells, OERR
Murray Newton, OERR
Betsy Shaw, OERR
John Cunningham, OERR
Paul Nadeau, OERR
Bruce Means, OERR
Earl Salo, OERR

NOTICE: This document provides guidance to EPA staff. The document does not, however, substitute for EPA's statutes or regulations, nor is it a regulation itself. Thus it cannot impose legally-binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the circumstances. EPA may change this guidance in the future, as appropriate.

Appendix
OSWER Directive # 9200.4-27P
August 1998

Factsheet: Using the IEUBK Model and Blood Lead Studies at Residential Lead Sites

Question: What is OSWER's policy on using the IEUBK model and blood-lead studies in conducting risk assessments and setting cleanup standards at residential lead contamination sites?

Answer: OSWER's policy on using the IEUBK model and blood-lead studies in conducting risk assessment and setting cleanup standards is as follows:

A. Use of the IEUBK Model:

1. The IEUBK model is a good predictor of potential long-term blood-lead levels for children in residential settings. OSWER recommends that the IEUBK model be used as the primary tool to generate risk-based soil cleanup levels at lead sites for current or future residential land use. If Regions propose an alternative method for generating cleanup levels, they are required to submit their approach to the National Lead Sites Consultation Group (LSCG) for review and comment.

2. Blood-lead distributions predicted by the IEUBK model illustrate a plausible range of variability in children's physiology, behavior, and household conditions.

3. Response actions can be taken, and remedial goals developed, using IEUBK predictions alone.

B. Use of Blood-Lead Studies/Data:

1. Blood-lead studies, surveys, and monitoring are useful tools at lead sites and can be used to help identify key site-specific exposure pathways and direct health professionals to individuals needing immediate assistance in minimizing lead exposure.

2. The utility of blood lead testing results and studies depends on how representative the information is of the population being evaluated, the design of the data collection, and the quality of the laboratory analysis. To this end, OSWER recommends that EPA Regions consult with ATSDR or CDC to assess or design studies according to their intended use.

3. Many blood-lead screening, monitoring, or testing programs differ from blood lead studies in that they do not attempt to identify risk factors for childhood exposure to lead sources. Although these programs may be extremely beneficial in identifying children with elevated blood lead levels and identifying candidates for referral to medical professionals for evaluation, they may not provide an accurate representation of community-wide exposure.

4. Well-designed blood lead studies may be used to identify site specific factors and pathways to be considered in applying the IEUBK model at residential lead sites. However, OSWER recommends that blood-lead studies not be used to determine future long-term risk where exposure conditions are expected to change over time; rather, they should be considered a snapshot of ongoing exposure under a specific set of circumstances (including community awareness and education) at a specific time. Long-term studies may be helpful in understanding exposure trends within a community and evaluating the effectiveness of cleanup strategies over time.

C. **IEUBK and Blood-Lead Studies/Data:**

1. Blood-lead data and IEUBK model predictions are expected to show a general concordance for most sites. However, some deviations between measured and predicted levels are expected. On some occasions, declines in blood-lead levels have been observed in association with lead exposure-reduction and health education. However, long-term cleanup goals should be protective in the absence of changes in community behavior as there is little evidence of the sustained effectiveness of these education/intervention programs over long periods of time.

2. Where actual blood-lead data varies significantly from IEUBK Model predictions, the model parameters should not automatically be changed. In such a case, the issue should be raised to the Lead Technical Review Workgroup (TRW) to further identify the source of those differences. Site work need not be put on hold while the issue is being reviewed by the TRW; the site manager should review other elements of the lead directive and the "Removal Actions at Lead Sites" guidance to determine appropriate interim actions to be taken at the site.

The Regions will be required to submit their rationale for deviating from the policies laid out in this factsheet to the Lead Sites Consultation Group.

Appendix
OSWER Directive # 9200.4-27P
August 1998

Factsheet: Determining Exposure and Remediation Units at Residential Lead Sites

Question: How does OSWER define an exposure unit, and subsequently apply this definition in conducting risk assessment and risk management activities at residential lead sites?

Answer: OSWER recognizes that defining and characterizing exposure unit(s) for a site is critically important in undertaking risk assessment activities and in designing protective cleanup strategies. An **exposure unit** is defined as a geographic area where exposures occur to the receptor of concern during the time of interest and that for a child, or group of similarly exposed children, this is typically the individual residence and other areas where chronic or ongoing exposures are occurring.

Various approaches to characterizing and managing risks by exposure units have been examined by OSWER. OSWER recognizes that lead ingestion can also cause adverse health effects in adults and fetuses but believes that by adequately limiting lead exposures to young children at residential sites, these other receptors will generally be likewise protected from adverse health impacts.

EPA's goal is to protect human health and the environment under current and future exposure scenarios. At lead sites, OSWER wants to assure that children's health is protected and promotes a program that proactively assesses risks rather than relying on biological monitoring to determine if an exposure has already occurred. OSWER emphasizes actions be taken at lead sites that will minimize or eliminate exposure of children to environmental lead contamination.

To achieve the above stated goal, OSWER recommends characterizing **exposure units as exposure potential at the individual residence as the primary unit of concern for evaluating potential risk at lead contaminated residential sites**. This recognizes that there are children whose domain and activities occur principally within the confines of a particular residential property. For determining exposure potential (and ultimately developing protective cleanup levels) at the individual home, OSWER recommends the scenario to be evaluated (through use of the IEUBK Model) would be a young child in full-time residence. This approach helps achieve OSWER's recommended health protection goal that an individual child or group of similarly exposed children would have <5% chance of exceeding a blood-lead concentration of 10 ug/dl. In designing community wide cleanup strategies, it is essential that non-residential areas (e.g., parks, day care facilities, playgrounds, etc.), where lead exposure may occur, also be characterized with respect to their contribution to soil-lead exposure, and appropriate cleanup actions implemented.

Appendix
OSWER Directive # 9200.4-27P
August 1998

OSWER recommends that risk management decisions for response to residential lead contamination sites focus on reducing risk at residences, but also recommends that response strategies be developed for other site locations (exposure units) where children receive exposure. Flexibility in determining appropriate response actions that provide protection at the individual residence should be considered in context of the NCP remedy selection criteria. The lead exposure issues are complex and OSWER recommends that EPA Regions try to communicate clearly the risk characterization and risk management decisions to the site residents. Affected communities must clearly understand the context of risk management decisions, how these decisions affect the health of their children, and how cleanup actions will influence the future growth and development of the community.

The Regions will be required to submit their rationale for deviating from the policies laid out in this factsheet to the Lead Sites Consultation Group.

Appendix
OSWER Directive # 9200.4-27P
August 1998

Factsheet: Addressing Multimedia Contamination at Residential Lead Sites

Question: What is OSWER's policy on addressing multimedia contamination at residential lead sites?

Answer: OSWER recognizes that several sources of lead-contamination, including soil, ground water, airborne particulates, lead plumbing, interior dust, and interior and exterior lead-based paint may be present at Superfund sites where children are at risk or have documented lead exposure. These lead sources may contribute to elevated blood-lead levels and may need to be evaluated in determining risks and cleanup actions at residential lead sites. However, there are limitations on the Agency's statutory authority under CERCLA to abate some of these sources, such as indoor lead-based paint and lead plumbing because CERCLA responses may be taken only to releases or threatened releases into the environment (CERCLA §104 (a)(3) and (4)).

When EPA's resources, or authority to respond or to expend monies under Superfund is limited, OSWER recommends that EPA Regions identify and coordinate to the greatest extent possible with other authorities and funding sources (e.g., other federal agencies and state or local programs). EPA Regions should coordinate with these other authorities to design a comprehensive, cost-effective response strategy that addresses as many sources of lead as practicable. These strategies should include actions to respond to lead-based paint, interior dust, and lead plumbing, as well as ground water sources and lead-contaminated soil.

Although OSWER will encourage that EPA Regions fully cooperate in the development of a comprehensive site management strategy, OSWER realizes that complete active cleanup of these other sources may be difficult to complete due to limited funding available to other authorities. Since complete cleanups of these sources is not guaranteed, and at most sites may be unlikely, OSWER recommends that the soil cleanup levels not be compromised. In other words, the soil cleanup levels should be calculated with the IEUBK model using existing pre-response action site specific data. This is due to the fact that soil cleanup levels at residential lead sites are generally established to protect individuals, from excess exposures to soils, and house dust attributable to those soils, and are not attributable to exposure to other sources such as interior lead paint which should be managed on a residence specific basis. Remediation of non-soil lead sources to mitigate overall lead exposure at individual residences should therefore not be used to modify sitewide soil lead cleanup levels.

The recommendations provided below represent OSWER's policy on addressing lead-contaminated media and/or sources for which EPA has limited or no authority to remediate.

Interior Paint: EPA has limited legal authority to use Superfund to address exposure from

interior lead-based paint. As a policy matter, OSWER recommends that such exposures not be addressed through actual abatement activities. However, EPA Regions should promote addressing interior paint risks through actions by others, such as HUD, local governments, or individual home owners as a component of an overall site management strategy. Any activities to clean up interior lead-based paint by PRPs or other parties should not result in an increase of the risk-based soil cleanup levels.

Exterior Paint: Because of other competing demands on the Superfund Trust Fund, OSWER recommends that EPA Regions avoid using the Superfund Trust Fund for removing exterior lead-based paint and soil contaminated from lead-based paint. Superfund dollars *may* be used to respond to exterior lead-based paint for protecting the overall site remedy (i.e., to prevent re-contamination of soils that have been remediated) but only after determining that other funding sources are unavailable. Where other sources of funding are not available, EPA may utilize the CERCLA monies to remediate exterior lead-based paint on homes/buildings, around which soil contaminated by other sources has been cleaned up to prevent recontamination of the soil. The Superfund should not be used to remediate exterior lead-based paint where no soil cleanup has occurred. As with interior lead-based paint abatement, EPA Regions should promote remediation of exterior lead-based paint by others, such as PRPs, local governments or individual homeowners. Cleanup activities of exterior paint conducted by PRPs or other parties should not result in an increase of the risk-based soil cleanup levels.

Interior Dust: Lead contaminated interior dust can be derived from several sources, including interior paint, home owner hobbies, exterior soil, and other exterior sources. In many cases, it may be difficult to differentiate the source(s) for the lead contamination in the dust. In general, EPA Regions should refrain from using the Superfund Trust Fund to remediate interior dust. Because of the multi-source aspects of interior dust contamination, potential for recontamination, and the need for a continuing effort to manage interior dust exposure, OSWER recommends the use of an aggressive health education program to address interior dust exposure. Such programs, administered through the local health department (or other local agency), should be implemented in conjunction with actions to control the dust source. At a minimum, the program should include blood-lead monitoring, and personal hygiene and good housekeeping education for the residents. OSWER believes that EPA Regions can also support the program by providing HEPA vacuums to the health agency for use in thoroughly cleaning home interiors.

Lead Plumbing: Generally CERCLA does not provide for legal authority to respond to risks posed by lead plumbing within residential dwellings. It should be noted that the water purveyor is responsible for providing clean water to the residences. As with interior dust, OSWER recommends that EPA Regions coordinate with local agencies to establish a health education program to inform residents of the hazards associated with lead plumbing and how to protect themselves by regularly flushing, or preferably, replacing lead pipes. Soil cleanup levels should not be adjusted to account for possible remediation of lead plumbing.

Appendix
OSWER Directive # 9200.4-27P
August 1998

Factsheet: Determining Appropriate Response Actions at Residential Lead Sites

Question: What is OSWER's position on the appropriate use of engineering and non-engineering response actions in developing risk management strategies for lead sites?

Answer: One goal emphasized in the recent third round of Superfund Reforms is for EPA to take a consistent approach in selecting and implementing both long- and short-term response actions at lead sites in all regions. One obstacle to achieving this consistency has been differing degrees of reliance on non-engineering response actions in reducing risk.

Site management strategies at lead sites typically include a range of response actions. Alternatives range from engineering controls that permanently remove or treat the contaminant source to non-engineering response actions, such as educational programs and land use restrictions. This continuum represents the range of response options available to risk managers. This position paper clarifies the relationship between engineering and non-engineering response actions in developing site management strategies.

In selecting site management strategies, OSWER's policy will be to seek early risk reduction with a combination of engineering controls (actions which permanently remove or treat contaminants, or which create reliable barriers to mitigate the risk of exposure) and non-engineering response actions. All potential lead sources should be identified in site assessment activities. Non-engineering response actions, such as education and health intervention programs, should be considered an integral part of early risk reduction efforts due to their potential to provide immediate health benefits (2). In addition, engineering controls should be implemented early at sites presenting the greatest risk to children and other susceptible subpopulations. Community concerns should receive a high priority in site decision-making; local support is vital to the success of health intervention and education programs.

(2) The actual effectiveness of health intervention and educational programs in reducing risk continues to be a subject of discussion. Anecdotal information suggests that such programs can provide short-term benefits in some populations. Rigorous statistical studies demonstrating the benefits of educational programs in preventing lead exposure are lacking. It is generally recognized that not all segments of the population will be influenced by such programs, and that long-term benefits are less certain. Local support for such programs is critical. The active (and long-term) participation of local and state public health agencies is needed in implementing institutional controls, including health intervention and education programs; without local implementation of such programs their success is uncertain. Additional research on the effectiveness of these programs is critical to consideration of their use in future cleanups.

Appendix
OSWER Directive # 9200.4-27P
August 1998

As the project progresses, OSWER's goal should be to reduce reliance on education and intervention programs to mitigate risk. The goal should be cleanup strategies that move away from reliance on long-term changes in community behavior to be protective; behavioral changes may be difficult to maintain over time. The actual remedy selected at each site must be determined by application of the NCP remedy selection criteria to site-specific circumstances. However, this approach recognizes the NCP preference for permanent remedies and emphasizes the use of engineering controls for long-term response actions. This approach also recognizes that well-designed health intervention and education programs, when combined with deed restrictions and/or other institutional controls, may be appropriate for reducing future exposure potential and may supplement engineering controls.

In instances where Regions believe that the use of engineering controls is impracticable, and education, health intervention, or institutional controls are proposed as the sole remedy, Regions will be required to consult with the LSCG.

87

The LSW
Who Are We?
Risk Management

The TRW
Who Are We?
Risk Assessment
Technical Assistance
The IEUBK Model
IEUBK FAQs
The ALM (Adult Lead Methodology)
Workshops

Products
Lead and Human Health
Related Sites
Contact Us

Adult Lead Methodology

The Adult Lead Methodology (*Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*, December 1996), the TRW's review of adult lead models, and the NHANES Report (March 2002) may be downloaded from the Products page.

Adult Lead Methodology (ALM) Frequently Asked Questions (FAQs)

The following FAQs were compiled from requests for assistance on proper use of the Adult Lead Methodology made to the Pb Hotline either by telephone (1-866-282-8622) or e-mail. Please refer to Technical Assistance for further information on the Pb Hotline.

Who is the receptor population for the Adult Lead Methodology?

In the commercial/industrial setting, the most sensitive receptor is the fetus of a worker who develops a body burden as a result of non-residential exposure to lead. This body burden is available to transfer to the fetus for several years after exposure ends (Gulson *et al.*, 1998; Gulson *et al.*, 1999). Based on the available scientific data, a fetus is more sensitive to the adverse effects of lead than an adult (National Academy of Sciences, 1993). We assume that cleanup goals (preliminary remediation goals, 'PRGs') that are protective of a fetus will also afford protection for male or female adult workers (see Stern section of Adult Lead Methodology Review Report). The model equations were developed to calculate cleanup goals such that there would be no more than a 5% probability that fetuses exposed to lead would exceed a blood lead (PbB) of 10 µg/dL. This same approach also appears to be protective for lead's effect on blood pressure in adult males (see Adult Lead Methodology Review Report).

Does the adult lead methodology calculate a value for a commercial worker or an industrial worker?

The ALM guidance does not distinguish between commercial and industrial workers; rather, it is applicable to non-residential exposure scenarios. According to EPA's ALM guidance, a soil ingestion rate of 50 mg/day is recommended as a plausible central tendency value for non-contact-intensive activities (U.S. Environmental Protection Agency, 1997). Either commercial or industrial workers may work primarily indoors, so that exposure to soil occurs primarily via indoor dust. Workers' limited and occasional contact with outdoor soils (*e.g.*, walking at noontime, picnicking, walking to parking lots, standing on a loading dock) should be adequately accounted for via the 50 mg/day incidental soil ingestion.If an individual is performing a contact-intensive activity with soil, then a soil ingestion rate greater than 50 mg/day would be expected. At sites where lead materials have been

historically used, exposure scenarios would have to be evaluated individually to determine the indoor and outdoor activities that may result in greater exposure to soil and the corresponding soil ingestion rate.

What is a reasonable screening value for soil lead at commercial/industrial sites?

A screening goal is often more protective than a cleanup goal. A screening goal is intended to provide health protection without knowledge of the specific exposure conditions at a site. A cleanup goal can be derived using exposure assumptions based on site-specific data rather than default values (which are often more conservative). An updated screening level for soil lead at commercial/industrial (*i.e.*, non-residential) sites of 800 ppm is based on a recent analysis of the combined phases of NHANES III that choose a cleanup goal protective for all subpopulations.

What is a reasonable baseline blood lead level (PbB_0) to use for a future exposure scenario?

Although the best estimates for PbB_0 are based on site-specific data, such information may not be available for a future exposure scenario. Application of this value should consider the proportion of each population (present on the site or anticipated in the future) as defined by the NHANES III study and as described in the recommendations of the TRW for use of the NHANES III data for adult lead risk assessment (see section 3.4, page 9 of Report). For site applications of the ALM, estimates of the $PbB_{adult,0}$ and $GSD_{i,adult}$ parameters could be based on either race/ethnicity or geographic categories determined appropriate based on the specific demographic or geographic characteristics of the site... It is not recommended to base estimates of the $PbB_{adult,0}$ and $GSD_{i,adult}$ from the NHANES III survey that are stratified by both census region and race/ethnicity group in the ALM to estimate site-specific risks because of the small sample sizes.

What is an appropriate GSD for my site?

The Geometric Standard Deviation (GSD) blood lead (PbB) for a population is a measure of inter-individual variability of observed blood lead levels. Factors that may contribute to variability in a population include occupational exposure, exposure history, socioeconomic and ethnic characteristics, activity patterns, degree of urbanization, geographic location, and sources of lead. A homogeneous population (*i.e.*, expected to have a low GSD) may have similar characteristics and exposure histories, and live within a small geographic area; there may be a single dominant source of lead exposure (*e.g.*, an ethnically and culturally homogeneous population living in a small town). By contrast, individuals with diverse backgrounds, who are exposed to multiple sources of lead within an urban community, may be considered a heterogeneous population.In the absence of demographic and environmental information that would indicate that the population is either homogeneous or heterogenous, an appropriate value for GSD would be based on analysis of the combined phases of NHANES III across all quadrants appropriate for the site. For site applications of the ALM, estimates of the $PbB_{adult,0}$ and $GSD_{i,adult}$ parameters could be based on either race/ethnicity or geographic categories determined appropriate based on the specific demographic or geographic characteristics of the site... It is not recommended to base estimates of the $PbB_{adult,0}$ and $GSD_{i,adult}$ from the NHANES III survey that are stratified by both census region and race/ethnicity group in the ALM to estimate site-specific risks because of the small sample sizes. Site-specific values should consider the region

as well as the present and future ethnicity of the exposed population. Application of this value should consider future land uses or development plans if available, whether any sensitive groups are present, and whether any major future changes in population are anticipated.

Should I assume that the indoor dust lead level is the same as the outdoor soil (dust) lead concentration when I run the model?

An appropriate assumption is that the concentration of lead in (sieved) outdoor soil and indoor soil-derived dust is the same. This is not the same as assuming the concentration of lead in outdoor soil and all sources of dust (*i.e.*, aggregate dust) are equal. The concentration of lead in aggregate dust may reflect a combination of outdoor soil, indoor lead sources (*e.g.*, paint), and non-lead sources (*e.g.*, organic material). Since the default assumption for the model is that soil ingestion represents outdoor soil and indoor soil-derived dust only (without contributions from other sources of lead), no distinction is needed between soil and dust concentrations.

What is the appropriate exposure frequency for a typical commercial/industrial worker -- 250 days, 219 days, or some other derived value for intermittent exposure?

The model default value for exposure frequency (EF) is 219 days/year. This value is a central tendency estimate for non-residential exposure scenarios (*i.e.*, both commercial and industrial), and corresponds to the average time spent at work by both full- and part-time workers engaged in non-contact-intensive activities. If workers are engaged in full-time activities, then an EF greater than 219 days/year may be appropriate.The model is designed to estimate blood lead concentrations (PbB) for workers who have a sustained period of contact with exposure media. The default assumption for the averaging time (AT) is 1 year (365 days), which is sufficient time for PbB to approach quasi-steady state (see ALM Guidance). If exposures are expected to occur over a shorter time interval, then EF should not be prorated over the entire year. For example, average daily lead intake from soil for a construction worker who works 5 days a week on a 26-week construction project and is not on site during the other 26 weeks (EF=130 days) would be assessed using an averaging time of 26 weeks (AT=182 days) rather than 52 weeks to avoid "diluting" the exposures over the entire year.

What is the shortest period of time for which I can apply the model?

The exposure duration (ED) should be sufficiently long to allow blood lead concentrations (PbB) to approach quasi-steady state. As discussed in the guidance, the shortest period of time appropriate for ED is 3 months (90 days). A minimum frequency of exposure of 1 day per week is also recommended. The ALM is recommended for repeated intermittent or continuous exposures over extended periods of time; it should not be used for acute exposures.

Is soil lead (from Equation 1) the site soil concentration to which the adult is exposed?

Yes, the soil lead in Equation 1 refers to the exposure point concentration. In most cases, exposure is assumed to be predominantly to the top layers of the soil (the recommendation is the top 2 cm); however, if that is not representative or available

then the most shallow samples of contaminated soil that can be collected under site conditions (see EPA Soil Screening Guidance, 1996) which give rise to transportable soil-derived dust should be considered. Exposure to soil-derived dust occurs in both outdoor and indoor environments, the latter occurring where soil-derived dust has been transported indoors. The model accounts for exposures that occur on a regular basis. Under both current and future exposure scenarios, an arithmetic mean concentration should be estimated from sampling data within the exposure area that a worker would be expected to have access to on a regular basis. Half an acre is a reasonable default assumption. Site-specific information may suggest workers are exposed to a greater area (*e.g.*, lineman) or a smaller area (*e.g.*, small commercial facility site).

Can the model be used to estimate adolescent trespassing? How would the model be applied when the receptor is an adolescent? What baseline blood lead level is appropriate? What about other input parameter values?

The adolescent population may be considered sensitive, since exposures during these years may result in a body burden of lead that is available to transfer to the fetus later in life. Given the limitations of currently available modeling tools, it is reasonable to apply the model to adolescent receptors (*e.g.*, trespasser scenarios), provided that appropriate values can be selected for important model parameters: (1) exposure frequency (EF); (2) exposure duration (ED); (3) baseline blood lead (PbB_0); (4) absorption fraction (AF). At this time, while empirical data on biokinetic slope factors (BKSF) appear to be similar for young children and adults, uncertainty arises when applying a similar estimate for adolescence (Mahaffey *et al.*, 1998). In addition, selecting an appropriate baseline blood lead (PbB_0) is likely to be difficult. Brody *et al.* (1994) reported low PbB_0 for children between the ages of 12 and 18 years (which results in PRGs ranging from 1800 to 2000 ppm). The low PbB_0 may be due to a growth spurt in which there is a increase in bone deposition that results in a lower concentration of lead in the blood; the total body burden of lead may still be increasing (Muth & Globel, 1983). Other factors may also contribute, such as increases in blood volume during periods of rapid growth. National databases (*e.g.*, NHANES III) can provide quality information on PbB_0. Presentation of calculations using a range of PbB_0 values is recommended. There is also a potential that lead absorption (AF) will be higher in adolescents than in adults.

Is 10 µg/dL (in the construction scenario) a level that should never be exceeded?

No. The 10 µg/dL is a multi-Agency goal that has been designated by the US Centers for Disease Control (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR) as a level of concern to protect sensitive populations (neonates, infants, and children). The protection of sensitive populations is assumed to also provide protection for adults. The EPA's stated goal for lead is that children (up to 84 months of age) exposed at a risk-based cleanup level would have no more than a 5% probability of exceeding the level of concern (U.S. Environmental Protection Agency, 1994; U.S. Environmental Protection Agency, 1998). The ALM extends that same concept to develop cleanup goals preventive of fetal risk. As a statistical goal, a probability of exceedance of up to 5% of the goal is acceptable.

Can the adult lead methodology be used to determine dermal exposure to lead at a site?

Although percutaneous absorption is generally not a significant route of exposure for inorganic lead, technically, the model can evaluate dermal exposure by incorporating the lead uptake from this pathway into the appropriate equation (see Equation A-3 in the Guidance). However, at this time, quantifying uptake from dermal exposure to soil-borne lead is not recommended due to the uncertainty in assigning a dermal absorption fraction that would apply to the numerous inorganic forms of lead that are typically found in environmental settings.

Should sieving be used to characterize samples for non-residential sites?

The lead concentration in the sieved (250 micron) fraction of surface soil provides the best estimate of the soil lead that is incidentally ingested and should be used in the ALM. However, sieving of samples from all depths may be useful in site characterization; users should proceed with caution when developing ratios between sieved and unsieved samples. Link to Sieving Short Sheet [EPA-540-F-00-010] in PDF format (87 KB, 3 pages).

Is there an appropriate default value for fish ingestion rate, or is this a site-specific issue? Can the ALM be used to establish fish advisories?

Fish ingestion rate is a site-specific parameter and therefore no appropriate default value exists. For fish advisories, it is recommended that concentration data be used to back-calculate an acceptable intake of fish. An appropriate absorption fraction should be used based on site specific data (portion of fish consumed -- fillets or entire fish).

What is an appropriate soil ingestion rate for a construction scenario (*i.e.*, soil contact-intensive scenario)?

The TRW recommends 50 mg/day as the default ingestion rate for indoor workers. This soil ingestion value is cited in two EPA documents: Recommendation of the Technical Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil (U.S. EPA, 1996), and the Exposure Factors Handbook (U.S. EPA, 1997). A reasonable default value that has been commonly used as a central tendency estimate for contact-intensive adult scenarios (such as an agricultural or construction worker) is 100 mg/day.There is high uncertainty in soil ingestion rates (IRs) for adults due to sparse empirical data. Empirical data on adult soil ingestion rates are available from two studies (Calabrese *et al.*, 1990; Calabrese *et al.*, 1997), each conducted concurrently with a study of childhood soil ingestion rates. Neither study group targeted a population expected to engage in frequent contact with soil, such as construction workers. The purpose of the pilot studies was to verify the tracer mass balance methodology used in the child studies, rather than to investigate the amount of soil normally ingested by adults. Despite their limitations, these studies provide an estimate of the amount of soil ingested by adults.The value of 50 mg/day represents a reasonable central tendency estimate of adult soil ingestion based on available data and is the recommended mean value. The value of 100 mg/day is equal to the recommended mean soil ingestion rate for young children, whose daily ingestion rates are expected to exceed that of adults (U.S. EPA, 1997). For construction workers and other soil contact-intensive occupations, OSWER guidance recommends an upper bound value for IRs of 330 mg/day based on Stanek et al. (1997) (as cited by EPA's Supplemental Guidance for Developing Soil Screening

Levels for Superfund Sites, 2001). The basis of the default IR is the 95th percentile value (330 mg/day). In this study, Stanek *et al.* (1997) also report the median, 75th percentile, and mean values as 1, 49, and 10 mg/day (SD = 94), respectively. The CV of 9.4 is indicative of significant uncertainties in these estimates. Because central tendency values are recommended as inputs to both the IEUBK Model for Lead in Children and the ALM model, a more plausible range for a soil lead IR is 50 to 200 mg/day for adult contact-intense soil exposures. Thus, there is reasonable support for use of 100 mg/day as a soil ingestion rate for the contact-intense worker scenario in the ALM.Although studies to directly measure adult soil ingestion are currently lacking, soil ingestion rates can be compared to measures of soil adherence to hands to provide additional perspective. Soil adhered to hands is relevant to soil ingestion because it is available for ingestion from hand-to-mouth activities. While soil adhesion to hands could be helpful in estimating soil ingestion, an accepted methodology that reliably estimates soil ingestion using soil adhesion data has not been developed for hazardous waste risk assessments.

REFERENCES

Gulson, B.L., Mahaffey, K.R., Jameson, C.W., Mizon, K.J., Korsch, M.J., Cameron, M.A. & J.A. Eisman. 1998. Mobilization of lead from the skeleton during the postnatal period is larger than during pregnancy. J Lab Clin Med, 131: 324-9.

Gulson, B.L., Pounds, J.G., Mushak, P., Thomas, B.J., Gray, B. & M.J Korsch. 1999. Estimation of cumulative lead releases (lead flux) from the maternal skeleton during pregnancy and lactation. J Lab Clin Med, 134: 631-40.

Holmes, K.K., Jr., Shirai, J.H., Richter, K.Y. and J.C. Kissel. 1999. Field measurement of dermal soil loadings in occupational and recreational activities. Environ Res, 80: 148-57.

Mahaffey, K., Gulson, B., Jameson, C.W., Vidal, M., Law, A., Mizon, K., Smith, A. & M. Korsch. 1998. Dietary lead intakes for mother-child pairs and relevance to pharmacokinetic models. Abstract No. 126. Society of Toxicology 37th Annual Meeting, 1-5 March 1998, Seattle, Washington. Toxicol Sci, 42, 27.

Muth, H. & B. Globel. 1983. Age Dependent Concentration of 236Ra in Human Bone and Some Transfer Factors from Diet to Human Tissues. Health Physics, 44 (Suppl. No. 1): 113-121.

National Academy of Sciences. 1993. Measuring lead exposure in infants, children, and other sensitive populations. National Academy Press: Washington, D.C.

Stanek, E.J., Calabrese, E.J., Barnes, R., & P. Pekow. 1997. Soil ingestion in adults -- results of a second pilot study. Ecotoxicol Environ Saf. 36(3): 249-57.

U.S. Environmental Protection Agency. 1994. OSWER Directive #9355.4-12 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. U.S. Environmental Protection Agency,: Washington, DC. EPA/540/F-94/043.

U.S. Environmental Protection Agency. 1997. Exposure Factors Handbook. U.S .Environmental Protection Agency, Office of Research and Development: Washington D.C.

U.S. Environmental Protection Agency. 1998. OSWER Directive #9200.4-27P Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. U.S. Environmental Protection Agency,: Washington, DC. EPA/540/F-98/030.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 13 1998

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

OSWER Directive 9200.4-26

MEMORANDUM

SUBJECT: Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites

FROM: Timothy Fields, Jr. Acting Administrator
Office of Solid Waste and Emergency Response

TO: Director, Office of Site Remediation and Restoration
Region I
Director, Emergency and Remedial Response Division
Region II
Director, Division of Environmental Planning and Protection
Region II
Director, Hazardous Waste Management Division
Regions IX
Director, Waste Management Division
Region IV
Director, Waste, Pesticides, & Toxics Division
Region V
Director, RCRA Multimedia Planning & Permitting Division
Region V
Director, Superfund Division
Regions III, V, VI, VII
Assistant Regional Administrator, Office of Ecosystems Protection and Remediation
Region VIII
Director, Hazardous Waste Program
Region VIII
Director, Office of Environmental Cleanup
Region X
Director, Office of Waste and Chemical Management
Region X

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PURPOSE

The purpose of this Directive is to recommend preliminary remediation goals (PRGs) or starting points for setting cleanup levels for dioxin in soil at Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) corrective action sites. These recommended levels are to be used pending the release of the U.S. Environmental Protection Agency (EPA) comprehensive dioxin reassessment report and cross-program assessment of the impacts of the report. One ppb (TEQs, or toxicity equivalents) is to be generally used as a starting point for setting cleanup levels for CERCLA removal sites and as a PRG for remedial sites for dioxin in surface soil involving a residential exposure scenario. For commercial/industrial exposure scenarios, a soil level within the range of 5 ppb to 20 ppb (TEQs) should generally be used as a starting point for setting cleanup levels at CERCLA removal sites and as a PRG for remedial sites for dioxin in surface soil. These levels are recommended unless extenuating site-specific circumstances warrant a different level.

The dioxin levels discussed in this Directive are also generally recommended for actions taken under RCRA at corrective action sites. The recommended levels of 1 ppb (TEQs) for residential soils and within the range of 5 ppb to 20 ppb (TEQs) for commercial/industrial soils should generally be used as starting points in setting soil cleanup levels at RCRA corrective action sites. These levels are generally consistent with soil cleanup levels set at RCRA facilities throughout the country where dioxin is a principal contaminant of concern at the facility. However, because states are the primary implementors of the RCRA Corrective Action program, this Directive does not prescribe specific procedures for implementation under RCRA.

This Directive sets forth the policy basis for these recommended levels and prescribes procedures for implementing these recommendations.

BACKGROUND

To date, EPA has generally selected 1 ppb as a cleanup level for dioxin in residential soils at Superfund and RCRA cleanup sites where dioxin is a principal contaminant of concern at the facility. EPA has also, to date, generally selected a cleanup level for dioxin within the range of 5 ppb to 20 ppb for commercial/industrial soils at Superfund and RCRA cleanup sites where dioxin is a principal contaminant of concern at the facility. The levels that EPA has selected at these sites are protective of human health and the environment. Based on presently available information, and using standard default assumptions for reasonable maximum exposure scenarios, the upper-

bound lifetime excess cancer risk from residential exposure to a concentration of 1 ppb dioxin is approximately 2.5×10^{-4}, which is at the higher end of the range of excess cancer risks that are generally acceptable at Superfund sites. The calculated upper-bound excess cancer risk associated with a lifetime commercial/industrial exposure to 5 ppb, or the lower end of the range recommended for commercial/industrial soils, is approximately 1.3×10^{-4}, which is also within the CERCLA risk range. It should be noted that there is more difficulty in generalizing about the cancer risk associated with commercial/industrial cleanup levels than there is with residential cleanup levels due to the greater variability in exposures associated with commercial/industrial scenarios. Accordingly, the consultation process for Superfund sites referenced in the implementation section of this Directive should be used to ensure the selection of appropriate, protective dioxin levels at CERCLA commercial/industrial sites. Similarly, for RCRA corrective action sites, please refer to the implementation section of this Directive.

EPA is presently completing work on a comprehensive reassessment of the toxicity of dioxin, to be embodied in the documents entitled "Health Assessment Document for 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds" and "Estimating Exposure to Dioxin-like Compounds." The reassessment report, which is scheduled to be issued in 1998, will represent the culmination of an Agency-wide effort to collect, analyze and synthesize all of the available information about dioxin. It has undergone significant internal and external review and is one of the most comprehensive evaluations of toxicity of a chemical ever performed by the Agency. Following release of the report, the Office of Solid Waste and Emergency Response (OSWER) will participate in a cross-program review of the implications of the report for the regulation and management of dioxin by EPA. We anticipate that this review will culminate in OSWER guidance addressing the management of dioxin at CERCLA and RCRA sites.

The Office of Solid Waste and Emergency Response does not believe it is prudent to establish new, and possibly varying, precedents for Superfund or RCRA dioxin levels just prior to the release of this reassessment report. As with any other pollutant, it is important that EPA ensure appropriate national consistency in remediation efforts. The Agency has used 1 ppb as a residential cleanup level and between 5 ppb and 20 ppb as a commercial/industrial cleanup level at CERCLA and RCRA cleanup sites for dioxin in soil in the past; it is anticipated that OSWER will be issuing guidance, informed by the reassessment effort, that will provide a basis for the selection of dioxin cleanup levels in the near future. In the interim, for sites that require the establishment of a final dioxin soil cleanup level prior to the release of the reassessment report and

development of OSWER guidance, EPA should generally use 1 ppb (TEQs) as a starting point for residential soil cleanup levels for CERCLA non-time critical removal sites (time permitting, for emergency and time critical sites) and as a PRG for remedial sites. EPA should generally use a level within the range of 5 ppb to 20 ppb (TEQs) as a starting point for cleanup levels at CERCLA non-time critical removal sites (time permitting, for emergency and time critical sites) and as a PRG for remedial sites for commercial/industrial soil. These levels should also be used as starting points in setting soil cleanup levels at RCRA corrective action sites.

For CERCLA remedial sites, consistent with 40 CFR § 300.430(f)(5)(iii)(D), EPA should commit to reviewing Records of Decision (RODs) (i.e., RODs in which this Directive has been used to develop dioxin soil cleanup levels) promptly following the release and analysis of the reassessment report and OSWER guidance, and, if necessary, to making changes to the RODs and cleanup actions, based on the information contained in the reassessment report and in the OSWER guidance. Similarly, in the case of non-time critical removal actions (time permitting, for emergency and time critical actions), EPA should commit to reviewing Action Memoranda promptly following the release and analysis of the reassessment report and OSWER guidance, and, if necessary, to making changes to the Action Memoranda and cleanup actions, based on the information contained in the reassessment report and the OSWER guidance. EPA should similarly commit to reviewing RCRA cleanup decisions (i.e., decisions for which this Directive has been used) promptly following the release and analysis of the reassessment report and OSWER guidance.

IMPLEMENTATION

Regional management should consult with the appropriate Office of Emergency and Remedial Response (OERR) Regional Centers on all proposed Fund and Potentially Responsible Party-lead site decisions under CERCLA, including other Federal agency-lead and state-lead site decisions, involving the development of dioxin soil cleanup levels for non-time critical removal sites (time permitting, for emergency and time critical removal sites) and remedial sites. Consultation should be initiated at the risk assessment stage. For Federal agency-lead sites, OERR will, in turn, notify the Federal Facilities Restoration Reuse Office of ongoing consultations. The Office of Site Remediation Enforcement will provide support if enforcement issues are identified. For consultation procedures, refer to the OSWER "Headquarters Consultation for Dioxin Sites", 9200.4-19, December 13, 1996, plus the OSWER "Consolidated Guide to Consultation Procedures for Superfund Response Decisions", 9200.1-18FS, May 1997.

In the case of EPA-lead RCRA corrective action sites, Regions should provide the Office of Solid Waste Permits and State Programs Division (OSW/PSPD) with proposed dioxin soil cleanup levels (i.e., prior to notice and comment) in order to ensure appropriate implementation of this Directive. For state-lead RCRA corrective action sites, it is also recommended that states use the dioxin levels recommended by this Directive as starting points in setting soil cleanup levels. States are encouraged to share their approaches with the Regions in a manner consistent with established procedures for EPA support and oversight of state RCRA Corrective Action programs.

The levels in this Directive are recommended unless extenuating site-specific circumstances warrant different levels, a more stringent state applicable or relevant and appropriate requirement (ARAR) establishes a cleanup level at CERCLA sites, or a more stringent state requirement applies at RCRA sites. We recommend that levels other than 1 ppb (TEQs) for residential soils and outside the range of 5 ppb to 20 ppb (TEQs) for commercial/industrial soils be used only where evidence exists that risks posed by the site differ from risks estimated using standard national default guidance values. These recommendations apply to RCRA corrective actions, CERCLA non-time critical removal actions (time permitting, for emergency and time-critical actions) and CERCLA remedial actions where cleanup levels are to be developed for dioxin in soil, regardless of whether dioxin itself drives the decision-making process.

The recommended levels found in this Directive, generally considered protective of human health and the environment, apply to surface soils. Please note that with respect to human health, these levels are based on the direct contact exposure pathway. The recommended levels in this Directive do not apply to other exposure pathways, such as migration of soil contaminants to ground water or to agricultural products. While the focus of this Directive is on soils, these recommended levels also apply to sediments in the event that this environmental medium is considered to be a direct exposure pathway for human receptors.

This document provides guidance to EPA staff. The guidance is designed to communicate national policy on dioxin cleanups for soil. The document does not, however, substitute for EPA's statutes or regulations, nor is it a regulation itself. Thus, it cannot impose legally-binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the circumstances. EPA may change this guidance in the future, as appropriate.

If you have any questions concerning this Directive, please contact either Marlene Berg at (703)603-8701 in Headquarters or Elmer Akin of Region 4 at (404)562-8634, as Marlene and Elmer are

co-chairs of the Superfund Dioxin Workgroup. For the RCRA Corrective Action program, please contact Robert Hall of the Office of Solid Waste Permits and State Programs Division at (703)308-8484. Attached, for your information, is a list of Regional points of contact who are serving on the dioxin workgroup.

Attachment: Superfund Dioxin Workgroup: Regional Points of Contact

cc: Mike Shapiro, OSWER
Peter Grevatt, OSWER
Steve Luftig, OERR
Elaine Davies, OERR
Larry Reed, OERR
Gershon Bergeisen, OERR
David Bennett, OERR
Bruce Means, OERR
Betsy Shaw, OERR
Paul Nadeau, OERR
Tom Sheckells, OERR
Murray Newton, OERR
John Cunningham, OERR
Dave Evans, OERR
Joe LaFornara, OERR
Mark Mjoness, OERR
Jim Woolford, FFRRO
Elizabeth Cotsworth, OSW
Barry Breen, OSRE
Tudor Davies, OW
Craig Hooks, FFEO
Earl Salo, OGC
Bill Sanders, OPPT
Bill Farland, ORD
Regional Counsel, Regions I-X
Peggy Schwebke, Region 5
Superfund Dioxin Workgroup

Appendix G-2
Remedial Goal Calculations

Remediation goals (RGs) based on carcinogenic effects were developed for arsenic in soil at SWMU 39. These goals were derived for three commercial/industrial scenarios (maintenance worker, excavation worker, and industrial worker) and two resident scenarios (adult and child). For each scenario, RGs were calculated at risk levels of 10^{-6}, 10^{-5}, and 10^{-4}.

By specifying the target risk, the RGs were back-calculated by re-arranging the risk and hazard calculations described in *Section 6.4*. The RGs were based on calculations for carcinogenic effects, as follows:

$$RG = \frac{TR \times BW \times AT \times 10^{6}\ mg/kg}{EF \times ED \times FI\,[A+B+C]}$$

where:

RG = remediation goal (mg/kg)
TR = target risk (unitless)
BW = body weight (kg)
AT = averaging time (days)
EF = exposure frequency (days/year)
ED = exposure duration (years)
FI = fraction ingested (unitless)

A – Ingestion Pathway

$A = (CSF_{oral})\,(IR_{oral})$

where:

CSF_{oral} = oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
IR_{oral} = ingestion rate (mg/day)

B – Dermal Absorption Pathway

$B = (CSF_{dermal})\,(SSA)\,(SSAF)\,(DABS)$

where:

CSF_{dermal} = oral Cancer Slope Factor, adjusted by oral absorption factor $(mg/kg\text{-}day)^{-1}$
SSA = skin surface area (cm^2)
SSAF = soil to skin adherence factor (mg/cm^2-day)
DABS = dermal absorption factor

C – Inhalation Pathway

$C = (CSF_{inhl})\ (IR_{inhl})\ (1/_{VF})\ (1/_{PEF})$

where:

CSF_{inhl}	=	inhalation Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
IR_{inhl}	=	inhalation rate (m^3/day)
VF	=	volatilization factor (m^3/day)
PEF	=	particulate emission factor (m^3/day)

To be consistent with the exposure parameters that were used in the risk and hazard calculations in *Section 6.0*, the same parameters were applied in derivation of RGs. The exposure parameters for the maintenance worker, excavation worker, adult resident, and child resident are summarized in **Appendix E-1, Tables E-7 through E-10.**

For purposes of the CMS, an additional commercial/industrial receptor was added to the scenarios used in the HHRA. An industrial outdoor worker was included to account for standard commercial/industrial exposures. The exposure parameters for this receptor are similar to those used for the maintenance worker except that the exposure frequency of 225 days/year is used rather than the more limited exposure frequency of 50 days/year.

The RGs for arsenic are shown in **Table G-1.**

Table G-1
Summary of Remediation Goal for Arsenic[a]

Medium	Receptor	Risk = 10^{-6}	Risk = 10^{-5}	Risk = 10^{-4}
Surface and Total Soil	Maintenance Worker	3.97	39.7	397
Surface and Total Soil	Industrial Worker	0.875	8.75	87.5
Total Soil	Excavation Worker	6.58	65.8	658
Total Soil	Adult Resident	0.5	5.0	50
Total Soil	Child Resident	0.28	2.8	28

[a] Values presented are in milligrams per kilogram.

RGs based on noncarcinogenic effects were developed for vanadium in soil at SWMU 39. These goals were derived for three commercial/industrial scenarios (maintenance worker, excavation worker, and industrial worker) and two resident scenarios (adult and child). For each scenario, RGs were calculated at target hazard index (HI) values of 1.0, 0.5, and 0.1.

By specifying the target HI, the RGs were back-calculated by re-arranging the risk and hazard calculations described in *Section 6.4*. Because levels of vanadium in soil resulted in exceedances of the HI, the RGs were based on calculations for noncarcinogenic effects, as follows:

$$RG = \frac{THI \ x \ BW \ x \ AT \ x \ 10^6 \ mg/kg}{EF \ x \ ED \ x \ FI \ [A+B+C]}$$

where:

RG = remediation goal (mg/kg)
THI = target hazard index (unitless)
BW = body weight (kg)
AT = averaging time (days)
EF = exposure frequency (days/year)
ED = exposure duration (years)
FI = fraction ingested (unitless)

A – Ingestion Pathway

$A = (1/RfD_{oral})\ (IR_{oral})$

where:

RfD_{oral} = oral Reference Dose (mg/kg-day)
IR_{oral} = ingestion rate (mg/day)

B – Dermal Absorption Pathway

$B = (1/RfD_{dermal})\ (SA)\ (SSAF)\ (DABS)$

where:

RfD_{dermal} = oral Reference Dose, adjusted by oral absorption factor (mg/kg-day)
SSA = skin surface area (cm^2)
SSAF = soil to skin adherence factor (mg/cm^2-day)
DABS = dermal absorption factor

C – Inhalation Pathway

$C = (1/RfD_{inhl})\ (IR_{inhl})\ (1/_{VF})\ (1/_{PEF})$

where:

RfD_{inhl} = inhalation Reference Dose (mg/kg-day)

IR_{inhl} = inhalation rate (m^3/day)
VF = volatilization factor (m^3/day)
PEF = particulate emission factor (m^3/day)

To be consistent with the exposure parameters that were used in the risk and hazard calculations in *Section 6.0*, the same parameters were applied in derivation of RGs. The exposure parameters for the maintenance worker, excavation worker, adult resident, and child resident are summarized in **Appendix E-1, Tables E-7 through E-10**.

For purposes of the CMS, an additional commercial/industrial receptor was added to the scenarios used in the HHRA. An industrial outdoor worker was included to account for standard commercial/industrial exposures. The exposure parameters for this receptor are similar to those used for the maintenance worker except that the exposure frequency of 225 days/year is used rather than the more limited exposure frequency of 50 days/year.

As stated, these RGs are based on HIs for noncarcinogenic effects. Although arsenic has noncarcinogenic effects, the resulting HIs for arsenic were below 1.0. The RGs calculated for the carcinogenic effects of arsenic are more conservative and, therefore, would be protective of noncarcinogenic effects.

The RGs for vanadium are shown in **Table G-2**.

Table G-2
Summary of Remediation Goals for Vanadium[a]

Medium	Receptor	Remediation Goals for Vanadium[a]		
		HI = 1.0	HI = 0.5	HI = 0.1
Surface and Total Soil	Maintenance Worker	1,440	722	144
Surface and Total Soil	Industrial Worker	321	160	32.1
Total Soil	Excavation Worker	144	71.9	14.4
Total Soil	Adult Resident	288	144	28.8
Total Soil	Child Resident	37.7	18.8	3.77

[a] Values presented are in milligrams per kilogram

Appendix H
National Environmental Policy Act Compliance Evaluation

Appendix H

Compliance With NEPA Requirements
SWMU 39

Environmental Consideration (i.e., Attributes)	**Alternative One:** No Further Action	**Alternative Two:** Institutional Controls (Land Use Controls, Groundwater Monitoring)	**Alternative Three:** Excavation with Waste in Place, Off-site Disposal, and Institutional Controls	**Alternative Four:** Excavation for Clean Close Out and Off-site Disposal,
Ecology – Impact on Wetlands	No wetlands identified at SWMU 39. No impact to wetlands.	No wetlands identified at SWMU 39. No impact to wetlands.	No wetlands identified at SWMU 39. No impact to wetlands.	No wetlands identified at SWMU 39. No impact to wetlands.
Ecology – Impact on Endangered and/or Threatened Species	No endangered and/or threatened species affected.	No endangered and/or threatened species affected.	While not observed during site reconnaissance, several threatened and endangered species have been found within the grassland community type at RFAAP. Some habitat may be disturbed during excavation activities in the excavation area. The area affected is minimal compared to overall site. Therefore, effects are expected to be minimal.	While not observed during site reconnaissance, several threatened and endangered species have been found within the grassland community type at RFAAP. Some habitat may be disturbed during excavation activities in the excavation area. The area affected is minimal compared to overall site. Therefore, effects are expected to be minimal.
Ecology – Impact on Vegetation	No impact.	No impact.	Limited vegetation will be removed during excavation activities as area is a former settling pond. No impact otherwise.	Limited vegetation will be removed during excavation activities as area is a former settling pond. No impact otherwise.
Archeological	None present in the SWMU 39 area.	None present in the SWMU 39 area.	None present in the SWMU 39 area.	None present in the SWMU 39 area.
Noise	None.	None.	Slight increase in noise levels (dB) due to excavation activities. Increases will not be significant.	Slight increase in noise levels (dB) due to excavation activities. Increases will not be significant.
Water – surface water, groundwater	No impact to surface water or groundwater.	No impact to surface water or groundwater.	Contaminants would be removed from surface and subsurface soil. Therefore, no migration of contaminants to groundwater will occur. Erosion control measures will be employed to prevent impacts to surface water bodies.	Contaminants would be removed from surface and subsurface soil. Therefore, no migration of contaminants to groundwater will occur. Erosion control measures will be employed to prevent impacts to surface water bodies.
Human Aspects	No human impact.	No human impact.	There will be minimal increase in traffic due to excavation activities.	There will be minimal increase in traffic due to excavation activities.

Appendix H

Compliance With NEPA Requirements
SWMU 39

Environmental Consideration (i.e., Attributes)	**Alternative One:** No Further Action	**Alternative Two:** Institutional Controls (Land Use Controls, Groundwater Monitoring)	**Alternative Three:** Excavation with Waste in Place, Off-site Disposal, and Institutional Controls	**Alternative Four:** Excavation for Clean Close Out and Off-site Disposal,
Land – Soil erosion, land use	No effect.	No effect.	Erosion control measures must be implemented during excavation activities. No impacts on current land use.	Erosion control measures must be implemented during excavation activities. No impacts on current land use.
Waste disposal – solid waste, hazardous waste	No effect. No waste generated.	No effect. No waste generated.	Will require disposal of decontamination water. In addition, soil will be disposed at appropriate (RCRA Subtitle C or D) landfill facility.	Will require disposal of decontamination water. In addition, soil will be disposed at appropriate (RCRA Subtitle C or D) landfill facility.
Resources	No effect. No increased use of resources.	No effect. No increased use of resources.	No effect. No increased use of resources.	No effect. No increased use of resources.
Air	Essentially no effect. Arsenic, lead, vanadium, and/or dioxins/furans are not likely to be carried on soil particles through air or volatilized into atmosphere.	Essentially no effect. Arsenic, lead, vanadium, and/or dioxins/furans are not likely to be carried on soil particles through air or volatilized into atmosphere.	Increase in dust during excavation activities. Dust suppression measures will be employed to keep dust generation to a minimum.	Increase in dust during excavation activities. Dust suppression measures will be employed to keep dust generation to a minimum.

RFAAP = Radford Army Ammunition Plant
RCRA = Resource Conservation and Recovery Act
dB = Decibels