RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Former Lead Furnace Area 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

Final Document

November 2008

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

December 19, 2008

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

P.W. Holt
Environmental Manager
Alliant Techsystems, Inc.
Radford Army Ammunition Plant
P.O. Box 1
Radford, VA 24141-0100

Re: Radford Army Ammunition Plant, Va.
Review of Army's Final RCRA Facility Investigation/Corrective Measures Study (RFI/CMS)
Report for the Former Lead Furnace Area

Dear Mr. McKenna and Ms. Holt:

The U.S. Environmental Protection Agency (EPA) and Virginia Department of Environmental Quality (VDEQ) have reviewed the U.S. Army's (Army's) November 2008 Final RFI/CMS Report for the Former Lead Furnace Area, located at the Radford Army Ammunition Plant (RFAAP) in Radford, Virginia. Based upon our review, the report is approved, and in accordance with Part II. (E) (5) of RFAAP's Corrective Action Permit, it can now be considered final.

If you have any questions, please call me at 215-814-3413. Thanks.

Sincerely,

William Geiger
RCRA Project Manager
General Operations Branch (3WC23)

cc: James Cutler, VDEQ

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

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

11 DEC 2008

MCHB-TS-REH

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

SUBJECT: Document Titled: "Final RCRA Facility Investigation/Corrective Measures Study Report for the Former Lead Furnace Area, Radford Army Ammunition Plant, Virginia, November 2008"

1. The U.S. Army Center for Health Promotion and Preventive Medicine reviewed, without additional comment, the subject document on behalf of the Office of The Surgeon General pursuant to Army Regulation 200-1 (Environmental Protection and Enhancement). We appreciate the opportunity to review this report addressing the regulators' comments and concur with the selected remedial alternative as being protective of human health and the environment.

2. The document was reviewed by Mr. Dennis Druck, Environmental Health Risk Assessment Program. He can be reached at DSN 584-2953, commercial (410) 436-2953 or electronic mail "dennis.druck@us.army.mil".

FOR THE COMMANDER:

JEFFREY S. KIRKPATRICK
Director, Health Risk Management

CF:
HQDA (DASG-PPM-NC)
IMCOM-NE (IMNE-PWD-E)
USACE (CEHNC-CX-ES)
USAEC (IMAE-CD/Mr. Rich Mendoza)

ATK

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

www.atk.com

November 25, 2008

Mr. William Geiger
RCRA General Operations Branch, Mail Code: 3WC23
Waste and Chemicals Management Division
U. S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Mr. James L. Cutler, Jr.
Virginia Department of Environmental Quality
629 East Main Street
Richmond, VA 24143-0100

Subject: With Certification,
Former Lead Furnace Area, RCRA Facility Investigation/Corrective Measures Study Report,
Final Document, November 2008
EPA ID# VA1 210020730

Dear Mr. Geiger and Mr. Cutler:

Enclosed is the certification for the subject document that was sent to you on November 24, 2008. Also enclosed is the November 24, 2008 transmittal email. As this report was revised to incorporate your comments, we anticipate formal approval.

Please coordinate with and provide any questions or comments to myself at (540) 639-8658, Jerry Redder ATK staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 731-5782.

Sincerely,

P.W. Holt, Environmental Manager
Alliant Techsystems Inc.

c: Karen Sismour
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

08-815-176
JMcKenna

Rich Mendoza
U.S. Army Environmental Command
1 Rock Island Arsenal
Bldg 90, 3rd Floor, Room 30A
IMAE-CDN
Rock Island, Illinois 61299

Tom Meyer
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
M.A. Miano
P.W. Holt
J. J. Redder
Env. File

Coordination: J. McKenna
J. McKenna

MAMiano
M. A. Miano

08-815-176
JMcKenna

Concerning the following:

Former Lead Furnace Area
RCRA Facility Investigation/Corrective Measure Study
Final Document November 2008

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: Jon R. Drushal
TITLE: Lieutenant Colonel (P), US Army
Commanding

SIGNATURE:
PRINTED NAME: Kent Holiday
TITLE: Vice President and General Manager
ATK Energetics Systems

08-815-176
JMcKenna

Greene, Anne

From:	TrackingUpdates@fedex.com
[illegible]	Wednesday, December 10, 2008 9:42 AM
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Subject:	FedEx Shipment 796169812084 Delivered

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Name:	PAIGE W HOLT
E-mail:	'not provided by requestor'

Our records indicate that the following shipment has been delivered:

Purchase order number:	PAIGE W HOLT
Reference:	24200008AL01.00
Ship (P/U) date:	Dec 9, 2008
Delivery date:	Dec 10, 2008 9:37 AM
Sign for by:	K.COOKE
Delivered to:	Mailroom
Service type:	FedEx Priority Overnight
Packaging type:	FedEx Envelope
Nu[illegible] of pieces:	1
We[illegible]:	0.50 lb.
Special handling/Services:	Deliver Weekday
Tracking number:	796169812084

Shipper Information
PAIGE W HOLT
US ARMY BLDG 220ALLIANT TECH
STATE ROUTE 114; RADFORD ARMY AMMUNITION PLANT
RADFORD
VA
US
24141

Recipient Information
WILLIAM GEIGER
EPA, REGION III
1650 ARCH ST; RCRA GEN OPER BRANCH 3WC23
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PA
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From: TrackingUpdates@fedex.com
S[illegible] Wednesday, December 10, 2008 10:46 AM
To: Greene, Anne
Subject: FedEx Shipment 796169807810 Delivered

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Company Name: US ARMY BLDG 220ALLIANT TECH
Name: PAIGE W HOLT
E-mail: 'not provided by requestor'

Our records indicate that the following shipment has been delivered:

Purchase order number: PAIGE W HOLT
Reference: 24200008AL01.00
Ship (P/U) date: Dec 9, 2008
Delivery date: Dec 10, 2008 10:44 AM
Sign for by: M.HENRY
Delivered to: Receptionist/Front Desk
Service type: FedEx Priority Overnight
Packaging type: FedEx Envelope
Nu[illegible] of pieces: 1
We[illegible]: 0.50 lb.
Special handling/Services: Deliver Weekday

Tracking number: 796169807810

Shipper Information
PAIGE W HOLT
US ARMY BLDG 220ALLIANT TECH
STATE ROUTE 114; RADFORD ARMY AMMUNITION PLANT
RADFORD
VA
US
24141

Recipient Information
JAMES L CULTER
VIRGINIA DEQ
629 E MAIN ST
RICHMOND
VA
US
23219

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Leahy, Timothy

From:	McKenna, Jim J Mr CIV USA AMC [jim.mckenna@us.army.mil]
Sent:	Monday, November 24, 2008 2:11 PM
To:	Rossbach, Anne; anne.greene@atk.com; ealohman@deq.virginia.gov; dennis.druck@us.army.mil; diane.wisbeck@arcadis-us.com; durwood willis2; Geiger.William@epamail.epa.gov; jerome.redder@atk.com; jim spencer; jlcutler@deq.virginia.gov; kjsismour@deq.virginia.gov; Llewellyn, Tim; Mendoza, Richard R Mr CIV USA IMCOM; Meyer, Tom NAB02; Parks, Jeffrey; Leahy, Timothy; Tina_Devine@URSCorp.com
Subject:	Radford AAP - Final FLFA RFI/CMS Report (UNCLASSIFIED)
Attachments:	EAS

Classification: UNCLASSIFIED
Caveats: NONE

All:

Note the contractor will ship the subject document with a copy of this email to the POCs and tracking numbers below. This final report was revised to reflect the attached responses to regulatory comments on the draft.

Certification letter will follow from Radford AAP under separate cover.

Immediately below are the POCs with tracking numbers:

Rich Mendoza, USAEC-RIA, 1Z63V8840199590494 William Geiger, US EPA Region III, 1Z63V8840199071303 Jim Cutler, VDEQ, 1Z63V8840195481716 Elizabeth Lohman, VDEQ, 1Z63V8840197673676 Tom Meyer, USACE-Baltimore, 1Z63V8840195463281 Dennis Druck, USACHPPM, 1Z63V8840197243256 Susan M. Ryan, USAEC-Legal, 1Z63V8840196165664

Thank you for your support of the Radford AAP Installation Restoration Program.

Jim McKenna
540 731 5782
Classification: UNCLASSIFIED
Caveats: NONE

Attachments:
FLFA EPA VDEQ RTCs complete.pdf (71976 Bytes)

Response to USEPA & VDEQ Comments, Dated 14 May 2008
for
Draft FLFA RFI/CMS Report
Dated February 2008

Comments from Will Geiger, USEPA and Jim Cutler, VDEQ

GENERAL COMMENTS

Comment 1

The figures in the RFI/CMS Report provide visual representations of the extent of soil and groundwater contamination at the Former Lead Furnace Area (FLFA). The extent of contamination of the following areas of interest does not appear to have been fully delineated based on the information presented on Figure 8-2. The RFI/CMS Report does not identify any data gaps or areas which would require the collection of additional data to fully define the extent of impacted soils. The RFI/CMS Report should be revised to address the perceived data gap, or lack of data for complete delineation of the extent of impacted soils to be excavated. Those areas of particular concern are described below:

- The area to the west of sample location LF2209 appears to be bounded by a sample that exceeds the residential remedial goal (RG). Also, the northern extent of this excavation area is bounded by an XRF value above the residential RG.
- The area to the west of sample locations LFSB16 and LSFB17 appears to be bounded by these two samples that exceed the residential RG. Also, the eastern extent of this excavation area is bounded by sample location LFSS02 whose result is above residential RGs.
- The area to the west of sample location LFSS13 appears to be bounded by a sample that exceeds the residential RG.
- The area north of sample location LFSB12 appears to be bounded by a sample that exceeds the residential RG.

The RFI/CMS Report should be revised to either propose that confirmation sampling be conducted of the excavation or allow for the pre-excavation verification of the limits of excavation to document that the intended limits of excavation extend until levels of contaminants of concern are below the proposed residential RGs. Please revise the RFI/CMS Report accordingly. Ensure that this discussion also addresses the vertical extent of contamination as well.

> **Response**
>
> The information requested is currently in the CMS on pages 9-4 and 9-6 as follows:
>
> **Page 9-4:**
>
> ***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 on **Figure 8-1** where contamination was previously determined to be above RGs. The entire area will be delineated to assess the area that needs remediation. Fixed-based laboratory samples will be collected and analyzed to

vertically and horizontally delineate the contamination at the site. A grid sampling program will be developed around the areas where these analytes were detected above RGs during the previous sampling events. For the purpose of this study, it is assumed that surface soil samples would be collected from a total of 71 locations and analyzed for arsenic and lead. Lead is the most widespread COI at the site and its presence will be used as a marker for the organic constituents (dioxins/furans). Details on sample locations, sample depths, etc. will be developed during the work planning phase.

Page 9-6:
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 15 samples will be collected from the bottom and sides of the excavation areas and sent to an off-site laboratory for arsenic, copper, and lead. Lead is the most widespread COI and its removal will indicate the removal of secondary COIs (dioxins/furans). Thirty-three percent of the confirmation samples will be analyzed for these COIs to ensure that they have also been removed.

Although this information is pertinent to Alternative Three in Section 9.3, the following statements are contained in Section 9.4 of the selected alternative "Alternative Four includes the cost items (up to site restoration) discussed in Alternative Three (*Section 8.3*) above, with longer durations for the additional volume of soil to be excavated. Since the Residential COIs for the FLFA are different than the Industrial, delineation and confirmation samples will be analyzed for the Residential COIs (lead, copper, dioxins/furans, and Aroclor-1254) as well as arsenic, an additional industrial COI. Once soil containing COIs at concentrations exceeding the RGs are removed, clean closure of the site will be achieved and land use controls, long-term monitoring, and the 5-year sampling/reporting is not required."

Comment 2
Except for Table 4-4, the data summary tables do not include soil screening levels (SSLs) for soils. Please revise all the soil data summary tables to include the applicable screening criteria for ease of comparison.

Response
Table 4-4 represents a screening of all applicable soil data that was collected at the FLFA. The first sentence of Section 4.1.1.2 will be modified as follows to clarify that all FLFA soil samples were compared to Region III Soil Screening Levels: "As shown in **Table 4-4**, detected soil results from all FLFA soil samples were compared to USEPA Region III Soil Screening Level (SSL) soil transfer to groundwater values, using a dilution attenuation factor of 20 (USEPA, 2007a)."

Comment 3
Figure 2–5: Amend the figure to provide notes, as in Figure 2-4. Include a water level for LFMW-01 and others, as needed.

Response

Notes similar to those contained on Figure 2-4 will be added to Figure 2-5, where applicable. In addition, the water level for monitoring well LFMW01 will be included in the notes.

Comment 4

Illustrate “INJ 1" on Figure 2-7.

Response

INJ1 will be added to Figure 2-7 as requested.

Comment 5

What is the source of perchlorate, as described in Subsection 4.2.3? The perchlorate plume should be delineated in three dimensions and risk associated with perchlorate should be evaluated similarly to the way in which risk for chloroform and PCE will be evaluated. These COIs were found at the site, but may not have originated there. RAAP has committed to assess chloroform and PCE at an adjacent site, but has not committed to assess perchlorate.

Response

Based on the discussion during the June 11, 2008 RFAAP/EPA/VDEQ partnering meeting, the stakeholders agreed that the ubiquitous, low-level detections of perchlorate do not constitute a plume and do not trigger a risk. Therefore further assessment of perchlorate is not required. A similar logic can be applied to other chemicals that are detected below actionable levels. Finally to clarify we assume the “adjacent site” referenced above is SWMU 40/71. If so note PCE was not detected and that RFAAP submitted a draft RFI/CMS report which proposed to repair the cap and perform long term monitoring at SWMU 40/71. Further assessment of any COI was not included.

Comment 6

When sampling ground water, both filtered and unfiltered samples should be obtained for metals analysis (p 4-35).

Response

Comment noted. Filtered and unfiltered samples will be obtained for metals analysis in future groundwater samples.

Comment 7

Although monitoring well 17MW3 has been determined as being cross gradient of the FLFA, the sampling results seem to be consistent with other wells in the area. Provide the basis for the determination of ‘cross gradient’. Is this really an ‘on-site well’?

Response

17MW3 was determined to be cross gradient based on the direction of groundwater flow and its location (see map). This well is downgradient from SWMU 17B (Air Curtain Destructor (ACD) Staging Area, SWMU 17C (ACD), SWMU 17D (Bottom Ash Staging Area) and SWMU 17E (Runoff Drainage Basin). This well was installed to monitor the

1994 dye-trace study and was located along the axis of the sinkhole containing SWMUs 17B-D and INJ2. The dye injected at SWMU17A was detected several days later at SPG3. This dye was not detected in well 17MW3.
No, this is not an onsite well. It was sampled for the FLFA investigation because it was associated with SWMU17, part of which is collocated with the FLFA.

Comment 8
Section 8-1: The report should elaborate on how offsite groundwater contamination will be addressed in a future report. SWMU 17 is adjacent, but not IR-eligible.

Response
[Note: see response to comment 5 above]. Chloroform detections were well below the MCL for this constituent and can be attributed to leaks in drinking water lines throughout the installation. PCE was detected in a single well at a concentration below its MCL. Based on the distribution and concentration of constituents in groundwater; as well as the discussion during the June 11, 2008 RFAAP/EPA/VDEQ partnering meeting, no further groundwater investigation is planned to assess these constituents.

Section 8.1 will be re-written as shown below to remove the reference to a future groundwater investigation and additional information will be added to Section 4.2.3 (also shown below).

Original Text (section 8.1, 2nd paragraph):

> *"For groundwater, the HHRA selected PCE, chloroform, and vanadium as COIs for a residential and/or industrial future-use scenario. However, chloroform and PCE were not detected in the on-site well (LFMW01) and are present in upgradient wells from the FLFA, indicating that the FLFA is not the source of these constituents in groundwater. In addition, chloroform has been found in groundwater at other sites at RFAAP and is suspected to be due to leaking water pipes. These constituents are outside the scope of the FLFA RFI/CMS and will be addressed in a future report associated with the source site."*

Revised Text (section 8.1, 2nd paragraph):

> *"For groundwater, the HHRA selected PCE, chloroform, and vanadium as COIs for a residential and/or industrial future-use scenario. However, chloroform and PCE were not detected in the on-site well (LFMW01) and are present in upgradient wells from the FLFA, indicating that the FLFA is not the source of these constituents in groundwater. In addition, the low level chloroform detections (below MCL) are attributable to leaking potable water supply lines throughout the installation. Chloroform has also been detected at other sites downgradient from water lines at similar concentrations (Area O, for example). PCE was only detected in a single well (17MW-2), and the concentration was below its MCL. Based on the limited detections and low concentrations, additional groundwater investigation or remediation is not warranted at this site."*

Original Text (section 4.2.3, 2nd paragraph):

> *"Two VOCs (chloroform and PCE), five metals (aluminum, chromium, iron, manganese, and vanadium), and perchlorate were detected in FLFA wells at concentrations exceeding groundwater screening levels. Neither of the VOCs are originating from the FLFA, as evidenced by the fact that: 1) they were not detected in site soil; and, 2) they were not detected in the on-site well."*

Revised Text (section 4.2.3, 2nd paragraph):

> *"Two VOCs (chloroform and PCE), five metals (aluminum, chromium, iron, manganese, and vanadium), and perchlorate were detected in FLFA wells at concentrations exceeding groundwater screening levels. PCE was detected in a single upgradient well (17MW-02) at a concentration below its MCL. Chloroform was detected in five of the seven wells sampled. The maximum concentration was 24 ug/L, well below the MCL of 80 ug/L. These detections of chloroform are attributable to leaks in potable water supply lines throughout the Installation. Chloroform has also been detected at similar concentrations at other sites downgradient from water lines (Area O, for example). Neither of the VOCs are originating from the FLFA, as evidenced by the fact that: 1) they were not detected in site soil; and, 2) they were not detected in the on-site well."*

Response to USEPA Comments, Dated 25 February 2008,
for
Draft FLFA RFI/CMS Report
Dated February 2008

Comments from Betty Ann Quinn, USEPA

GENERAL COMMENTS

Comment 1

In the human health risk assessment (HHRA), it cannot be determined whether RFAAP considered recent guidance for estimating cancer risk for carcinogens that act via a mutagenic mode of action (i.e., benzo(a)pyrene). This will not affect the current risk assessment substantially, however, in future reports, age-dependent adjustment factors (ADAFs) should be applied to calculated risk for these carcinogens, in accordance with the *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (EPA, 2005).

> **Response**
>
> The ADAFs were not applied in the HHRA for the FLFA. As noted in the comment, however, this result would not substantially change the conclusions of the risk assessment. In addition, development of the FLFA for residential use is highly unlikely because the site is located on a 45 degree slope. In response to this comment, it is agreed that ADAF calculations will be included in future risk assessments for carcinogens that act via a mutagenic mode of action.

Comment 2

The uncertainty section has not discussed uncertainties and/or limitations associated with several models that were used in the HHRA, including the Johnson and Ettinger (J&E) model used to estimate indoor air concentrations from groundwater, the volatilization model to ambient air outlined in American Society for Testing and Materials (ASTM) Risk-Based Corrective Action Guidance, and several other models. Many of these models, including the J&E model, include limitations that may affect the results. Please revise the HHRA to address any uncertainties or limitations associated with use of the J&E model, and other models in this risk assessment.

> **Response**
>
> A discussion will be added regarding the limitations and uncertainties associated with the each of the models used in the HHRA. As acknowledged in the *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings* (USEPA, 2003), the Johnson and Ettinger (J&E) model "…was developed for use as a screening level model and consequently is based on a number of simplifying assumptions regarding contaminant distribution and occurrence, subsurface characteristics, transport mechanisms, and building construction." There are assumptions that are not likely to be met at the FLFA. For example, contaminants are assumed to be homogeneously distributed at the source, soil properties are assumed to be homogeneous in any horizontal plane, and the model does not account for contaminant attenuation (biodegradation, hydrolysis, sorption, and

oxidation/reduction). In addition, there are currently no structures located at the FLFA. Therefore, default values were used to represent the building characteristics. It is likely that these same conditions would preclude the use of the J&E model for FLFA as well as many other RCRA and Superfund sites. While the J&E has a number of limitations, the results of the risk assessment would be more uncertain if a less accepted or documented approach was used. As stated in Comment 1, however, the FLFA is located on a 45 degree slope. Due to the topography at the site, it is unlikely that buildings would be constructed on this site in the future. This limitation will also be discussed in the uncertainty section.

Comment 3

It appears that total site risks and noncarcinogenic hazards for the hypothetical future residential receptor were based on exposure point concentrations (EPCs) for total soil and not surface soil. Under typical circumstances, the residential receptor would likely be exposed to surface soil or shallow soil during gardening or other outdoor activities. It is noted on some report tables that if the site is developed in the future, exposure to surface and subsurface soil may occur as a result of soil mixing associated with construction activities/development. However, given that most of the elevated soil concentrations are in surface soil this approach may not be sufficiently conservative. Clarify whether use of total soil concentrations to generate risk estimates results in a reduced number of contaminants of concern, or a reduced area expected to be remediated. If no significant impact on remedial actions to be taken is demonstrated, no modification of the risk assessment is necessary.

Response

While residential receptors were evaluated with respect to total soil, it is noted that the total soil data set includes both surface and subsurface soil. Therefore, the lists of COPCs for surface soil and total soil are nearly identical with the exception of thallium. Thallium was identified as a COPC in total soil only. The risks and hazards associated with surface soil and total soil would be expected to parallel the industrial scenario. For the industrial scenario, the cumulative risk for surface soil was 1.0E-05 and for total soil was 1.1E-05. The cumulative HI for surface soil was 0.75 and for total soil was 0.86. Although many of the EPCs in surface soil were slightly higher than those in total soil, the EPC for arsenic was higher in total soil and had the greatest contribution to cumulative risk and hazard. The differences in the arithmetic mean lead concentrations between surface soil (1,210 mg/kg) and total soil (763 mg/kg) were more pronounced. In both cases, however, lead exceeds the health protective criterion for lead, and the goal for remediation (400 mg/kg) is the same. Due to the topography of the site, however, it is unlikely that the area would be developed for residential use.

SPECIFIC COMMENTS

Comment 4

Section 6.1.1, Data Summary, Page 6-1: This section discusses the method for calculating toxicity equivalence factors (TEFs) relative to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) for those dioxin congeners for which toxicity criteria are unavailable. However, it does not describe how non-detected congeners were used in the calculations. If a result is reported as non-detected the common conservative practice for determining its concentration is to set it to one-half the detection level. Please revise the HHRA to clarify the use of non-detect congener values in the calculation of TEFs.

> **Response**
> In some data sets, the inclusion of the non-detect congeners at half (½) of the detection limit can lead to risks driven by constituents that were not detected. In addition, the User's Guide for ProUCL 4.0 now recommends against using ½ the detection limit to represent non-detect results. Other estimation techniques are recommended instead. For constituents that have not been detected in at least one sample, including these estimated concentrations leads to greater uncertainty.
>
> The TCDD TEs for each medium at FLFA will be re-calculated because some of the detected concentrations were inadvertently left out of out the total TCDD TE calculation. The text will be revised to clarify that results for non-detect congeners that were detected in at least one sample are included in the calculation of the TCDD TE. Results for non-detect congeners that were not detected in at least one sample are not included.

Comment 5
Section 6.1.2, Identification of COPCs, Page 6-4: This section describes the initial screening for contaminants of potential concern (COPC), but it does not indicate whether surrogates were used for some of the screening concentrations. Tables E.1-2 and E.1-4 of Appendix E appear to include screening values for benzo(g,h,i)perylene and phenanthrene, but EPA Region 3 RBCs have not been established for these constituents. It appears that toxicity data from other constituents may have been used as surrogates for these two compounds, but neither the tables nor the text of the HHRA appear to identify the surrogate compounds. For clarity and completeness, please identify those compounds for which surrogates were used, and identify the applicable surrogate compounds in the notes of the screening tables in Appendix E.

> **Response**
> The screening values and the toxicity values for pyrene were used for benzo(g,h,i)perylene and phenanthrene. This surrogate, and other surrogate compounds, will be explained in footnotes to Tables E.1-2, E.1-4, E.1-36, E.1-37, E.1-38, and E.1-39.

Comment 6
Section 6.1.2, Identification of COPCs, Page 6-4: Section 6 does not include a list of those constituents that were identified as COPCs in surface soil, total soil, and groundwater. Although this information can be found in the Appendix E tables, a summary of the identified COPCs should also be included in the main text of the document for easy reference. Please revise Section 6 to include a summary list of the COPCs identified during the screening process.

> **Response**
> A summary table of COPCs will be added to the report, as requested. The COPCs will be identified for each medium.

Comment 7

Section 8.1, Summary of Chemicals of Interest, Page 8-1: The first paragraph summarizes the Chemicals of Interest (COI) that were identified during the HHRA. However, it is not clear why some of the constituents noted were selected as COIs. In particular, dioxins/furans as TCDD TE is identified as a COI under an industrial future-use scenario, but this constituent is not identified as a risk driver in Table 6-1, Summary of Risks and Hazards, nor is it discussed in the HHRA Summary and Conclusions. Please revise Section 8.1 (and the HHRA as necessary) to better define a COI. Additionally, please clarify why dioxins/furans as TCDD TE is identified as a COI for the industrial future-use scenario when it is otherwise not discussed in the HHRA in Section 6.0.

> **Response**
>
> Dioxins/furans will be added to Table 6-2 as a COI for surface soil via exposures by industrial workers. As noted in the response to Comment 4, the TCDD TE values and cancer risk for dioxin/furan values will be re-calculated.

Comment 8

Section 8.2, Remedial Goals, Page 8-2: The RG calculated for arsenic was based on a target risk (TR) of 1E-05, and the RG for copper was based on a hazard index (HI) of 1.0. The document has not provided the rationale for selection of this TR and HI for the RGs. It is not clear why the more conservative values (TR of 1E-06 and HI of 0.5 or 0.1) were not selected and shown in Table 8-1, Identification of Remedial Goals for Arsenic and Copper in FLFA Soil, in Section 8. Please revise the RFI/CMS Report to provide additional justification for selection of a TR of 1E-05 for the arsenic RG, and a HI of 1.0 for the copper RG.

> **Response**
>
> The copper RG was based on an HI of 1.0 because it was the main risk driver for non-carcinogenic effects. Although arsenic does add to the total HI, the RG calculated for the carcinogenic risk was lower and that value was selected. Published PRGs were selected for the remaining COIs.
>
> Although more conservative values could have been selected, the TR and HI are consistent with other RPA and VDEQ approved Radford RFI/CMS documents where excavation and off-site disposal remedies were selected, including:
>
> - SWMU 51 RFI/CMS - see shallow soil remedial goals (July, 2008)
> - SWMU 39 RFI/CMS (October, 2004)
> - AOC Building 4343 RFI/CMS (February, 2004)
>
> Finally, it should be noted that lead is the contaminant present in the greatest quantities and with the greatest lateral extent. Lead will be used as a “tracer” during excavation activities by monitoring with an XRF. Removing lead-containing soil to a concentration of 400 mg/kg will encompass the other, minor constituents as well.

Comment 9

Appendix E, Tables E.1-2 and E.1-4, Occurrence, Distribution, and Selection of Contaminants of Potential Concern, Surface Soil and Total Soil, respectively: These tables identify the residential soil screening value for 2,4-dinitrotoluene (2,4-DNT) as 9.4E-01 mg/kg, the screening value for the dinitrotoluene mix. For clarity, include the rationale for use of this value over the value for 2,4-DNT (include on Tables E.1-2 and E.1-4 also).

> **Response**
> Because the resulting screening value for the dinitrotoluene mix is based on the cancer endpoint, it is more conservative than the screening level for 2,4-DNT based on the noncancer endpoint. The rationale for selecting the screening value for dinitrotoluene mix will be added to the footnotes of Tables E.1-2 and E.1-4.

Comment 10
Appendix E, Table E.1-2, RAGS D Surface Soil results: It is not clear why the maximum lead concentration listed on this table (and subsequent tables) is 25,900 mg/kg, when Table 4-1 lists a maximum lead concentration (in the same sample, LFSS20) of 36,500 mg/kg. Clarify, and revise EPCs and risk estimates as necessary.

> **Response**
> The maximum lead concentration listed in Table E.1-2 represents the average concentration between Sample LFSS20 (36,500 mg/kg) and its duplicate, Sample TMSS20 (15,200 mg/kg). The concentration of the duplicate pair was averaged prior to generating Table E.1-2. Therefore, the average concentration (25,900 mg/kg) is shown as the maximum value in Table E.1-2.

Comment 11
Appendix E, Table E.1-41a, RAGS D Adult Lead Worksheet: The response to the question on what statistics were used to represent exposure concentration terms for the model should state that the exposure concentration was based on lead concentrations in total soil, not surface soil.

> **Response**
> The table will be revised, as requested.

Comment 12
Appendix E, Table E.1-43, IEUBK model output: Note that dietary lead intake values to be used in the IEUBK model have been revised. These new, lower, values can be found on the EPA lead website at http://www.epa.gov/superfund/lead/ieubkfaq.htm#fda , and should be used in future risk assessments.

> **Response**
> The new dietary lead intake values will be used in subsequent HHRAs. Given the high concentrations of lead at FLFA, the use of these new values would not likely change the conclusions of the HHRA.

Comment 13
Appendix G-2, Remedial Goal Calculations: This appendix references Appendix E-1, Tables E-7 through E-10 for the exposure parameters to be used in the calculation of RGs. These are the same exposure parameters used in the initial calculations of risk. The referenced tables do

not appear to include exposure parameters (many of them instead include the EPC calculations/results). It appears that exposure parameters are included on Tables E.1-15 and subsequent tables. Please revise Appendix G-2 to include the correct reference for the exposure parameters used in the calculation of RGs.

Response

The correct reference to the tables containing the exposure parameters is Tables E.1-15 through E.1-24.

Response to Comments
from Ruth Prince, USEPA Ecological Risk Assessor, via e-mail from Will Geiger
Dated 17 June 2008
for
Draft FLFA RFI/CMS Report
Dated February 2008

Comment 1

The “USEPA published recommended residential and industrial cleanup levels” for PCBs (Aroclor 1254) shown on pg 8-2 are incorrect, as follows:

a) 50 mg/kg PCBs is not an EPA industrial cleanup level. In fact, 40 C.F.R. Part 761.61 does not specify any industrial cleanup level. Instead, 50 ppm PCBs is the trigger level for TSCA authority if found in at least one analytical sample from a site.

b) The low occupancy designation is not characterized as residential. Low occupancy is defined in Part 761.30 as an average occupancy of 6.7 hrs per week, typical of an electrical substation or portion of an industrial operation that requires a minimal human presence. Therefore, it is by no means “residential”.

> **Response**
> The text regarding an industrial cleanup level for PCBs will be deleted. Due to low exposure frequency, the low occupancy level does not apply to the worker or residential scenarios at the FLFA. The text regarding low occupancy will be deleted. Based on the definition of high occupancy, 1 mg/kg will be considered the RG for the FLFA. The text will be revised accordingly.

Leahy, Timothy

From:	Geiger.William@epamail.epa.gov
Sent:	Friday, November 14, 2008 10:33 AM
To:	McKenna, Jim J Mr CIV USA AMC
Cc:	dennis.druck@us.army.mil; diane.wisbeck@arcadis-us.com; jim spencer; Parks, Jeffrey; jlcutler@deq.virginia.gov; Mendoza, Richard R Mr CIV USA IMCOM; Leahy, Timothy; Llewellyn, Tim; Tina_Devine@URSCorp.com; Meyer, Tom NAB02
Subject:	Approved - FLFA RFI/CMS response to comments (RTCs) complete set attached

Jim, EPA and VDEQ approve of the complete set of FLFA RFI/CMS responses to comments.

William A. Geiger
USEPA Region III
1650 Arch Street, 3LC20
Philadelphia, PA 19103
(215)814-3413

"McKenna, Jim J Mr CIV USA AMC" <jim.mckenna@us.army.mil>

11/03/2008 10:56 AM

To
William Geiger/R3/USEPA/US@EPA, <jlcutler@deq.virginia.gov>, "Meyer, Tom NAB02" <Tom.Meyer@usace.army.mil>, "Llewellyn, Tim" <Tim.Llewellyn@arcadis-us.com>, <Timothy.Leahy@shawgrp.com>, <Tina_Devine@URSCorp.com>, <diane.wisbeck@arcadis-us.com>, "Parks, Jeffrey N" <Jeffrey.Parks@shawgrp.com>, "jim spencer" <james_o_spencer@urscorp.com>, "Meyer, Tom NAB02" <Tom.Meyer@usace.army.mil>, "Mendoza, Richard R Mr CIV USA IMCOM" <richard.r.mendoza@us.army.mil>, <dennis.druck@us.army.mil>

cc

Subject
FLFA RFI/CMS response to comments (RTCs) complete set attached (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Will and Jim Cutler,

Complete set of RTCs attached. Please disregard earlier emails and forward this along to other in your organizations that need it.

Thanks.
Jim

Classification: UNCLASSIFIED
Caveats: NONE

[attachment "FLFA EPA VDEQ RTCs complete.pdf" deleted by William Geiger/R3/USEPA/US]

Leahy, Timothy

From:	McKenna, Jim J Mr CIV USA AMC [jim.mckenna@us.army.mil]
Sent:	Monday, November 03, 2008 10:56 AM
To:	Geiger.William@epamail.epa.gov; jlcutler@deq.virginia.gov; Meyer, Tom NAB02; Llewellyn, Tim; Leahy, Timothy; Tina_Devine@URSCorp.com; diane.wisbeck@arcadis-us.com; Parks, Jeffrey; jim spencer; Meyer, Tom NAB02; Mendoza, Richard R Mr CIV USA IMCOM; dennis.druck@us.army.mil
Subject:	FLFA RFI/CMS response to comments (RTCs) complete set attached (UNCLASSIFIED)
Importance:	High
Attachments:	FLFA EPA VDEQ RTCs complete.pdf

FLFA EPA VDEQ
RTCs complete.pd...

Classification: UNCLASSIFIED
Caveats: NONE

Will and Jim Cutler,

Complete set of RTCs attached. Please disregard earlier emails and forward this along to other in your organizations that need it.

Thanks.
Jim

Classification: UNCLASSIFIED
Caveats: NONE

Response to USEPA & VDEQ Comments, Dated 14 May 2008
for
Draft FLFA RFI/CMS Report
Dated February 2008

Comments from Will Geiger, USEPA and Jim Cutler, VDEQ

GENERAL COMMENTS

Comment 1

The figures in the RFI/CMS Report provide visual representations of the extent of soil and groundwater contamination at the Former Lead Furnace Area (FLFA). The extent of contamination of the following areas of interest does not appear to have been fully delineated based on the information presented on Figure 8-2. The RFI/CMS Report does not identify any data gaps or areas which would require the collection of additional data to fully define the extent of impacted soils. The RFI/CMS Report should be revised to address the perceived data gap, or lack of data for complete delineation of the extent of impacted soils to be excavated. Those areas of particular concern are described below:

- The area to the west of sample location LF2209 appears to be bounded by a sample that exceeds the residential remedial goal (RG). Also, the northern extent of this excavation area is bounded by an XRF value above the residential RG.
- The area to the west of sample locations LFSB16 and LSFB17 appears to be bounded by these two samples that exceed the residential RG. Also, the eastern extent of this excavation area is bounded by sample location LFSS02 whose result is above residential RGs.
- The area to the west of sample location LFSS13 appears to be bounded by a sample that exceeds the residential RG.
- The area north of sample location LFSB12 appears to be bounded by a sample that exceeds the residential RG.

The RFI/CMS Report should be revised to either propose that confirmation sampling be conducted of the excavation or allow for the pre-excavation verification of the limits of excavation to document that the intended limits of excavation extend until levels of contaminants of concern are below the proposed residential RGs. Please revise the RFI/CMS Report accordingly. Ensure that this discussion also addresses the vertical extent of contamination as well.

Response

The information requested is currently in the CMS on pages 9-4 and 9-6 as follows:

<u>Page 9-4</u>:

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 on **Figure 8-1** where contamination was previously determined to be above RGs. The entire area will be delineated to assess the area that needs remediation. Fixed-based laboratory samples will be collected and analyzed to vertically and horizontally delineate the contamination at the site. A grid sampling program will be developed around the areas where these analytes were detected above RGs during the previous sampling events. For the purpose of this study, it is assumed that surface soil samples would be collected from a total of 71 locations and analyzed for arsenic and lead. Lead is the most widespread COI at the site and its presence will be used as a marker for the organic constituents (dioxins/furans). Details on sample locations, sample depths, etc. will be developed during the work planning phase.

Page 9-6:
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 15 samples will be collected from the bottom and sides of the excavation areas and sent to an off-site laboratory for arsenic, copper, and lead. Lead is the most widespread COI and its removal will indicate the removal of secondary COIs (dioxins/furans). Thirty-three percent of the confirmation samples will be analyzed for these COIs to ensure that they have also been removed.

Although this information is pertinent to Alternative Three in Section 9.3, the following statements are contained in Section 9.4 of the selected alternative "Alternative Four includes the cost items (up to site restoration) discussed in Alternative Three (*Section 8.3*) above, with longer durations for the additional volume of soil to be excavated. Since the Residential COIs for the FLFA are different than the Industrial, delineation and confirmation samples will be analyzed for the Residential COIs (lead, copper, dioxins/furans, and Aroclor-1254) as well as arsenic, an additional industrial COI. Once soil containing COIs at concentrations exceeding the RGs are removed, clean closure of the site will be achieved and land use controls, long-term monitoring, and the 5-year sampling/reporting is not required."

Comment 2
Except for Table 4-4, the data summary tables do not include soil screening levels (SSLs) for soils. Please revise all the soil data summary tables to include the applicable screening criteria for ease of comparison.

Response
Table 4-4 represents a screening of all applicable soil data that was collected at the FLFA. The first sentence of Section 4.1.1.2 will be modified as follows to clarify that all FLFA soil samples were compared to Region III Soil Screening Levels: "As shown in **Table 4-4**, detected soil results from all FLFA soil samples were compared to USEPA Region III Soil Screening Level (SSL) soil transfer to groundwater values, using a dilution attenuation factor of 20 (USEPA, 2007a)."

Comment 3
Figure 2–5: Amend the figure to provide notes, as in Figure 2-4. Include a water level for LFMW-01 and others, as needed.

> **Response**
> Notes similar to those contained on Figure 2-4 will be added to Figure 2-5, where applicable. In addition, the water level for monitoring well LFMW01 will be included in the notes.

Comment 4
Illustrate “INJ 1" on Figure 2-7.

> **Response**
> INJ1 will be added to Figure 2-7 as requested.

Comment 5
What is the source of perchlorate, as described in Subsection 4.2.3? The perchlorate plume should be delineated in three dimensions and risk associated with perchlorate should be evaluated similarly to the way in which risk for chloroform and PCE will be evaluated. These COIs were found at the site, but may not have originated there. RAAP has committed to assess chloroform and PCE at an adjacent site, but has not committed to assess perchlorate.

> **Response**
>
> Based on the discussion during the June 11, 2008 RFAAP/EPA/VDEQ partnering meeting, the stakeholders agreed that the ubiquitous, low-level detections of perchlorate do not constitute a plume and do not trigger a risk. Therefore further assessment of perchlorate is not required. A similar logic can be applied to other chemicals that are detected below actionable levels. Finally to clarify we assume the “adjacent site” referenced above is SWMU 40/71. If so note PCE was not detected and that RFAAP submitted a draft RFI/CMS report which proposed to repair the cap and perform long term monitoring at SWMU 40/71. Further assessment of any COI was not included.

Comment 6
When sampling ground water, both filtered and unfiltered samples should be obtained for metals analysis (p 4-35).

> **Response**
> Comment noted. Filtered and unfiltered samples will be obtained for metals analysis in future groundwater samples.

Comment 7
Although monitoring well 17MW3 has been determined as being cross gradient of the FLFA, the sampling results seem to be consistent with other wells in the area. Provide the basis for the determination of ‘cross gradient’. Is this really an ‘on-site well’?

> **Response**
> 17MW3 was determined to be cross gradient based on the direction of groundwater flow and its location (see map). This well is downgradient from SWMU 17B (Air Curtain Destructor (ACD) Staging Area, SWMU 17C (ACD), SWMU 17D (Bottom Ash Staging Area) and SWMU 17E (Runoff Drainage Basin). This well was installed to monitor the

1994 dye-trace study and was located along the axis of the sinkhole containing SWMUs 17B-D and INJ2. The dye injected at SWMU17A was detected several days later at SPG3. This dye was not detected in well 17MW3.
No, this is not an onsite well. It was sampled for the FLFA investigation because it was associated with SWMU17, part of which is collocated with the FLFA.

Comment 8
Section 8-1: The report should elaborate on how offsite groundwater contamination will be addressed in a future report. SWMU 17 is adjacent, but not IR-eligible.

Response
[Note: see response to comment 5 above]. Chloroform detections were well below the MCL for this constituent and can be attributed to leaks in drinking water lines throughout the installation. PCE was detected in a single well at a concentration below its MCL. Based on the distribution and concentration of constituents in groundwater; as well as the discussion during the June 11, 2008 RFAAP/EPA/VDEQ partnering meeting, no further groundwater investigation is planned to assess these constituents.

Section 8.1 will be re-written as shown below to remove the reference to a future groundwater investigation and additional information will be added to Section 4.2.3 (also shown below).

Original Text (section 8.1, 2nd paragraph):

> *"For groundwater, the HHRA selected PCE, chloroform, and vanadium as COIs for a residential and/or industrial future-use scenario. However, chloroform and PCE were not detected in the on-site well (LFMW01) and are present in upgradient wells from the FLFA, indicating that the FLFA is not the source of these constituents in groundwater. In addition, chloroform has been found in groundwater at other sites at RFAAP and is suspected to be due to leaking water pipes. These constituents are outside the scope of the FLFA RFI/CMS and will be addressed in a future report associated with the source site."*

Revised Text (section 8.1, 2nd paragraph):

> *"For groundwater, the HHRA selected PCE, chloroform, and vanadium as COIs for a residential and/or industrial future-use scenario. However, chloroform and PCE were not detected in the on-site well (LFMW01) and are present in upgradient wells from the FLFA, indicating that the FLFA is not the source of these constituents in groundwater. In addition, the low level chloroform detections (below MCL) are attributable to leaking potable water supply lines throughout the installation. Chloroform has also been detected at other sites downgradient from water lines at similar concentrations (Area O, for example). PCE was only detected in a single well (17MW-2), and the concentration was below its MCL. Based on the limited detections and low concentrations, additional groundwater investigation or remediation is not warranted at this site."*

Original Text (section 4.2.3, 2nd paragraph):

> *"Two VOCs (chloroform and PCE), five metals (aluminum, chromium, iron, manganese, and vanadium), and perchlorate were detected in FLFA wells at concentrations exceeding groundwater screening levels. Neither of the VOCs are originating from the FLFA, as evidenced by the fact that: 1) they were not detected in site soil; and, 2) they were not detected in the on-site well."*

Revised Text (section 4.2.3, 2nd paragraph):

> *"Two VOCs (chloroform and PCE), five metals (aluminum, chromium, iron, manganese, and vanadium), and perchlorate were detected in FLFA wells at concentrations exceeding groundwater screening levels. PCE was detected in a single upgradient well (17MW-02) at a concentration below its MCL. Chloroform was detected in five of the seven wells sampled. The maximum concentration was 24 ug/L, well below the MCL of 80 ug/L. These detections of chloroform are attributable to leaks in potable water supply lines throughout the Installation. Chloroform has also been detected at similar concentrations at other sites downgradient from water lines (Area O, for example). Neither of the VOCs are originating from the FLFA, as evidenced by the fact that: 1) they were not detected in site soil; and, 2) they were not detected in the on-site well."*

Response to USEPA Comments, Dated 25 February 2008,
for
Draft FLFA RFI/CMS Report
Dated February 2008

Comments from Betty Ann Quinn, USEPA

GENERAL COMMENTS

Comment 1

In the human health risk assessment (HHRA), it cannot be determined whether RFAAP considered recent guidance for estimating cancer risk for carcinogens that act via a mutagenic mode of action (i.e., benzo(a)pyrene). This will not affect the current risk assessment substantially, however, in future reports, age-dependent adjustment factors (ADAFs) should be applied to calculated risk for these carcinogens, in accordance with the *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (EPA, 2005).

> **Response**
>
> The ADAFs were not applied in the HHRA for the FLFA. As noted in the comment, however, this result would not substantially change the conclusions of the risk assessment. In addition, development of the FLFA for residential use is highly unlikely because the site is located on a 45 degree slope. In response to this comment, it is agreed that ADAF calculations will be included in future risk assessments for carcinogens that act via a mutagenic mode of action.

Comment 2

The uncertainty section has not discussed uncertainties and/or limitations associated with several models that were used in the HHRA, including the Johnson and Ettinger (J&E) model used to estimate indoor air concentrations from groundwater, the volatilization model to ambient air outlined in American Society for Testing and Materials (ASTM) Risk-Based Corrective Action Guidance, and several other models. Many of these models, including the J&E model, include limitations that may affect the results. Please revise the HHRA to address any uncertainties or limitations associated with use of the J&E model, and other models in this risk assessment.

> **Response**
>
> A discussion will be added regarding the limitations and uncertainties associated with the each of the models used in the HHRA. As acknowledged in the *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings* (USEPA, 2003), the Johnson and Ettinger (J&E) model "…was developed for use as a screening level model and consequently is based on a number of simplifying assumptions regarding contaminant distribution and occurrence, subsurface characteristics, transport mechanisms, and building construction." There are assumptions that are not likely to be met at the FLFA. For example, contaminants are assumed to be homogeneously distributed at the source, soil properties are assumed to be homogeneous in any horizontal plane, and the model does not account for contaminant attenuation (biodegradation, hydrolysis, sorption, and

> oxidation/reduction). In addition, there are currently no structures located at the FLFA. Therefore, default values were used to represent the building characteristics. It is likely that these same conditions would preclude the use of the J&E model for FLFA as well as many other RCRA and Superfund sites. While the J&E has a number of limitations, the results of the risk assessment would be more uncertain if a less accepted or documented approach was used. As stated in Comment 1, however, the FLFA is located on a 45 degree slope. Due to the topography at the site, it is unlikely that buildings would be constructed on this site in the future. This limitation will also be discussed in the uncertainty section.

Comment 3

It appears that total site risks and noncarcinogenic hazards for the hypothetical future residential receptor were based on exposure point concentrations (EPCs) for total soil and not surface soil. Under typical circumstances, the residential receptor would likely be exposed to surface soil or shallow soil during gardening or other outdoor activities. It is noted on some report tables that if the site is developed in the future, exposure to surface and subsurface soil may occur as a result of soil mixing associated with construction activities/development. However, given that most of the elevated soil concentrations are in surface soil this approach may not be sufficiently conservative. Clarify whether use of total soil concentrations to generate risk estimates results in a reduced number of contaminants of concern, or a reduced area expected to be remediated. If no significant impact on remedial actions to be taken is demonstrated, no modification of the risk assessment is necessary.

> **Response**
>
> While residential receptors were evaluated with respect to total soil, it is noted that the total soil data set includes both surface and subsurface soil. Therefore, the lists of COPCs for surface soil and total soil are nearly identical with the exception of thallium. Thallium was identified as a COPC in total soil only. The risks and hazards associated with surface soil and total soil would be expected to parallel the industrial scenario. For the industrial scenario, the cumulative risk for surface soil was 1.0E-05 and for total soil was 1.1E-05. The cumulative HI for surface soil was 0.75 and for total soil was 0.86. Although many of the EPCs in surface soil were slightly higher than those in total soil, the EPC for arsenic was higher in total soil and had the greatest contribution to cumulative risk and hazard. The differences in the arithmetic mean lead concentrations between surface soil (1,210 mg/kg) and total soil (763 mg/kg) were more pronounced. In both cases, however, lead exceeds the health protective criterion for lead, and the goal for remediation (400 mg/kg) is the same. Due to the topography of the site, however, it is unlikely that the area would be developed for residential use.

SPECIFIC COMMENTS

Comment 4

Section 6.1.1, Data Summary, Page 6-1: This section discusses the method for calculating toxicity equivalence factors (TEFs) relative to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) for those dioxin congeners for which toxicity criteria are unavailable. However, it does not describe how non-detected congeners were used in the calculations. If a result is reported as non-detected the common conservative practice for determining its concentration is to set it to one-half the detection level. Please revise the HHRA to clarify the use of non-detect congener values in the calculation of TEFs.

> **Response**
> In some data sets, the inclusion of the non-detect congeners at half (½) of the detection limit can lead to risks driven by constituents that were not detected. In addition, the User's Guide for ProUCL 4.0 now recommends against using ½ the detection limit to represent non-detect results. Other estimation techniques are recommended instead. For constituents that have not been detected in at least one sample, including these estimated concentrations leads to greater uncertainty.
>
> The TCDD TEs for each medium at FLFA will be re-calculated because some of the detected concentrations were inadvertently left out of out the total TCDD TE calculation. The text will be revised to clarify that results for non-detect congeners that were detected in at least one sample are included in the calculation of the TCDD TE. Results for non-detect congeners that were not detected in at least one sample are not included.

Comment 5
Section 6.1.2, Identification of COPCs, Page 6-4: This section describes the initial screening for contaminants of potential concern (COPC), but it does not indicate whether surrogates were used for some of the screening concentrations. Tables E.1-2 and E.1-4 of Appendix E appear to include screening values for benzo(g,h,i)perylene and phenanthrene, but EPA Region 3 RBCs have not been established for these constituents. It appears that toxicity data from other constituents may have been used as surrogates for these two compounds, but neither the tables nor the text of the HHRA appear to identify the surrogate compounds. For clarity and completeness, please identify those compounds for which surrogates were used, and identify the applicable surrogate compounds in the notes of the screening tables in Appendix E.

> **Response**
> The screening values and the toxicity values for pyrene were used for benzo(g,h,i)perylene and phenanthrene. This surrogate, and other surrogate compounds, will be explained in footnotes to Tables E.1-2, E.1-4, E.1-36, E.1-37, E.1-38, and E.1-39.

Comment 6
Section 6.1.2, Identification of COPCs, Page 6-4: Section 6 does not include a list of those constituents that were identified as COPCs in surface soil, total soil, and groundwater. Although this information can be found in the Appendix E tables, a summary of the identified COPCs should also be included in the main text of the document for easy reference. Please revise Section 6 to include a summary list of the COPCs identified during the screening process.

> **Response**
> A summary table of COPCs will be added to the report, as requested. The COPCs will be identified for each medium.

Comment 7

Section 8.1, Summary of Chemicals of Interest, Page 8-1: The first paragraph summarizes the Chemicals of Interest (COI) that were identified during the HHRA. However, it is not clear why some of the constituents noted were selected as COIs. In particular, dioxins/furans as TCDD TE is identified as a COI under an industrial future-use scenario, but this constituent is not identified as a risk driver in Table 6-1, Summary of Risks and Hazards, nor is it discussed in the HHRA Summary and Conclusions. Please revise Section 8.1 (and the HHRA as necessary) to better define a COI. Additionally, please clarify why dioxins/furans as TCDD TE is identified as a COI for the industrial future-use scenario when it is otherwise not discussed in the HHRA in Section 6.0.

> **Response**
>
> Dioxins/furans will be added to Table 6-2 as a COI for surface soil via exposures by industrial workers. As noted in the response to Comment 4, the TCDD TE values and cancer risk for dioxin/furan values will be re-calculated.

Comment 8

Section 8.2, Remedial Goals, Page 8-2: The RG calculated for arsenic was based on a target risk (TR) of 1E-05, and the RG for copper was based on a hazard index (HI) of 1.0. The document has not provided the rationale for selection of this TR and HI for the RGs. It is not clear why the more conservative values (TR of 1E-06 and HI of 0.5 or 0.1) were not selected and shown in Table 8-1, Identification of Remedial Goals for Arsenic and Copper in FLFA Soil, in Section 8. Please revise the RFI/CMS Report to provide additional justification for selection of a TR of 1E-05 for the arsenic RG, and a HI of 1.0 for the copper RG.

> **Response**
>
> The copper RG was based on an HI of 1.0 because it was the main risk driver for non-carcinogenic effects. Although arsenic does add to the total HI, the RG calculated for the carcinogenic risk was lower and that value was selected. Published PRGs were selected for the remaining COIs.
>
> Although more conservative values could have been selected, the TR and HI are consistent with other RPA and VDEQ approved Radford RFI/CMS documents where excavation and off-site disposal remedies were selected, including:
>
> - SWMU 51 RFI/CMS - see shallow soil remedial goals (July, 2008)
> - SWMU 39 RFI/CMS (October, 2004)
> - AOC Building 4343 RFI/CMS (February, 2004)
>
> Finally, it should be noted that lead is the contaminant present in the greatest quantities and with the greatest lateral extent. Lead will be used as a “tracer” during excavation activities by monitoring with an XRF. Removing lead-containing soil to a concentration of 400 mg/kg will encompass the other, minor constituents as well.

Comment 9

Appendix E, Tables E.1-2 and E.1-4, Occurrence, Distribution, and Selection of Contaminants of Potential Concern, Surface Soil and Total Soil, respectively: These tables identify the residential soil screening value for 2,4-dinitrotoluene (2,4-DNT) as 9.4E-01 mg/kg, the screening value for the dinitrotoluene mix. For clarity, include the rationale for use of this value over the value for 2,4-DNT (include on Tables E.1-2 and E.1-4 also).

> **Response**
> Because the resulting screening value for the dinitrotoluene mix is based on the cancer endpoint, it is more conservative than the screening level for 2,4-DNT based on the noncancer endpoint. The rationale for selecting the screening value for dinitrotoluene mix will be added to the footnotes of Tables E.1-2 and E.1-4.

Comment 10

Appendix E, Table E.1-2, RAGS D Surface Soil results: It is not clear why the maximum lead concentration listed on this table (and subsequent tables) is 25,900 mg/kg, when Table 4-1 lists a maximum lead concentration (in the same sample, LFSS20) of 36,500 mg/kg. Clarify, and revise EPCs and risk estimates as necessary.

> **Response**
> The maximum lead concentration listed in Table E.1-2 represents the average concentration between Sample LFSS20 (36,500 mg/kg) and its duplicate, Sample TMSS20 (15,200 mg/kg). The concentration of the duplicate pair was averaged prior to generating Table E.1-2. Therefore, the average concentration (25,900 mg/kg) is shown as the maximum value in Table E.1-2.

Comment 11

Appendix E, Table E.1-41a, RAGS D Adult Lead Worksheet: The response to the question on what statistics were used to represent exposure concentration terms for the model should state that the exposure concentration was based on lead concentrations in total soil, not surface soil.

> **Response**
> The table will be revised, as requested.

Comment 12

Appendix E, Table E.1-43, IEUBK model output: Note that dietary lead intake values to be used in the IEUBK model have been revised. These new, lower, values can be found on the EPA lead website at http://www.epa.gov/superfund/lead/ieubkfaq.htm#fda , and should be used in future risk assessments.

> **Response**
> The new dietary lead intake values will be used in subsequent HHRAs. Given the high concentrations of lead at FLFA, the use of these new values would not likely change the conclusions of the HHRA.

Comment 13

Appendix G-2, Remedial Goal Calculations: This appendix references Appendix E-1, Tables E-7 through E-10 for the exposure parameters to be used in the calculation of RGs. These are the same exposure parameters used in the initial calculations of risk. The referenced tables do not appear to include exposure parameters (many of them instead include the EPC calculations/results). It appears that exposure parameters are included on Tables E.1-15 and subsequent tables. Please revise Appendix G-2 to include the correct reference for the exposure parameters used in the calculation of RGs.

> **Response**
> The correct reference to the tables containing the exposure parameters is Tables E.1-15 through E.1-24.

Response to Comments
from Ruth Prince, USEPA Ecological Risk Assessor, via e-mail from Will Geiger
Dated 17 June 2008
for
Draft FLFA RFI/CMS Report
Dated February 2008

Comment 1

The "USEPA published recommended residential and industrial cleanup levels" for PCBs (Aroclor 1254) shown on pg 8-2 are incorrect, as follows:

a) 50 mg/kg PCBs is not an EPA industrial cleanup level. In fact, 40 C.F.R. Part 761.61 does not specify any industrial cleanup level. Instead, 50 ppm PCBs is the trigger level for TSCA authority if found in at least one analytical sample from a site.

b) The low occupancy designation is not characterized as residential. Low occupancy is defined in Part 761.30 as an average occupancy of 6.7 hrs per week, typical of an electrical substation or portion of an industrial operation that requires a minimal human presence. Therefore, it is by no means "residential".

> **Response**
>
> The text regarding an industrial cleanup level for PCBs will be deleted. Due to low exposure frequency, the low occupancy level does not apply to the worker or residential scenarios at the FLFA. The text regarding low occupancy will be deleted. Based on the definition of high occupancy, 1 mg/kg will be considered the RG for the FLFA. The text will be revised accordingly.

From: McKenna, Jim J Mr CIV USA AMC [jim.mckenna@us.army.mil]
Sent: Friday, August 01, 2008 4:48 PM
To: Leahy, Timothy; Parks, Jeffrey
Cc: Meyer, Tom NAB02; Llewellyn, Tim; diane.wisbeck@arcadis-us.com; Tina_Devine@URSCorp.com; jim spencer; dennis.druck@us.army.mil; USAEC Servicecenter
Subject: FW: Radford FLFA risk assessment review memo (UNCLASSIFIED)

Attachments: Radford-FLFA.doc

Radford-FLFA.doc
(57 KB)

Classification: UNCLASSIFIED
Caveats: NONE

Tim Leahy,

Attached are EPA comments. Ccing the rest of the team so they can see nature of EPA comments in re their effort.

Dennis, fyi .

Thanks,
Jim

-----Original Message-----
From: Quinn.Elizabeth@epamail.epa.gov
[mailto:Quinn.Elizabeth@epamail.epa.gov]
Sent: Friday, August 01, 2008 4:11 PM
To: Geiger.William@epamail.epa.gov
Cc: McKenna, Jim J Mr CIV USA AMC
Subject: Radford FLFA risk assessment review memo

see attached.

(See attached file: Radford-FLFA.doc)

Betty Ann Quinn
Toxicologist
Technical Support Branch
215-814-3388
Classification: UNCLASSIFIED
Caveats: NONE

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

SUBJECT: Former Lead Furnace Area RFI, Radford Army Ammunition Plant

DATE: August 1, 2008

FROM: Elizabeth Quinn, Toxicologist

TO: William Geiger, Project Manager

1. In the human health risk assessment (HHRA), it cannot be determined whether RFAAP considered recent guidance for estimating cancer risk for carcinogens that act via a mutagenic mode of action (i.e., benzo(a)pyrene). This will not affect the current risk assessment substantially, however, in future reports, age-dependent adjustment factors (ADAFs) should be applied to calculated risk for these carcinogens, in accordance with the *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (EPA, 2005).

2. The uncertainty section has not discussed uncertainties and/or limitations associated with several models that were used in the HHRA, including the Johnson and Ettinger (J&E) model used to estimate indoor air concentrations from groundwater, the volatilization model to ambient air outlined in American Society for Testing and Materials (ASTM) Risk-Based Corrective Action Guidance, and several other models. Many of these models, including the J&E model, include limitations that may affect the results. Please revise the HHRA to address any uncertainties or limitations associated with use of the J&E model, and other models in this risk assessment.

3. It appears that total site risks and noncarcinogenic hazards for the hypothetical future residential receptor were based on exposure point concentrations (EPCs) for total soil and not surface soil. Under typical circumstances, the residential receptor would likely be exposed to surface soil or shallow soil during gardening or other outdoor activities. It is noted on some report tables that if the site is developed in the future, exposure to surface and subsurface soil may occur as a result of soil mixing associated with construction activities/development. However, given that most of the elevated soil concentrations are in surface soil this approach may not be sufficiently conservative. Clarify whether use of total soil concentrations to generate risk estimates results in a reduced number of contaminants of concern, or a reduced area expected to be remediated. If no significant impact on remedial actions to be taken is demonstrated, no modification of the risk assessment is necessary.

SPECIFIC COMMENTS

4. **Section 6.1.1, Data Summary, Page 6-1:** This section discusses the method for calculating toxicity equivalence factors (TEFs) relative to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) for those dioxin congeners for which toxicity criteria are unavailable. However, it does not describe how non-detected congeners were used in the calculations. If a result is reported as non-detected the common conservative practice for determining its concentration is to set it to one-half the detection level. Please revise the HHRA to clarify the use of non-detect congener values in the calculation of TEFs.

5. **Section 6.1.2, Identification of COPCs, Page 6-4**: This section describes the initial screening for contaminants of potential concern (COPC), but it does not indicate whether surrogates were used for some of the screening concentrations. Tables E.1-2 and E.1-4 of Appendix E appear to include screening values for benzo(g,h,i)perylene and phenanthrene, but EPA Region 3 RBCs have not been established for these constituents. It appears that toxicity data from other constituents may have been used as surrogates for these two compounds, but neither the tables nor the text of the HHRA appear to identify the surrogate compounds. For clarity and completeness, please identify those compounds for which surrogates were used, and identify the applicable surrogate compounds in the notes of the screening tables in Appendix E.

6. **Section 6.1.2, Identification of COPCs, Page 6-4:** Section 6 does not include a list of those constituents that were identified as COPCs in surface soil, total soil, and groundwater. Although this information can be found in the Appendix E tables, a summary of the identified COPCs should also be included in the main text of the document for easy reference. Please revise Section 6 to include a summary list of the COPCs identified during the screening process.

7. **Section 8.1, Summary of Chemicals of Interest, Page 8-1:** The first paragraph summarizes the Chemicals of Interest (COI) that were identified during the HHRA. However, it is not clear why some of the constituents noted were selected as COIs. In particular, dioxins/furans as TCDD TE is identified as a COI under an industrial future-use scenario, but this constituent is not identified as a risk driver in Table 6-1, Summary of Risks and Hazards, nor is it discussed in the HHRA Summary and Conclusions. Please revise Section 8.1 (and the HHRA as necessary) to better define a COI. Additionally, please clarify why dioxins/furans as TCDD TE is identified as a COI for the industrial future-use scenario when it is otherwise not discussed in the HHRA in Section 6.0.

8. **Section 8.2, Remedial Goals, Page 8-2:** The RG calculated for arsenic was based on a target risk (TR) of 1E-05, and the RG for copper was based on a hazard index (HI) of 1.0. The document has not provided the rationale for selection of this TR and HI for the RGs. It is not clear why the more conservative values (TR of 1E-06 and HI of 0.5 or 0.1) were not selected and shown in Table 8-1, Identification of Remedial Goals for Arsenic and Copper in FLFA Soil, in Section 8. Please revise the RFI/CMS Report to provide additional justification for selection of a TR of 1E-05 for the arsenic RG, and a HI of 1.0 for the copper RG.

9. **Appendix E, Tables E.1-2 and E.1-4, Occurrence, Distribution, and Selection of Contaminants of Potential Concern, Surface Soil and Total Soil, respectively:** These tables identify the residential soil screening value for 2,4-dinitrotoluene (2,4-DNT) as 9.4E-01 mg/kg,

the screening value for the dinitrotoluene mix. For clarity, include the rationale for use of this value over the value for 2,4-DNT (include on Tables E.1-2 and E.1-4 also).

10. **Appendix E, Table E.1-2, RAGS D Surface Soil results:** It is not clear why the maximum lead concentration listed on this table (and subsequent tables) is 25,900 mg/kg, when Table 4-1 lists a maximum lead concentration (in the same sample, LFSS20) of 36,500 mg/kg. Clarify, and revise EPCs and risk estimates as necessary.

11. **Appendix E, Table E.1-41a, RAGS D Adult Lead Worksheet:** The response to the question on what statistics were used to represent exposure concentration terms for the model should state that the exposure concentration was based on lead concentrations in total soil, not surface soil.

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13. **Appendix G-2, Remedial Goal Calculations:** This appendix references Appendix E-1, Tables E-7 through E-10 for the exposure parameters to be used in the calculation of RGs. These are the same exposure parameters used in the initial calculations of risk. The referenced tables do not appear to include exposure parameters (many of them instead include the EPC calculations/results). It appears that exposure parameters are included on Tables E.1-15 and subsequent tables. Please revise Appendix G-2 to include the correct reference for the exposure parameters used in the calculation of RGs.

From:	Geiger.William@epamail.epa.gov
Sent:	Wednesday, May 14, 2008 9:38 AM
To:	McKenna, Jim J Mr CIV USA AMC
Cc:	jim spencer; Parks, Jeffrey; jeremy.flint@atk.com; jerome.redder@atk.com; jlcutler@deq.virginia.gov; Mendoza, Richard R Mr CIV USA IMCOM; Leahy, Timothy; Llewellyn, Tim; Tina_Devine@URSCorp.com; Meyer, Tom NAB02
Subject:	Draft EPA/VDEQ FLFA Comments
Attachments:	Draft FLFA Comments.doc

Draft FLFA
omments.doc (39 KB

Jim, here are the draft EPA/VDEQ Former Lead Furnace Area RFI/CMS Comments, minus the Risk Assessment. Let me know if you have any questions.

(See attached file: Draft FLFA Comments.doc)

William A. Geiger
USEPA Region III
1650 Arch Street
Philadelphia, PA 19103
(215)814-3413

Draft EPA/VDEQ Comments on the Radford Army Ammunition Plant's Former Lead Furnace Area February 2008 Draft RFI/CMS (non-risk assessment)

1. The figures in the RFI/CMS Report provide visual representations of the extent of soil and groundwater contamination at the Former Lead Furnace Area (FLFA). The extent of contamination of the following areas of interest does not appear to have been fully delineated based on the information presented on Figure 8-2. The RFI/CMS Report does not identify any data gaps or areas which would require the collection of additional data to fully define the extent of impacted soils. The RFI/CMS Report should be revised to address the perceived data gap, or lack of data for complete delineation of the extent of impacted soils to be excavated. Those areas of particular concern are described below:

- The area to the west of sample location LF2209 appears to be bounded by a sample that exceeds the residential remedial goal (RG). Also, the northern extent of this excavation area is bounded by an XRF value above the residential RG.

- The area to the west of sample locations LFSB16 and LSFB17 appears to be bounded by these two samples that exceed the residential RG. Also, the eastern extent of this excavation area is bounded by sample location LFSS02 whose result is above residential RGs.

- The area to the west of sample location LFSS13 appears to be bounded by a sample that exceeds the residential RG.

- The area north of sample location LFSB12 appears to be bounded by a sample that exceeds the residential RG.

The RFI/CMS Report should be revised to either propose that confirmation sampling be conducted of the excavation or allow for the pre-excavation verification of the limits of excavation to document that the intended limits of excavation extend until levels of contaminants of concern are below the proposed residential RGs. Please revise the RFI/CMS Report accordingly. Ensure that this discussion also addresses the vertical extent of contamination as well.

2. Except for Table 4-4, the data summary tables do not include soil screening levels (SSLs) for soils. Please revise all the soil data summary tables to include the applicable screening criteria for ease of comparison.

3. Figure 2 – 5: Amend the figure to provide notes, as in Figure 2 - 4. Include a water level for LFMW-01 and others, as needed.

4. Illustrate "INJ 1" on Figure 2 - 7.

5. What is the source of perchlorate, as described in Subsection 4.2.3? The perchlorate plume should be delineated in three dimensions and risk associated with perchlorate should be evaluated similarly to the way in which risk for chloroform and PCE will be evaluated. These COIs were found at the site, but may not have originated there. RAAP has committed to assess chloroform and PCE at an adjacent site, but has not committed to assess perchlorate.

6. When sampling ground water, both filtered and unfiltered samples should be obtained for metals analysis (p 4-35).

7. Although monitoring well 17MW3 has been determined as being cross gradient of the FLFA, the sampling results seem to be consistent with other wells in the area. Provide the basis for the determination of ‘cross gradient’. Is this really an ‘on-site well’?

8. Section 8-1: The report should elaborate on how offsite groundwater contamination will be addressed in a future report. SWMU 17 is adjacent, but not IR-eligible.

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

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

MCHB-TS-REH

27 FEB 2008

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

SUBJECT: Review of Document Titled: "Draft RCRA Facility Investigation/ Corrective Measures Study Report for the Former Lead Furnace Area, Radford Army Ammunition Plant, Virginia, February 2008"

1. The U.S. Army Center for Health Promotion and Preventive Medicine reviewed the subject document on behalf of the Office of The Surgeon General pursuant to Army Regulation 200-1 (Environmental Protection and Enhancement). We appreciate the opportunity to review this report.

2. Although we concur with the selected corrective measures alternative as being protective of human health and the environment, the only comment that we have is that it is unclear from Section 6.1.1.1 which soil samples were included in the risk assessment. If the samples collected in 1991 and 1998 were used, would they still be representative of present conditions considering that soil removal actions were performed during the 1998 investigation?

3. The document was reviewed by Mr. Dennis Druck, Environmental Health Risk Assessment Program. He can be reached at DSN 584-2953, commercial (410) 436-2953 or electronic mail "dennis.druck@us.army.mil".

FOR THE COMMANDER:

JEFFREY S. KIRKPATRICK
Director, Health Risk Management

CF:
HQDA (DASG-PPM-NC)
IMCOM, NERO (IMNE-PWD-E)
USACE (CEHNC-CX-ES)
USAEC (IMAE-CD/Mr. Rich Mendoza)

Ammunition Systems Group
Energetic Systems Division
Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100

www.atk.com

February 25, 2008

Mr. William Geiger
RCRA General Operations Branch, Mail Code: 3WC23
Waste and Chemicals Management Division
U. S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Mr. James L. Cutler, Jr.
Virginia Department of Environmental Quality
629 East Main Street
Richmond, VA 24143-0100

Subject: With Certification, Radford Army Ammunition Plant,
Former Lead Furnace Area RCRA Facility Investigation/Corrective Measures Study Report, Draft Document, February 2008
EPA ID# VA1 210020730

Dear Mr. Geiger and Mr Cutler:

Enclosed is the certification for the subject document that was sent to you on February 21, 2008. Also enclosed is a copy of the transmittal email message.

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,

P.W. Holt, Environmental Manager
Alliant Techsystems Inc.

c: 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

08-815-37
JMcKenna

Rich Mendoza
U.S. Army Environmental Command
1 Rock Island Arsenal
Bldg 90, 3rd Floor, Room 30A
IMAE-CDN
Rock Island, Illinois 61299

Tom Meyer
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
M.A. Miano
P.W. Holt
J. J. Redder
Env. File

Coordination:
J. McKenna
M. A. Miano

08-815-37
JMcKenna

Concerning the following:

Radford Army Ammunition Plant
Former Lead Furnace Area
RCRA Facility Investigation/Corrective Measures Study
Draft Document, February 2008

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: for Jon R. Drushal
TITLE: Lieutenant Colonel, US Army
Commanding

SIGNATURE:
PRINTED NAME: Kent Holiday
TITLE: Vice President and General Manager
ATK Energetics Systems

08-815-37
JMcKenna

Greene, Anne

From: McKenna, Jim
Sent: Thursday, February 21, 2008 1:12 PM
To: Greene, Anne; beth lohman; dennis.druck@us.army.mil; durwood willis2; Geiger.William@epamail.epa.gov; Redder, Jerome; jim spencer; jlcutler@deq.virginia.gov; Mendoza, Richard R Mr CIV USA SA; Parks, Jeffrey N; Timothy.Leahy@shawgrp.com; Tina_Devine@URSCorp.com; Tom.Meyer@nab02.usace.army.mil
Subject: Area of Concern Former Lead Furnace Area, draft RFI/CMS report (UNCLASSIFIED)

Importance: High

Classification: UNCLASSIFIED
Caveats: NONE

All:

Note the contractor will ship the subject document with a copy of this email to the POCs and tracking numbers below.

Certification letter will follow from RFAAP under separate cover.

Immediately below are the POCs with tracking numbers:

Rich Mendoza, USAEC-RIA, 1 hard copy, 1 CD, 1Z63V8840194796807 William Geiger, US EPA Region III, 3 hard copies, 1Z63V8840191199637 Jim Cutler, VDEQ, 1 hard copy, 1Z63V8840191293418 Tom Meyer, USACE-Baltimore, 1 hard copy, 1 CD, 1Z63V8840191471190 Elizabeth Lohman, VDEQ, 1 CD, 1Z63V8840199318716 Dennis Druck, USACHPPM, 1 CD, 1Z63V8840199188303

Thank you for your support of the Radford AAP Installation Restoration Program.

Jim McKenna

Classification: UNCLASSIFIED
Caveats: NONE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

LIST OF APPENDICES

The Appendices are Included on a CD Located at the Back of This Report

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LIST OF ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
ADI	Allowable Daily Intake
ALM	Adult Lead Model
ATSDR	Agency for Toxic Substances Disease Registry
AUF	Area Use Factor
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
bgs	below ground surface
BRA	Baseline Risk Assessment
BTAG	Biological Technical Assistance Group
CCME	Canadian Council of Ministers of the Environment
CDI	Chronic Daily Intake
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
DQO	Data Quality Objective
EcoSSL	Ecological Soil Screening Level
EEQ	Environmental Effects Quotient
EPC	Exposure Point Concentration
ERAGS	Ecological Risk Assessment Guidance for Superfund
FLFA	Former Lead Furnace Area
ft	feet
ft^2	square feet
g/dL	grams per deciliter
GI	Gastrointestinal
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
ICF KE	ICF Kaiser Engineers
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
LOAEL	Lowest-Observed-Adverse-Effect Level
MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
MDL	Method Detection Limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mm Hg	millimeters mercury
MMA	Main Manufacturing Area
msl	mean sea level
MWP	Master Work Plan
NOAEL	No-Observed-Adverse-Effect Level
NTU	Nephelometric Turbidity Unit
ORNL	Oak Ridge National Laboratory
OSWER	Office of Solid Waste and Emergency Response
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PEF	Particulate Emission Factor
PPRTV	Provisional Peer Reviewed Toxicity Value
PRG	Preliminary Remedial Goal
QA	Quality Assurance
QC	Quality Control

RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RFAAP	Radford Army Ammunition Plant
RfD	Risk Reference Dose
RFI	RCRA Facility Investigation
RG	Remedial Goal
SCS	Soil Conservation Service
Shaw	Shaw Environmental, Inc.
SLERA	Screening Level Ecological Risk Assessment
SQL	Sample Quantitation Limit
SRC	Syracuse Research Corporation
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
TOC	Total Organic Carbon
TOX	Total Organic Halides
TPH	Total Petroleum Hydrocarbons
TRV	Toxicity Reference Value
tw-RBC	Tap Water Risk-Based Concentration
UCL	Upper Confidence Limit
URS	URS Corporation
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USEPA	U.S. Environmental Protection Agency
UST	Underground Storage Tank
UTL	Upper Tolerance Limit
VDEQ	Virginia Department of Environmental Quality
VI	Verification Investigation
VOC	Volatile Organic Compound
WHO	World Health Organization
WPA	Work Plan Addendum
XRF	X-ray Fluorescence

EXECUTIVE SUMMARY

Shaw Environmental, Inc. (Shaw) conducted a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at the Former Lead Furnace Area (FLFA) (RAAP-040), during August 2007. The investigation was performed in accordance with *Master Work Plan (MWP) Addendum 019* (Shaw, 2007). In addition to the MWP Addendum 019 field investigation (2007 RFI), four other investigations have been conducted to assess the FLFA, including the 1992 Verification Investigation, the 1996 RFI, the 1998 RFI, and the 2002 RFI. Information and data was compiled and evaluated from all of the investigations to perform a Nature and Extent of Contamination Assessment (*Section 4.0*), a Contaminant Fate and Transport Analysis (*Section 5.0*), and to assess potential impacts to human health (*Section 6.0*) and/or ecological receptors (*Section 7.0*). Based on the results of the human health and ecological risk assessments, a Corrective Measures Study (CMS) was performed (*Sections 8.0 through 12.0*) to evaluate potential remedial actions for site contaminants.

RCRA Facility Investigation

Five investigations have been conducted at the FLFA to delineate the nature and extent of contamination. In 1998, the furnace foundations, debris, and associated soil were taken out as part of the investigative activities and addressed the main source of lead contamination at the site.

Samples have been collected and analyzed by an off-site laboratory for full suite analyses [target compound list volatile organic compounds, semivolatile organic compounds, pesticides/polychlorinated biphenyls (PCBs), herbicides, polynuclear aromatic hydrocarbons, explosives, target analyte list metals, dioxins/furans, total organic carbon, grain size, and pH] across the entire site. In addition to laboratory analyses, an X-ray fluorescence survey was performed across the site, which further delineated the extent of lead within the established FLFA boundary.

Soil sample results indicate that metals (primarily lead), dioxins/furans, and PCBs, mostly in surface soil, are the constituents of most concern at the FLFA based on exceedances of residential (and limited industrial) screening criteria.

A collocated surface water and sediment sample was collected during the 2007 Investigation from spring SPG 3 to assess the fate and transport of site constituents. This spring was shown to be hydraulically connected to the FLFA/Solid Waste Management Unit (SWMU) 17A (an adjoining SWMU) sinkhole based on the results of a dye trace study conducted in 1994. Metals, dioxin/furans, and perchlorate were detected at concentrations below levels of concern (with the exception of one residential dioxin exceedance). These results indicate that there is not significant migration of contaminants from the FLFA to the spring surface water.

Groundwater results indicate that FLFA constituents are not present in site groundwater at elevated concentrations. These findings support the Fate and Transport Analysis (*Section 5.0*) conclusions - that FLFA constituents have low mobility in soil under current site conditions.

A human health risk assessment (*Section 6.0*) was conducted at the FLFA to identify potential risks at the site for the following scenarios: current maintenance workers, future maintenance workers, future industrial workers, future excavation workers, future adult (lifetime) residents, and future child residents. Off-site residents were also evaluated with respect to potential future exposures to groundwater from the FLFA. The potential cumulative risks for current and future maintenance workers, future industrial workers, future excavation workers, future off-site adult residents, and future on-site and off-site child residents were within the U.S. Environmental Protection Agency's (USEPA) target risk range. The potential cumulative risk for on-site lifetime residents was above the target risk range, primarily due to Aroclor-1254, dioxins/furans, and arsenic in total soil, and dioxins/furans, chloroform, and tetrachloroethene (PCE) in upgradient groundwater. Arsenic is within background concentrations in soil. Chloroform and PCE are not associated with the site. The potential cumulative hazard indices (HIs) for current and future maintenance workers were below the USEPA's target HI of 1. While the cumulative HIs for future industrial workers, future excavation workers, and future on-site and off-site adult residents exceeded 1, none of the hazard quotients (HQs) for individual chemicals of potential concern (COPCs) exceeded 1. The cumulative HIs for future on-site and off-site child residents exceeded 1 due to copper, thallium, and vanadium in total soil and vanadium in groundwater. Thallium and vanadium are within background in total soil. The evaluation of lead in soil was performed using the USEPA's Adult Lead Model for the industrial scenario and the Integrated Exposure Uptake Biokinetic (IEUBK) Model for the residential scenario. For the maintenance and industrial worker scenarios, site concentrations of lead in surface and total soil were below the health protective criterion for lead. For the excavation and residential scenarios, site concentrations of lead in total soil were above the health protective criterion for lead. These results indicate that for current scenarios, health risks are limited, but are more elevated for future scenarios, especially residential scenarios.

A screening level ecological risk assessment (SLERA) (*Section 7.0*) was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at the FLFA. The Tier 2 lowest observable adverse effect level-based food chain assessment results suggested potential adverse impacts to terrestrial wildlife (risk driver in parenthesis), such as the short-tailed shrew [copper, lead, hexachlorobenzene, TCDD toxicity equivalent (TE), zinc, hexachlorobutadiene, and Aroclor-1254], American robin (lead, copper, DDT, DDE, zinc, and chromium), and meadow vole (copper, lead, and zinc), as estimated environmental effects quotients (EEQs) were all above 1. The direct contact assessment results for soil invertebrates suggested that a reduction in wildlife food supply was possible due to the following chemicals of potential ecological concern (COPECs) in surface soil (arsenic, barium, copper, lead, nickel, and zinc). Based on the results of the SLERA conducted at the FLFA, further action to address ecological concerns was recommended for surface soil. The recommended further action included an evaluation of the residual ecological hazards that were estimated to remain at the site following a proposed cleanup to address human health concerns.

FLFA residual surface soil concentrations, using the selected land use scenario for the proposed human health cleanup, resulted in predicted EEQ or hazard quotient (HQ) percent reductions that ranged from 0% (for hexachlorobutadiene) to 99% (for copper and DDE). Scaled food-chain EEQs or direct contact HQs were less than or equal to 1 when rounded to one significant figure for arsenic, barium, chromium, lead, nickel, zinc, Aroclor-1254, DDE, DDT, and TCDD. For the shrew, the estimated residual concentration of copper in surface soil was expected to reduce this receptors' EEQ from 191 to 1.9, or by 99%. This percentage reduction was considered significant. In conclusion, the proposed human health remedial goals (RGs) are expected to result in residual COPEC concentrations in surface soil that are protective of the environment, especially given the conservativeness of the SLERA approach and the small size of the site (0.78 acres).

Corrective Measures Study

Because the RFI indicated that arsenic, copper, lead, dioxin/furans, and PCBs are present in soil at concentrations associated with unacceptable human health concerns and potential impacts to ecological receptors, an evaluation of corrective measures was performed.

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

- Alternative One: No Further Action
- Alternative Two: Institutional Controls (Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring)
- Alternative Three: Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring)
- Alternative Four: Excavation of Soil for Clean Closure (residential Use) 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 in adherence to the current and foreseeable use of the property in support of the Army mission. The Army has also elected to evaluate residential exposure pathways to assess what the increase in remedial efforts would be to remediate the site for unrestricted use and facilitate clean closure. Therefore, residential RGs were developed and credit was given to those alternatives that met these more stringent criteria.

Alternative Four was selected as the final alternative for the FLFA 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 closure. By achieving clean closure, Alternative Four exceeds the CMO for this RFI/CMS. The other two cleanup alternatives do not achieve such a goal. In addition, Alternative Four has a lower cost than Alternative Three, which meets the CMOs, and Alternative Two, which does not meet the CMOs. Alternative Four can be implemented in approximately one year. This timeframe 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 contaminants of interest (COIs) 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.
- Site restoration activities.

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

1.0 INTRODUCTION

Shaw Environmental, Inc. (Shaw) was tasked by the U.S. Army Corps of Engineers, Baltimore District, to perform characterization and remediation activities at eleven Solid Waste Management Units (SWMUs) and Areas of Concern at Radford Army Ammunition Plant (RFAAP), in accordance with Contract No. W912QR-04-D-0027, Delivery Order DA0101. The investigative activities were detailed in *Work Plan Addendum (WPA) 019* (Shaw, 2007) to the *RFAAP MWP* (URS, 2003). Task objectives were to collect additional data in order to complete Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFIs)/Corrective Measures Studies (CMSs) for nine of the eleven sites, including the Former Lead Furnace Area (FLFA) (RAAP-040). In order to complete the RFI/CMS of the FLFA, additional sampling was conducted in August 2007 to fully delineate the extent of lead, polychlorinated biphenyls (PCBs), and dioxins/furans previously detected in soil and investigate groundwater in the area. The investigation is required by the 2000 RCRA Corrective Action permit (USEPA, 2000a) and was performed in accordance with the MWP, Master Quality Assurance Plan, and the Master Health and Safety Plan.

1.1 Former Lead Furnace Area Overview

The FLFA encompasses an approximately 0.78 acre area [33, 976 square feet (ft^2)] located in the Main Manufacturing Area (MMA) at the bottom of a steeply-sloping hillside in the southeast portion of SWMU 17A, the Stage and Burn Area (**Figure 1-1**). The FLFA was first investigated in 1992. Furnace structures, debris, and soil (0.05 acre/2,280 ft^2 area) were taken out between March and May of 1998 as part of the investigative activities at the site. While the confirmation sample results indicated that major contamination associated with activities at the FLFA had been taken out, it was determined that small areas of elevated lead still remained in soil and additional samples for the full suite of chemical analyses were required for risk assessment purposes. Additional samples were collected by Shaw during the 2002 RFI to further delineate lead-containing soil and characterize site media for previously untested parameters. The draft RFI report was submitted to the Army in August 2005, but was never finalized. This assessment indicated that volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, herbicides, and explosives compounds did not exceed industrial (or residential) screening levels. Metals (predominantly lead), dioxins/furans, and PCBs, mostly in surface soil, are the constituents of concern at the FLFA based on exceedances of residential (and limited industrial) screening criteria. In order to complete the characterization of the FLFA, additional sampling was conducted in August 2007 to fully delineate the extent of lead, PCBs, and dioxins/furans in soil and investigate the groundwater in the area.

1.1.1 SWMU 17A

SWMU 17A is an active site. SWMU 17A consists of a sinkhole, that is approximately 30 feet (ft) deep by 200 ft wide by 400 ft long, and a surrounding steeply-sloping hillside. Large metallic items considered contaminated with energetics were accumulated into large piles and burned on

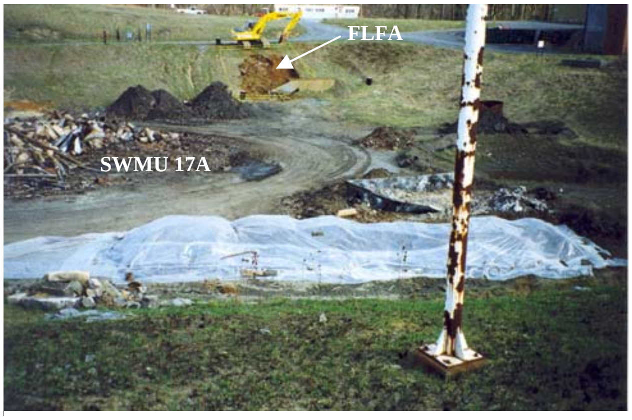
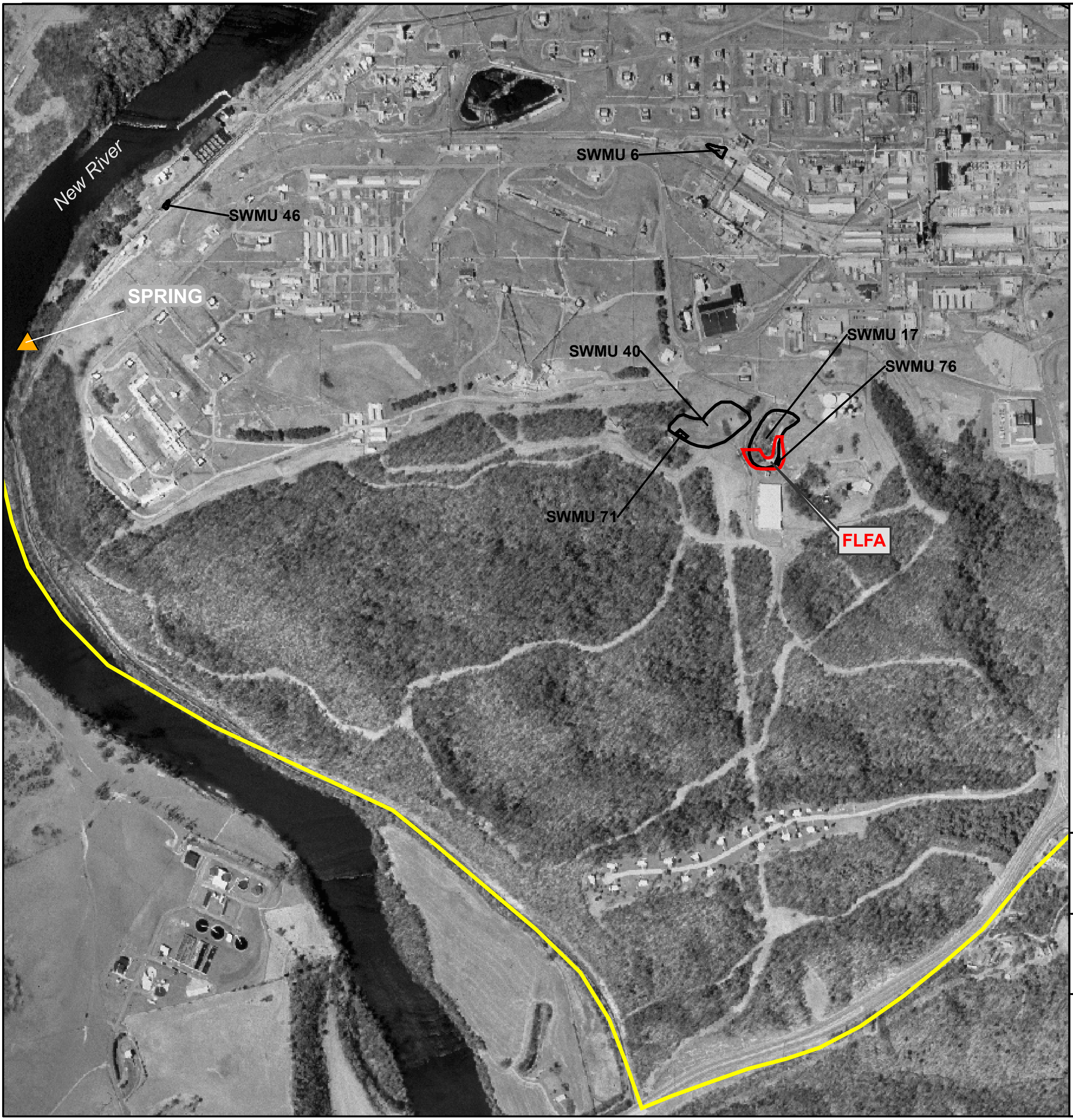


Photo 1. View of SWMU 17A and the FLFA before the burn pad.



LEGEND

▲ Surface Water/Sediment Sample Location

🟨 Installation Boundary

🟥 Former Lead Furnace Area Boundary

☐ Other SWMU Boundary

Notes:
1) Aerial photo, dated 25 May 2000, was obtained from the Army Topographic Engineering Center.

N

Scale:
0 500 1,000 2,000
Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 1-1
Former Lead Furnace Area Site Location Map

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: RFAAP_Fig1-1_FLFA_Site_Loc_Map.mxd (1/24/2008 4:16:42 PM) the ground at SWMU 17A until 2002 (**Photo 1**). The items were not reactive waste. They were burned to allow the metal to be safely recycled. An engineered burn pad was constructed at the site in 2002 (see **Photo 2** in *Section 2.0*), and the pad is now used for occasional or emergency burning. Facility representatives reported that used oil and diesel fuel are used to fuel the burning operations. Wood, paper, and cardboard contaminated with energetics were often added to the piles to increase combustion. Used oil utilized for these operations was stored in an underground oil tank (SWMU 76) formerly located along the Stage and Burn Area embankment east of the waste pile. Accumulated ash and residue piles awaiting disposal are staged immediately adjacent to the FLFA. SWMU 17A was recently renovated with drainage being diverted from the sinkhole. In August 2007, a No Further Action Decision Document for SWMU 76 was prepared by RFAAP in accordance with the U.S. Environmental Protection Agency (USEPA) RFAAP Permit No. VA 1210020730 for Corrective Action and Waste Minimization, October 2000 (USEPA, 2000a) and subsequently approved by the USEPA, Virginia Department of Environmental Quality (VDEQ), and RFAAP project coordinators.

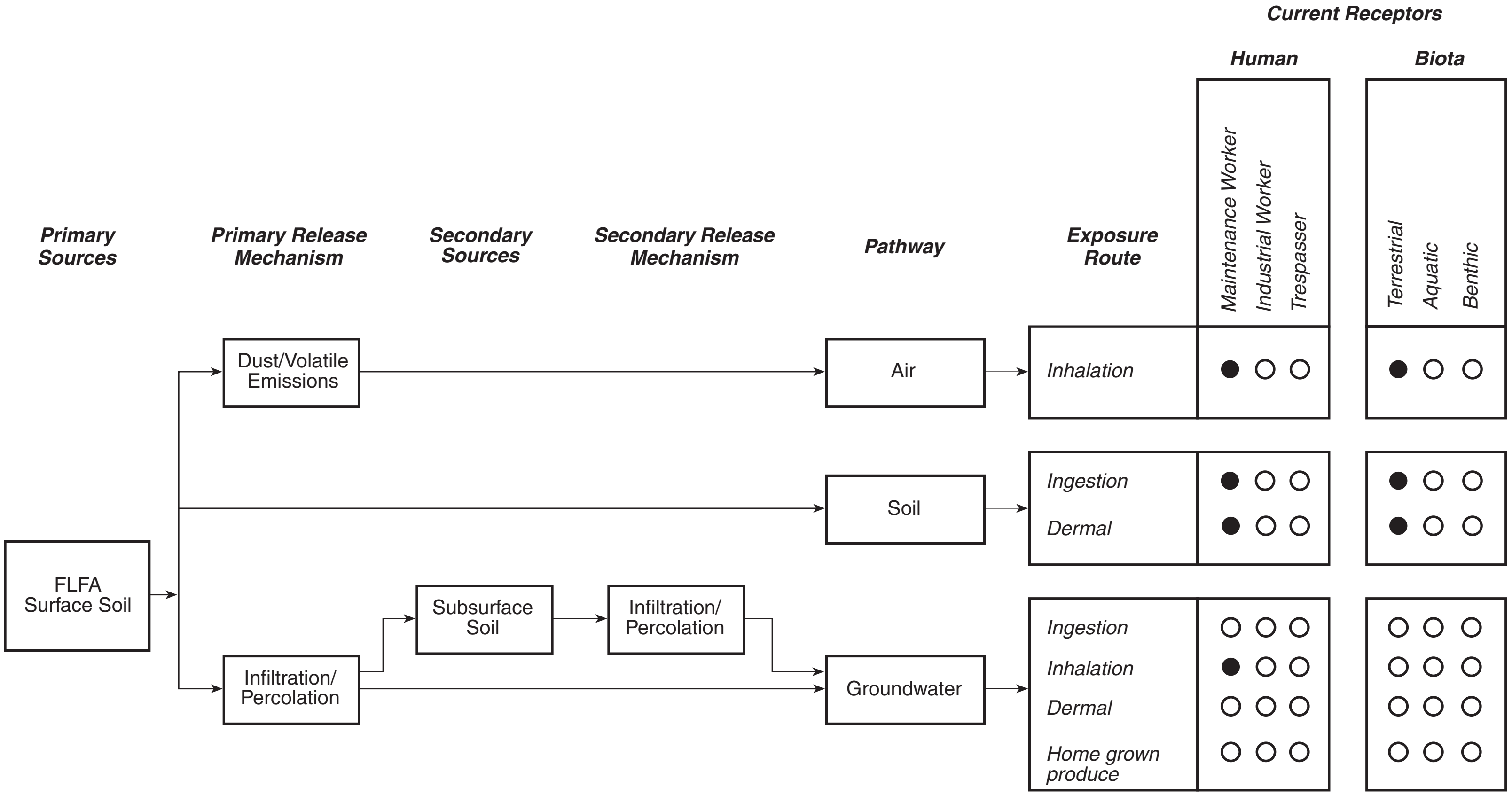
1.2 Conceptual Site Model

A site-specific conceptual site model (CSM) was developed for the FLFA in WPA 019 (Shaw, 2007) to identify potential contaminant sources, exposure pathways, and human and ecological receptors. Potentially affected media at the FLFA include surface and subsurface soil, and groundwater. Surface water and sediment at a spring (SPG 3) were evaluated to assess the fate and transport of FLFA constituents because a 1994 dye trace study (Engineering Science, 1994) indicated that this spring is the discharge point for the FLFA/SWMU 17A sinkhole. The spring is not on site and is not evaluated in the risk assessments. The FLFA is located in a steeply-sloping depression formed by a sinkhole. Based on the occurrence of lead slag discovered in 1991, lead was most likely off-loaded at the rim of the sinkhole and transported to the furnace located at the bottom of the depression. Precipitation is expected to flow down the hill sides of the depression towards the FLFA and infiltrate into the ground. Site workers and terrestrial biota are considered current potential receptors. Ecological and human exposure pathways are shown on **Figure 1-2** (current) and **Figure 1-3** (future). The exposures pathways associated with each media type are described in more detail in the following paragraphs.

Surface soil was impacted by operations at the lead furnace. In 1998, this pathway was mitigated, as the furnace structure and lead-containing soil around the structure were taken out as part of the investigative activities. Confirmatory sampling indicated that there was at least one remaining area of soil with an elevated lead concentration. The presence of lead in soil beyond the limits of the excavation area indicates that current site workers and ecological receptors could be impacted through incidental ingestion of soil, dermal absorption through direct contact with impacted soil, and the inhalation of ash or dust.

Subsurface soil was also potentially impacted by the lead smelting operations. In 1998, the furnace foundations, debris, and associated soil were taken out as part of the investigative activities mitigating this pathway. Future site workers could be negatively impacted through the inhalation of dust during removal/construction activities. Incidental ingestion and dermal absorption may also affect site workers during future construction activities that expose the subsurface soil.

Groundwater was also potentially impacted through leaching of constituents from soil to groundwater. Although groundwater is not currently in use, hypothetical future residents and site workers scenarios were evaluated through ingestion, absorption, and inhalation.



Pathway	Exposure Route	Human: Maintenance Worker	Human: Industrial Worker	Human: Trespasser	Biota: Terrestrial	Biota: Aquatic	Biota: Benthic
Air	*Inhalation*	●	○	○	●	○	○
Soil	*Ingestion*	●	○	○	●	○	○
	Dermal	●	○	○	●	○	○
Groundwater	*Ingestion*	○	○	○	○	○	○
	Inhalation	●	○	○	○	○	○
	Dermal	○	○	○	○	○	○
	Home grown produce	○	○	○	○	○	○

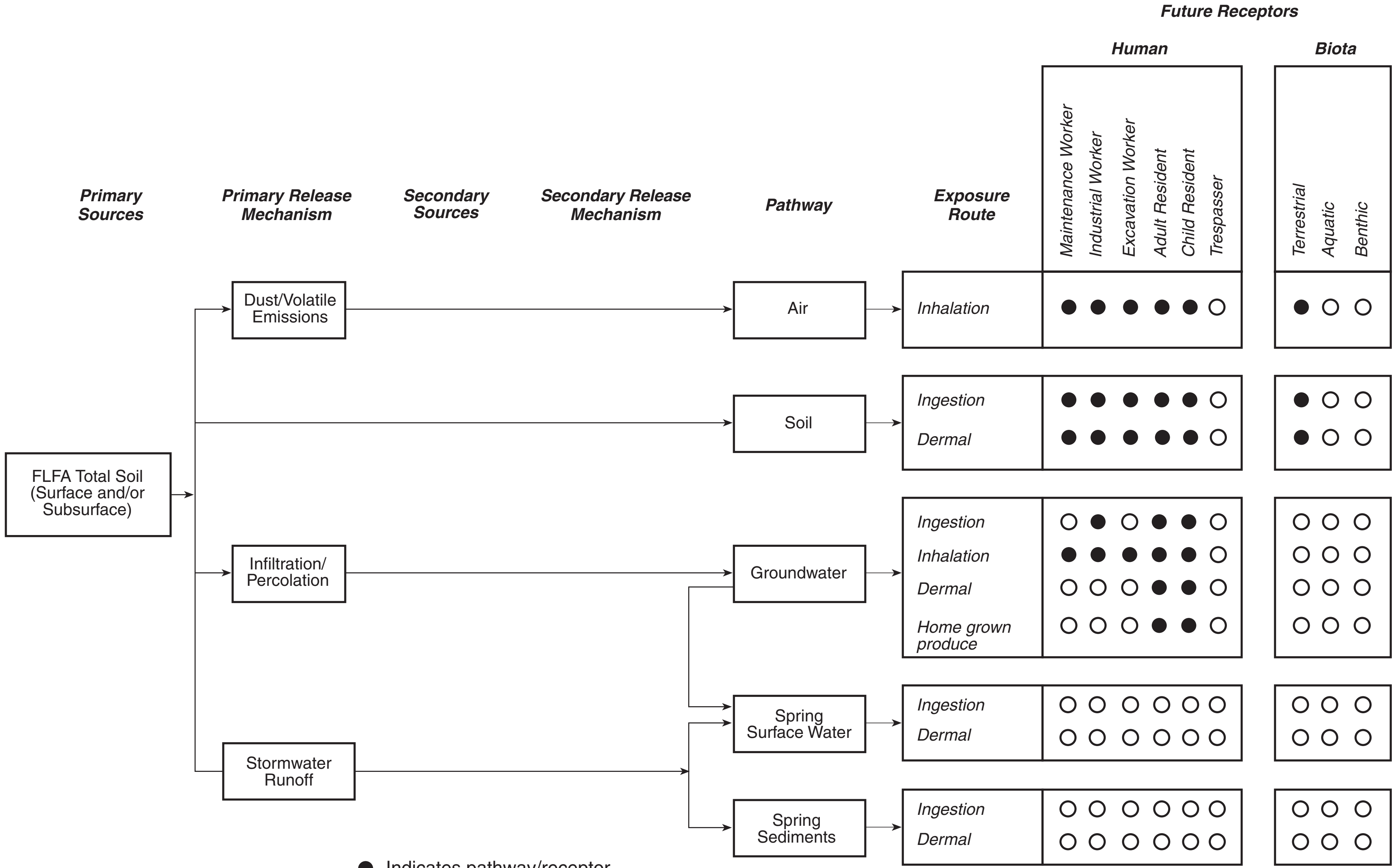
● Indicates pathway/receptor combinations to be evaluated

○ Indicates pathway/receptor combinations incomplete or no source

Figure 1-2. Current Land Use Conceptual Site Model for the FLFA Radford Army Ammunition Plant, Virginia

Shaw™ Shaw Environmental, Inc.

DRAWING BY	JIS, III	CHECKED BY	CH	1-21-08	DRAWING NO.
	4/26/07	APPROVED BY	CH	1-21-08	S-123461-1/07-w



Pathway	Exposure Route	Maintenance Worker	Industrial Worker	Excavation Worker	Adult Resident	Child Resident	Trespasser	Terrestrial	Aquatic	Benthic
Air	*Inhalation*	●	●	●	●	●	○	●	○	○
Soil	*Ingestion*	●	●	●	●	●	○	●	○	○
	Dermal	●	●	●	●	●	○	●	○	○
Groundwater	*Ingestion*	○	●	○	●	●	○	○	○	○
	Inhalation	●	●	●	●	●	○	○	○	○
	Dermal	○	○	○	●	●	○	○	○	○
	Home grown produce	○	○	○	●	●	○	○	○	○
Spring Surface Water	*Ingestion*	○	○	○	○	○	○	○	○	○
	Dermal	○	○	○	○	○	○	○	○	○
Spring Sediments	*Ingestion*	○	○	○	○	○	○	○	○	○
	Dermal	○	○	○	○	○	○	○	○	○

● Indicates pathway/receptor combinations to be evaluated

○ Indicates pathway/receptor combinations incomplete or no source

Figure 1-3. Future Land Use Conceptual Site Model for the FLFA Radford Army Ammunition Plant, Virginia

Shaw™ Shaw Environmental, Inc.

DRAWING BY	JIS, III	CHECKED BY	CH	1-21-08	DRAWING NO.
	4/26/07	APPROVED BY	CH	1-21-08	S-123461-1/07-w

2.0 SITE BACKGROUND

2.1 Site Description

The FLFA encompasses an approximately 0.78 acre (33, 976 ft^2) area located in the MMA at the bottom of a steeply sloping hillside in the southeast portion of SWMU 17A, the Stage and Burn Area (**Figure 2-1** and **Photo 2**). Building foundations and surrounding soil have been taken out (0.05 acre/2,280 ft^2 area) and replaced by clean fill. The FLFA was built into the sloping side of the sinkhole. The elevation of the top of the slope above the FLFA is approximately 1,892 ft mean sea level (msl), while the bottom of the slope is approximately 1,874 ft msl. The location of the former used oil tank (SWMU 76) is upslope to the east of the FLFA at an elevation of approximately 1,895 ft msl. The area immediately surrounding the FLFA is a maintained grassy area and the gravel burn area of SWMU 17A. There are paved and gravel roads in the vicinity.

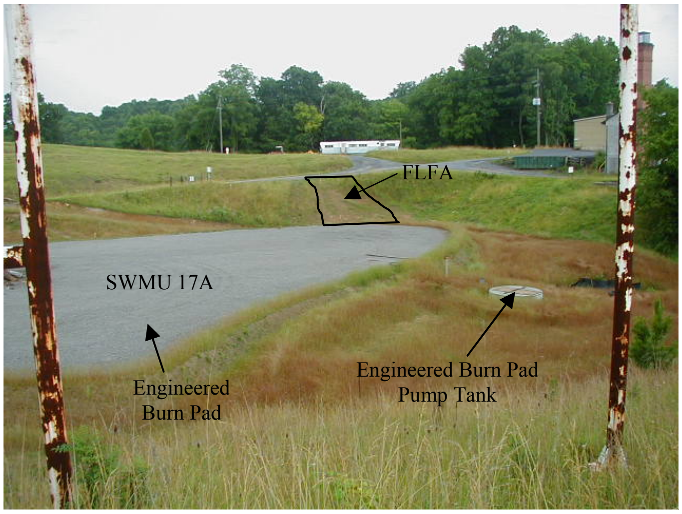
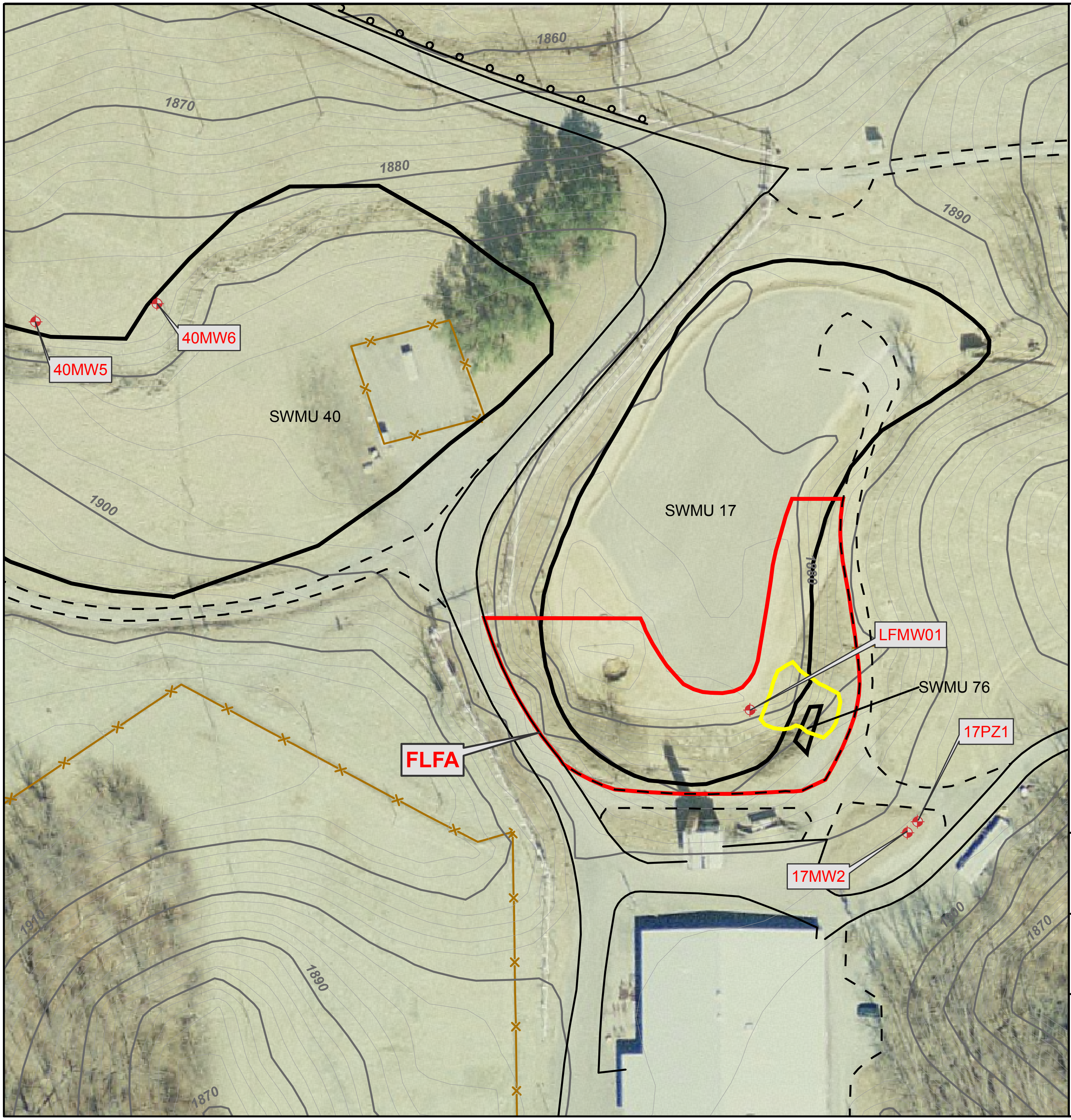


Photo 2. Recent photo of the FLFA and surrounding area.

2.2 Site History

The primary function of the lead furnace was to melt and cast recovered lead into ingots for salvage. Although little is known about the operations at the FLFA, typical smelter operations involved melting the lead in a tank with an overhead heater, then pouring the molten lead into molds. The location of lead slag remnants suggests that the lead was off-loaded at the top of the hill. Although exact furnace operation dates are not available, the historical records and document search conducted in conjunction with the Verification Investigation (VI), (Dames & Moore, 1992) date its operation during World War II. A concrete retaining wall was visible at the base of the slope at the commencement of the 1998 RFI site activities. Additional structures discovered during the 1998 RFI included a foundation, brick flue, cement retaining wall, and a stone retaining wall. Based on 1998 RFI activities, it was determined that the FLFA structures encompassed an area that was 35 ft long (north-south) by 30 ft wide (east-west). These structures more clearly delineate the area of former lead furnace activities.

Environmental interest in the FLFA occurred as the result of underground storage tank (UST) removal activities that occurred in 1991 at SWMU 76 (Used Oil UST). Solid lead slag was observed in the soil around and below the tank at the time of the UST removal. Associated soil samples were found to contain lead at concentrations of 3,200 and 63,000 milligrams per kilogram (mg/kg). It was assumed that the high lead concentrations were attributed to the FLFA because of the proximity to the lead furnace. Based on these observations, additional activity was performed at the FLFA between March and May of 1998. Structure, debris, and soil were taken out to assess lead contamination at the site and to access subsurface soil at the level of the furnace structures, where lead associated with the operations of the lead furnace would be



LEGEND

⊕ Monitoring Well
— Fence Line
- - - Dirt Road
— Paved Road
— 10 Ft Elevation Contour
□ 1998 RFI Excavation Boundary
□ Other SWMU Boundary
□ Former Lead Furnace Area Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

N

Scale:
0 55 110 220 Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-1
Former Lead Furnace Area
Site Map
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: RFAAP_Fig2-1_FLFA_Site_Map.mxd (1/31/2008 2:40:11 PM) expected to be present. The structure and debris were taken out to characterize the extent of FLFA-related lead contamination.

2.3 Site Soil

Although the Soil Conservation Service (SCS) Map (SCS, 1985) for the FLFA area shows that the site is underlain by the Unison-Urban Land Complex (**Figure 2-2**), soil at the FLFA has been extensively reworked during the history of the site. Native material was excavated during initial construction of the furnace, which was anchored to bedrock. Fill material was added to fill in the foundation after the furnace was no longer used. Railroad ties, ash and other man-made debris were encountered during the 1998 RFI excavation. The installation and removal of the used oil tank at the adjacent SWMU 76 caused further reworking of the soil. The excavation at the FLFA during the 1998 RFI resulted in another excavation and fill at the site. Finally, soil was reworked throughout the entire sinkhole area, including the FLFA, during the construction of the burn cap at SWMU 17A in 2002. Fill material used during the various excavations ranged from debris and ash (initial filling of the furnace foundation) to yellowish-brown and orange-brown silt and clay with varying amounts of sand and fine gravel (possibly during the SWMU 76 closure) to a red compactable clay and silt (1998 RFI). Deeper samples from the base of the sinkhole (boring LFSB1) suggest that the original, native material at the site was brownish-yellow clay with moderate plasticity. This material is present now at deeper intervals from borings within the sinkhole.

2.4 Site Geology

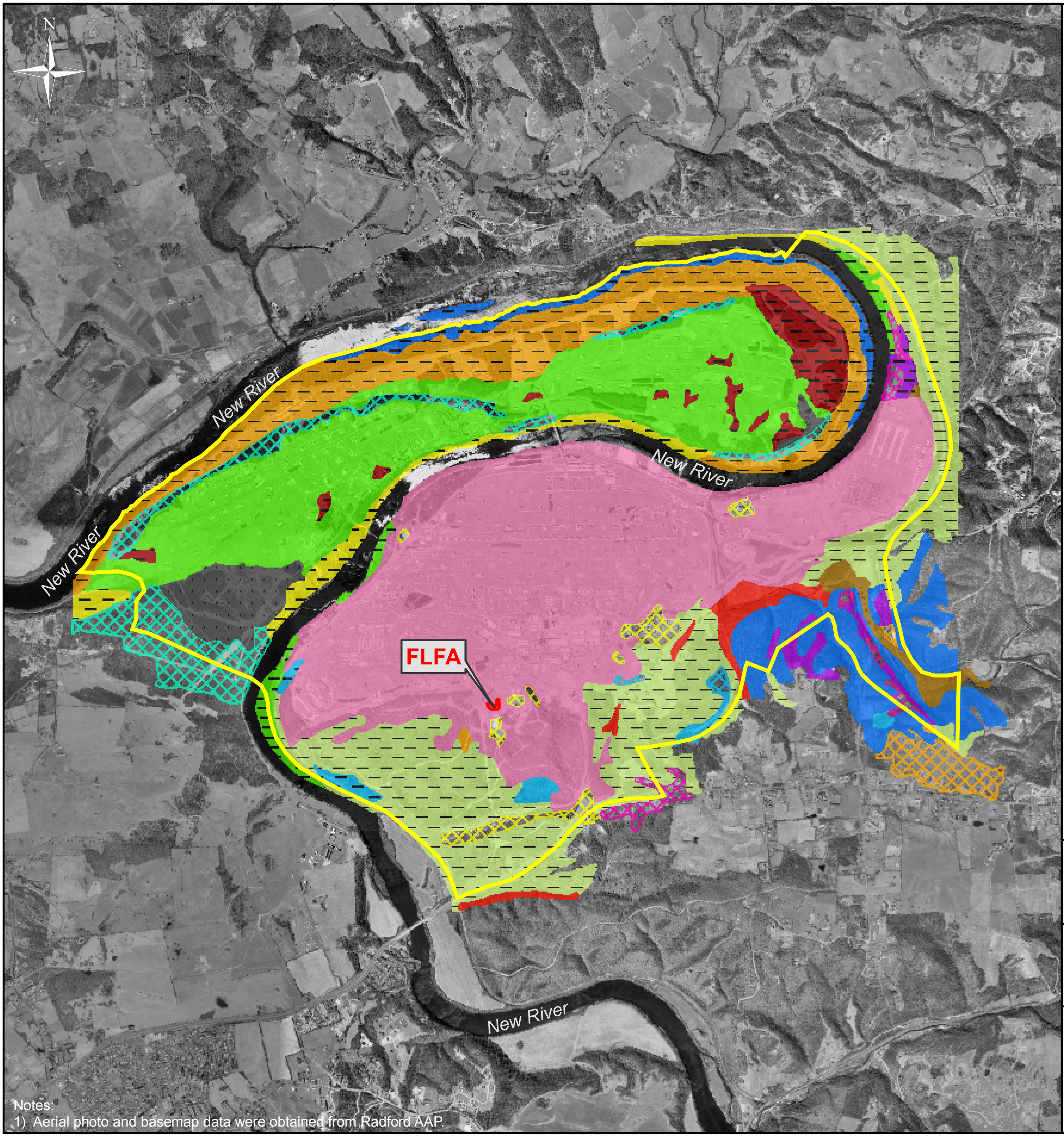
Stratigraphic characterization of the subsurface in the vicinity of the FLFA was performed during the installation of monitoring wells and the advancement of soil borings. Two geologic cross-sections (A-A’ and B-B’) were developed based on the boring logs from these wells and soil borings. A plan view of the cross-section lines is presented on **Figure 2-3**. The cross-sections are presented as **Figure 2-4** (A-A’) and **Figure 2-5** (B-B’).

Cross-section A-A’ depicts the geology of the overburden on a line crossing through the sinkhole. Cross-section B-B’ is perpendicular to A-A’. Bedrock under the site is a grayish-brown argillaceous limestone. Depth to bedrock ranges from less than 2 ft at the top of the slope to the east of the site (e.g., LFSB8 and LFSB9) to more than 10 ft at the base of the slope (e.g., LFSB1). The top 10 ft of bedrock has turned to saprolite – a dense, clay-rich, weathered limestone.

2.5 Hydrology and Hydrogeology

Based on topography, surface water in the area of the FLFA would flow from the surrounding hillsides to the base of the engineered burn cap at SWMU 17A (located over the previous SWMU 17A burning area). This water runoff would probably percolate into the hillsides and subsurface and eventually enter the water table or would migrate to the adjacent sinkhole, ultimately discharging to the New River. A dye trace study conducted by Engineering Science, Inc. (Engineering Science, 1994) in 1994 identified a specific flow path connecting the FLFA/SWMU 17A sinkhole to a spring in the New River (**Figure 2-6**).

RFAAP utility maps predate the construction of the burn cap at SWMU 17A and do not show manholes, catch basins, or storm drains in the vicinity of the FLFA. The engineered burn cap contains porous pipe to collect precipitation that falls on the capped area. The piping system directs runoff into a 7,000-gallon tank that can be pumped out through a manhole adjacent to the



Notes:
1) Aerial photo and basemap data were obtained from Radford AAP.

LEGEND

- 🟥 Former Lead Furnace Area Boundary
- 🟨 Installation Boundary

SCS Soil Types

- 🟦 BERKS AND WEIKERT SOILS
- ▨ BERKS AND WEIKERT, VERY STONEY SOILS
- 🟪 BERKS-CLYMER COMPLEX
- ▨ BERKS-GROSECLOSE COMPLEX
- 🟩 BERKS-WEIKERT COMPLEX
- 🟩 BRADDOCK LOAM
- ▤ CANEYVILLE-OPEQUON-ROCK OUTCROP COMPLEX
- ▨ CARBO AND CHILHOWIE SOILS
- ▨ CARBO-ROCK OUTCROP COMPLEX
- 🟥 COTACO LOAM
- 🟫 CRAIGSVILLE SOIL
- ▤ FLUVAQUENTS
- 🟧 FREDERICK AND VERTREES SILT LOAMS
- 🟨 FRENCH SOILS
- 🟦 GROSECLOSE AND POPLIMENTO
- ▤ GUERNSEY SILT LOAM
- ▨ HAYTER LOAM
- ⬛ LOWELL SILT LOAM
- ▤ McGARY AND PURDY SOILS
- ▤ ROCK OUTCROP-NEWBERN-CARBO COMPLEX
- ▤ ROSS SOILS
- ▨ UDORTHENTS AND URBAN LAND
- ▤ UNISON AND BRADDOCK SOILS
- 🟪 UNISON-URBAN LAND COMPLEX
- 🟥 WEAVER SOILS
- ▤ WHEELING SANDY LOAM
- ▦ WURNO-NEWBERN-FAYWOOD SILT LOAMS

Scale:

0 1,750 3,500 7,000 Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-2

SCS Soil Types at the
Main Manufacturing Area

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: RFAAP_Fig2-2_FLFA_MMA_SCS_Soils.mxd (11/19/2007 3:26:12 PM)

LEGEND

- ■ Soil Sample Location
- ⊕ Monitoring Well
- – – – Dirt Road
- —— Paved Road
- —— Fence Line
- **——** Geologic Cross Section Line
- ▭ Former Lead Furnace Area Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

N

Scale:

0 37.5 75 150 Feet

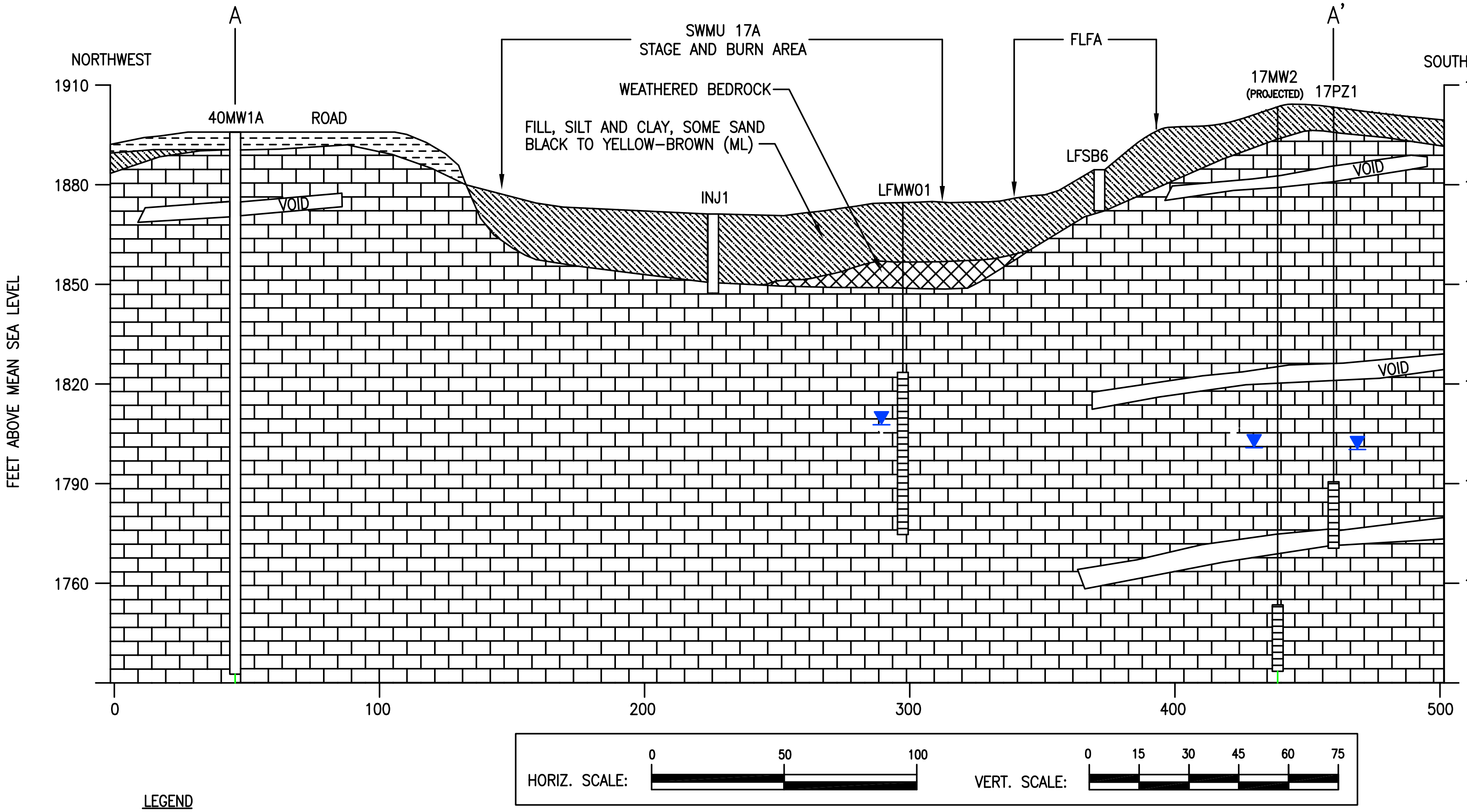
U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-3
Former Lead Furnace Area
Geologic Cross Section Lines A-A' and B-B'

Radford Army Ammunition Plant,
Radford, VA

GIS File: RFAAP_Fig2-3_FLFA_XSect.mxdjoy.pasquarelli (1/29/2008 11:28:55 AM)



LEGEND

☷ CLAY AND SILT, LITTLE SAND, RED-BROWN (CL)

▨ SILT AND CLAY (ML/CL)

▩ WEATHERED BEDROCK

▤ LIMESTONE, GRAY-BROWN, ARGILLACEOUS (LMSN)

▼ STATIC GROUNDWATER LEVEL

NOTES

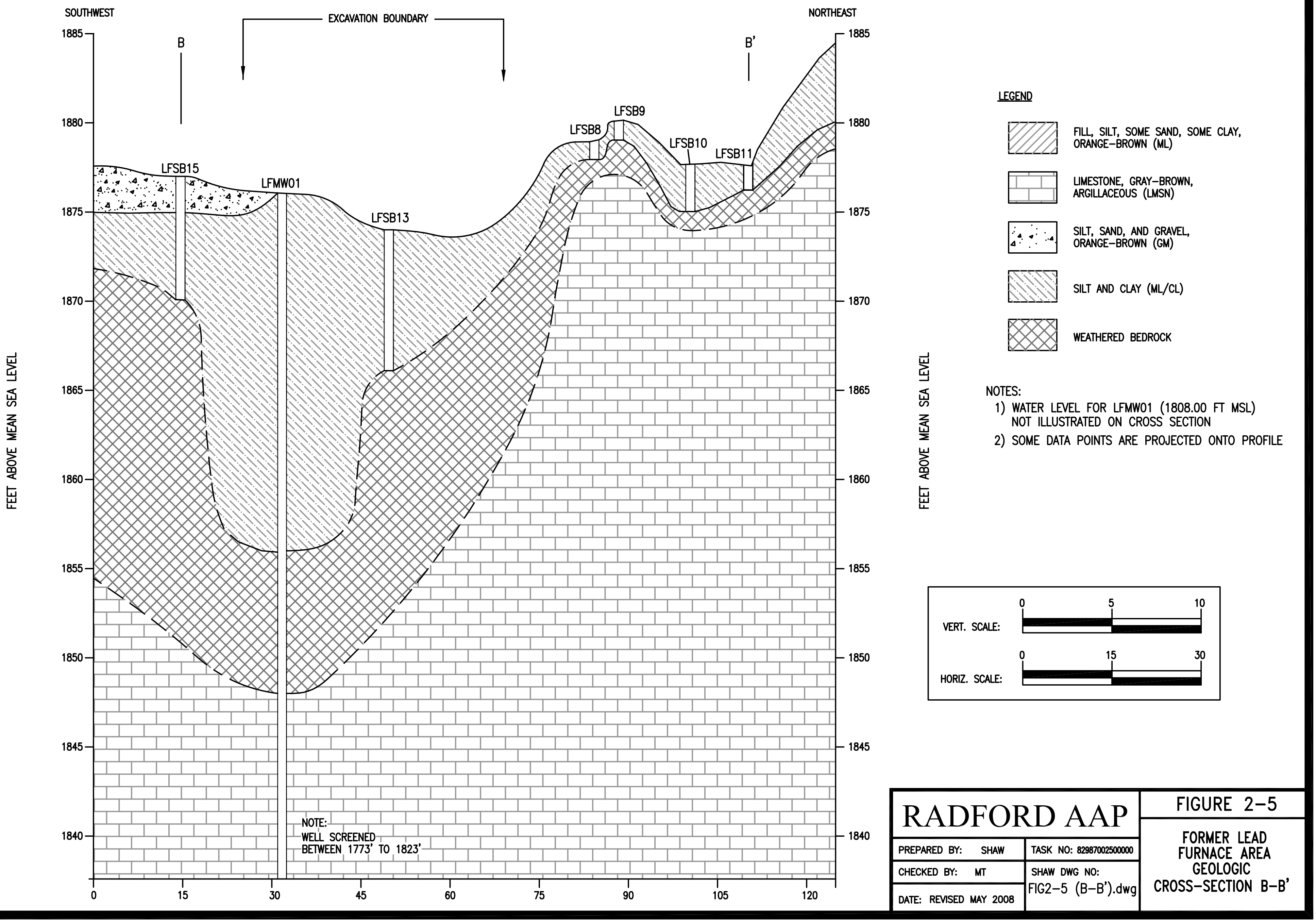
1) WATER LEVELS MEASURED DECEMBER 2007 (17MW2 AND 17PZ1) AND AUGUST 2007 (LFMW01)
2) SOME DATA POINTS ARE PROJECTED ONTO PROFILE.
3) 40MW1A AND 17PZ1 LITHOLOGY FROM DAMES AND MOORE.
4) 40MW1A IS A BORING.
5) INJECTION WELL IS AN OPEN HOLE AT THE BEDROCK INTERFACE.

SOURCE: PARSONS ENGINEERING SCIENCE INC

FILE: FIG2-3.dwg

PLOT: 8-19-05

RADFORD AAP		FIGURE 2-4
PREPARED BY: SHAW	TASK NO: 12346161030000	FORMER LEAD FURNACE AREA GEOLOGIC CROSS-SECTION A-A'
CHECKED BY: MT	SHAW DWG NO: FIG 2-4 (A-A').dwg	
DATE: REVISED DECEMBER 2007		



NOTES:
1) WATER LEVEL FOR LFMW01 (1808.00 FT MSL) NOT ILLUSTRATED ON CROSS SECTION
2) SOME DATA POINTS ARE PROJECTED ONTO PROFILE

RADFORD AAP		FIGURE 2-5
PREPARED BY: SHAW	TASK NO: 82987002500000	FORMER LEAD FURNACE AREA GEOLOGIC CROSS-SECTION B-B'
CHECKED BY: MT	SHAW DWG NO: FIG2-5 (B-B').dwg	
DATE: REVISED MAY 2008		

LEGEND

▲ Surface Water/Sediment Sample Location

⬅ - - Groundwater Flow Path Suggested by Engineering Science, Inc. (May 1994)

▭ Former Lead Furnace Area Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

N

Scale:
0 400 800 1,600 Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-6
Former Lead Furnace Area
Groundwater Flow Path From
FLFA Sinkhole to Spring Discharge
Radford Army Ammunition Plant
Radford, VA

ArcGIS File: RFAAP_Fig2-6_FLFA_GW_Flow.mxd (2/18/2008 10:18:20 AM) cap. The drainage system for the burn cap; however, does not collect runoff from the hill sides adjacent to the burn cap, where the FLFA is located.

Groundwater at RFAAP occurs in two types of aquifers, an alluvium water table aquifer, which is present in the floodplain areas along the New River, and a bedrock aquifer. The FLFA is located in the uplands and is underlain by the bedrock aquifer, with locally saturated overburden. Groundwater elevation measurements were collected from FLFA vicinity wells during August and December of 2007. As illustrated on **Figure 2-7**, stabilized groundwater measurements ranged from 1,762.54 ft msl (40MW3, measured in December 2007) to 1,808.00 ft msl (LFMW01, measured in August 2007).

Groundwater flow, based on the results of the dye trace study in 1994, is inward towards the SWMU 17A sinkhole and then west through karst conduits to the spring (SPG 3) at the New River. **Figure 2-7** presents groundwater elevations for each of the FLFA vicinity wells and direction of groundwater flow at the site.

2.6 Previous Investigations

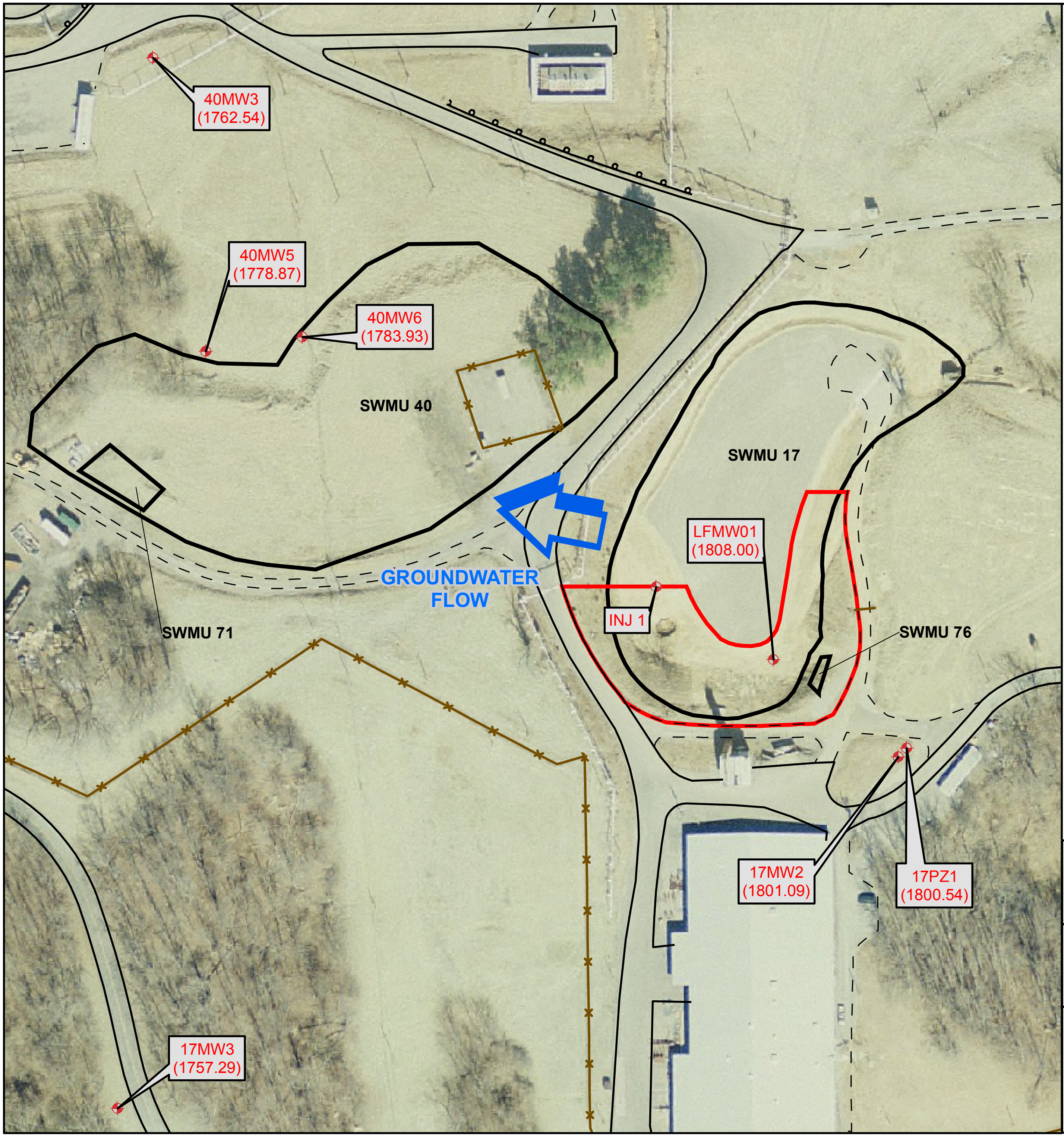
There have been four previous investigations at the FLFA prior to the 2007 Investigation, the 1992 VI, the 1996 RFI, the 1998 RFI, and the 2002 RFI. A summary of the samples collected and analyses to support these investigations is presented in **Table 2-1**. Details and results from these investigations are discussed in the following sections.

2.6.1 Verification Investigation, Dames & Moore, 1992

Three borings were advanced for subsurface soil sampling at SWMU 17A during the VI. Two of the soil borings for this investigation (17SB1 and 17SB2) were advanced upslope of the FLFA. The third boring (17SB3) was advanced downslope from the FLFA. The locations of these borings are illustrated on **Figure 2-8**. 17SB2 was advanced to 10 ft below ground surface (bgs) and samples were collected from 4-6 ft bgs and 8-10 ft bgs. The other borings were advanced to depths of 9 ft bgs (17SB1) and 7 ft bgs (17SB3). Two samples were collected from each of these borings. Soil samples were analyzed for target analyte list (TAL) metals and Toxicity Characteristic Leachate Procedure (TCLP) metals. Detected analytical results are presented in **Table 2-2**.

Sample results indicated that concentrations of antimony, lead, mercury, and thallium exceeded industrial screening levels. Antimony, lead, and mercury exceeded their respective industrial screening levels of 41 mg/kg, 800 mg/kg, and 31 mg/kg, in one sample [17SB2 (7.5-10 ft bgs)], with reported concentrations of 249 mg/kg (antimony), 100,000 mg/kg (lead), and 64 mg/kg (mercury). The TCLP concentration for lead in this sample also exceeded the Toxicity Characteristic Leachate Procedure Regulatory Limit [(TCLPRL); 5,000 micrograms per liter (µg/L)]. TCLP results for the remaining samples were below the TCLPRL. Thallium exceeded its industrial screening level (7.2 mg/kg) and background (2.11 mg/kg) in five of the six samples, with a maximum reported concentration of 96.7 mg/kg. Aluminum and copper exceeded their respective background concentrations, as well as the residential screening levels.

A Baseline Risk Assessment (BRA) was also performed during the VI program. The BRA conducted during the VI stated that workers do not frequently enter the area; however, burn activities occur approximately once per week at SWMU 17A. Due to the nature of operations conducted in this area, the dust inhalation pathway was considered to be the most viable and significant exposure pathway; exposure via incidental ingestion and dermal absorption was



LEGEND

- ⊕ Monitoring Well Location
- – – – Dirt Road
- —— Paved Road
- —— Fence Line
- 🟥 Former Lead Furnace Area Boundary
- ⬛ Other Site Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) All water levels measured in December 2007, except LFMW01, which was measured in August 2007.
3) Water levels are expressed in feet above mean sea level.
4) Groundwater flow direction is based on the 1994 dye trace study results (Engineering Science, 1994).

N

Scale:
0 70 140 280 Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-7
Former Lead Furnace Area
Groundwater Flow Map
Radford Army Ammunition Plant,
Radford, VA

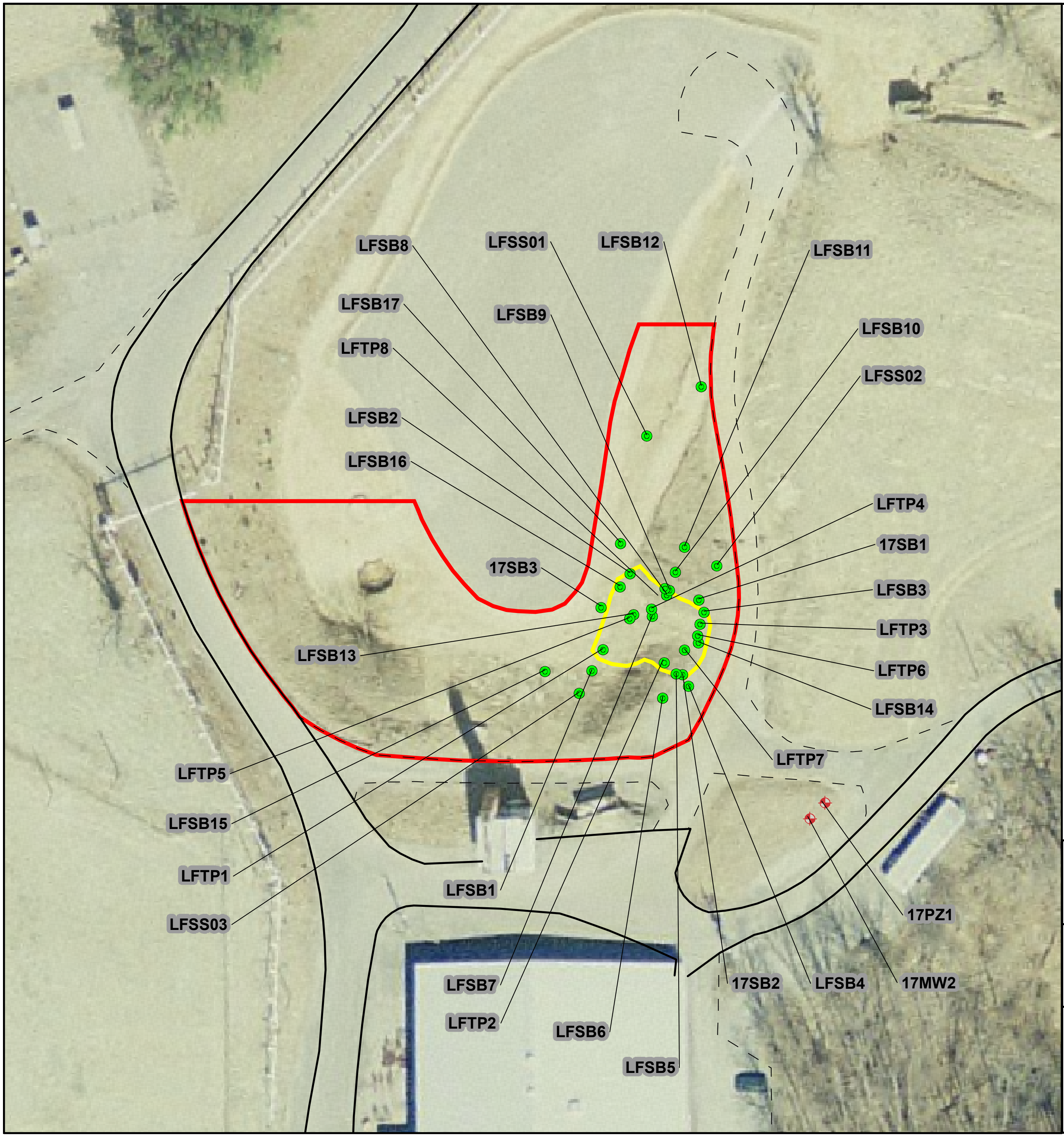
GIS File: RFAAP_Fig2-7_FLFA_GW_Flow.mxd (5/15/2008 11:08:29 AM)

Table 2-1
Previous Investigation Samples and Analyses

Media	Sampling ID	Depth	Analytes
1992 Verification Investigation			
Soil	17SB1 (RFIS*75)	6.5-8 ft bgs	TAL metals, TCLP metals
	17SB1 (RFIS*80)	8-9 ft bgs	
	17SB2 (RFIS*82)	2.5-5 ft bgs	
	17SB2 (RFIS*83)	7.5-10 ft bgs	
	17SB3 (RFIS*84)	2.5-5 ft bgs	
	17SB3 (RFIS*85)	5.5-7 ft bgs	
1996 RCRA Facility Investigation			
Groundwater	17PZ1	mid-point of well screen	Metals (total and dissolved), explosives, TOC, TOX
	17MW2	mid-point of well screen	
	17MW3	mid-point of well screen	
	40MW3	mid-point of well screen	
Surface Water	SPG3SW1	NA	Total metals, explosives, TOC, TOX, Hardness, TPH
Sediment	SPG3SE1	NA	
1998 RCRA Facility Investigation			
Soil	LFSB1A	0-1 ft bgs	Lead
	LFSB1B	10-12 ft bgs	
	LFSB2A	0-2 ft bgs	
	LFSB2B	6-7 ft bgs	
	LFSB3A	0-2 ft bgs	
	LFSB3B	12-14 ft bgs	
	LFSB4A	8-10 ft bgs	
	LFSB5A	4-6 ft bgs	
	LFSB5B	8-10 ft bgs	
	LFSB6A	2-4 ft bgs	
	LFSB6B	10-12 ft bgs	
	LFSB7A	0-2 ft bgs	
	LFTP1	5-6 ft bgs	
	LFTP2	4-5 ft bgs	
	LFTP3	6-8 ft bgs	
	LFTP4	5-7 ft bgs	
	LFTP5	5-7 ft bgs	
	LFTP6	8-10 ft bgs	
	LFTP7	8-10 ft bgs	
	LFTP8	5-6 ft bgs	
	LFSB8A	0.5-1 ft bgs	Lead, TCLP Lead

Table 2-1 (Continued)
Previous Investigation Samples and Analyses

Media	Sampling ID	Depth	Analytes
Soil	LFSB9A	0.5-1 ft bgs	Lead
	LFSB10A	0.5-1 ft bgs	
	LFSB10B	2-2.5 ft bgs	
	LFSB11A	0.5-1 ft bgs	
2002 RCRA Facility Investigation			
Surface Soil	LFSS01	0-0.5 ft bgs	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans
	LFSS02	0-0.5 ft bgs	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans
	LFSS03	0-0.5 ft bgs	TCL VOCs, SVOCs, pesticides/PCBs, herbicides, PAHs, explosives, TAL metals, dioxins/furans
	LFSB12A	0-0.5 ft bgs	TCL VOCs, SVOCs, pesticides/PCBs, herbicides, PAHs, explosives, TAL metals, dioxins/furans, TOC, grain size, pH
	LFSB15A	0-0.5 ft bgs	TCL VOCs, SVOCs, pesticides/PCBs, herbicides, PAHs, explosives, TAL metals, dioxins/furans
	LFSB16A	0-0.5 ft bgs	TCL SVOCs, TAL metals, dioxins/furans
	LFSB17A	0-0.5 ft bgs	TCL SVOCs, TAL metals, dioxins/furans
Subsurface Soil	LFSB12B	2-4 ft bgs	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans
	LFSB12C	4-5.4 ft bgs	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans, TOC, grain size, pH
	LFSB13A	Immediately below contact with native soil (8.3-9 ft bgs)	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans
	LFSB14A	Immediately below contact with native soil (5.5-7 ft bgs)	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans
	LFSB14B	7-8.8 ft bgs	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans
	LFSB15B	2-4 ft bgs	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans
	LFSB15C	4-6 ft bgs	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans
	LFSB16B	1-3 ft bgs	TCL SVOCs, TAL metals
	LFSB16C	3-5 ft bgs	TCL SVOCs, TAL metals
	LFSB17B	1-3 ft bgs	TCL SVOCs, TAL metals



ArcGIS File: RFAAP_Fig2-8_FLFA_PrevSampleLocations.mxd (1/28/2008 10:11:34 AM)

LEGEND

⊕ Monitoring Well Location

● Previous Investigation Soil Sample Location

- - - Dirt Road

— Paved Road

▭ Excavation Boundary

▭ Former Lead Furnace Area Boundary

Notes:
1) Aerial photo, dated 25 May 2000, was obtained from the Army Topographic Engineering Center.

N

Scale:
0 37.5 75 150
Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-8
Former Lead Furnace Area
Previous Investigation Sample Locations
Radford Army Ammunition Plant,
Radford, VA

Table 2-2
Former Lead Furnace Area - VI Detected Soil Results - 1992

SITE ID	Comparison Criteria			17SB1	17SB1	17SB2	17SB2	17SB3	17SB3
FIELD ID				RFIS*75	RFIS*80	RFIS*82	RFIS*83	RFIS*84	RFIS*85
SAMPLING DATE	Industrial RBC	Residential RBC	Facility-Wide Background	05-NOV-91	05-NOV-91	05-NOV-91	05-NOV-91	05-NOV-91	05-NOV-91
DEPTH (ft)				6.5-8	8-9	2.5-5	7.5-10	2.5-5	5.5-7
Metals (mg/kg)									
Aluminum	100000	7800	40041	15800	23400	15500	7460	33200	**42300**
Antimony	41	3.1	na	nd	nd	nd	**249**	nd	nd
Arsenic	1.9	0.43	15.8	3.46	3.06	5.6	5.77	2.65	3.84
Barium	20000	1600	209	93	70.9	27	183	73.6	106
Beryllium	200	16	1.02	**1.09**	**1.09**	nd	nd	**2.45**	**2.71**
Cadmium	51	3.9	0.69	nd	nd	nd	**2.57**	nd	nd
Calcium	na	na	na	3910	2000	1150	13900	1860	3890
Chromium	310	23	65.3	43.2	38.7	24.1	36.1	45.3	50.4
Cobalt	2000	160	72.3	14.5	21.2	2.97	7.92	15.4	10.3
Copper	4100	310	53.5	19.7	16.3	4.95	**2260**	38.2	23.8
Iron	72000	5500	50962	20700	33900	22200	22200	45300	49000
Lead	800	400	26.8	25.3	19.9	20.9	**100000**	**372**	nd
Magnesium	na	na	na	12400	13900	846	11100	8880	49100
Manganese	2000	160	2543	426	577	130	246	453	575
Mercury	31	2.3	0.13	nd	nd	0.0615	**64**	0.104	nd
Nickel	2000	160	62.8	22.4	25.8	4.13	52	45.3	35.2
Potassium	na	na	na	1450	1980	494	855	2580	8210
Silver	510	39	na	0.985	0.97	nd	23.9	nd	nd
Sodium	na	na	na	300	171	180	278	172	227
Thallium	7.2	0.55	2.11	**12.9**	**14.2**	nd	**96.7**	**21.5**	**26.9**
Vanadium	102	7.8	108	56.6	67.2	53.8	26.5	83.3	90.5
Zinc	31000	2300	202	68.6	60	23.5	**801**	124	67.6
TCLP Metals (ug/L)	**TCLP Criteria (ug/L)**								
Barium	100000			311	209	222	1240	329	220
Lead	5000			nd	nd	nd	500000	2230	63.3

expected to be low. Lead exposure to site workers via inhalation was expected to be moderate to high because of the high lead concentrations assumed to be present in the surface soil.

Conclusions from the BRA indicated that because this site is located in a sinkhole at the bottom of a steep hill within an active weekly burn area, it is unlikely that environmental receptors frequent this area. Therefore, potential exposure to environmental receptors was estimated to be low.

2.6.2 RCRA Facility Investigation, Parsons Engineering Science, 1996

An RFI was performed by Parsons Engineering Science as a follow up to the VI to investigate potential contamination at SWMU 17. As part of this investigation, groundwater, surface water, and sediment samples were collected to assess SWMU 17. Detected results for are presented in **Tables 2-3** (groundwater), **2-4** (surface water), and **2-5** (sediment). Sample locations are illustrated on **Figures 2-7** (groundwater) and **2-6** (surface water/sediment).

Groundwater. Groundwater samples were collected from crossgradient wells 17MW3 and 40MW3 and upgradient wells 17MW2 and 17PZ1. As shown in **Table 2-1**, groundwater samples were analyzed for metals (total and dissolved), explosives, total organic carbon (TOC), and total organic halides (TOX). Data from upgradient wells 17MW2 and 17PZ1 are used to assess groundwater at the FLFA. Because wells 17MW3 and 40MW3 are considered crossgradient, the data was not used to assess groundwater conditions at the FLFA.

As shown in **Table 2-3**, sample results from 17MW2 and 17PZ1 indicated that explosives were not detected in either well. Three metals (antimony, barium, and beryllium) were detected in the wells. Antimony was only detected in well 17MW2 at a concentration exceeding both the tap water risk-based concentration (tw-RBC) and maximum contaminant level (MCL). Beryllium (total and dissolved) was detected in both upgradient wells at concentrations exceeding the MCL. TOC was not detected in either well. TOX was detected in well 17MW2 at a concentration of 27.5 μg/L and in well 17PZ1 at a concentration of 15.7 μg/L.

Surface Water. Based on the dye tracing study performed by Engineering Science in 1994, which revealed that a spring on the New River was hydraulically connected to SWMU 17A, a surface water sample (SPG3SW1) was collected and analyzed for total metals, explosives, TOC, TOX, hardness, and total petroleum hydrocarbons (TPH) (**Table 2-1**). As shown in **Table 2-4**, explosives and TOX were not detected in the sample. Three metals (barium, beryllium, and lead) were detected in surface water sample SPG3SW1. Lead was the only metal that was detected at a concentration exceeding the MCL. TOC was detected at a concentration of 1,200 μg/L. Hardness of the sample was 152,000 μg/L.

Sediment. Sediment sample SPG3SE1 was collocated with surface water sample SPG3SW1. As indicated in **Table 2-1**, the sample was analyzed for total metals, explosives, TOC, and TOX. As shown in **Table 2-5**, explosives were not detected in the sample. Eight metals (arsenic, barium, beryllium, chromium, lead, nickel, mercury, and silver) were detected in sediment sample SPG3SE1. Arsenic and lead were the only metals detected at concentrations exceeding residential soil screening levels (SSLs), but below industrial screening levels. TOC was detected at a concentration of 33,740 mg/kg and TOX was detected at a concentration of 240 mg/kg.

Table 2-3
Analytes Detected in FLFA Groundwater - 1996 RFI

Analyte	Sample ID Sample Date		**17MW2** **1/18/95**			**17MW2-Diss** **7/19/95**			**17PZ1** **1/18/95**			**17PZ1-Diss** **7/19/95**		
	MCL	**tw-RBC**	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q
Explosives (ug/L)	None detected													
Metals (ug/L)														
Antimony	6	1.5	60.2			60	U		60	U		60	U	
Barium	2000	730	63.2			63.2			117			110		
Beryllium	4	7.3	4.1			4.26			4.66			4.28		
Misc. (ug/L)														
Total Organic Carbon	na	na	1000	U		NT			1000	U		NT		
Total Organic Halides	na	na	27.5			NT			15.7			NT		

Table 2-4
Analytes Detected in FLFA Surface Water - 1996 RFI

Analyte	Sample ID Sample Date		SPG3SW1 1/13/95		
	MCL	**tw-RBC**	Result	Lab Q	Val Q
Explosives (ug/L)	None detected				
Metals (ug/L)					
Barium	2000	730	26.6	J	
Beryllium	4	7.3	1.64		
Lead	15	na	25.2		
Misc. (ug/L)					
Total organic carbon	na	na	1200		
Total organic halides	na	na	10	U	
Hardness	na	na	152000		
TPH	na	na	100	U	

Table 2-5
Analytes Detected in FLFA Sediment - 1996 RFI

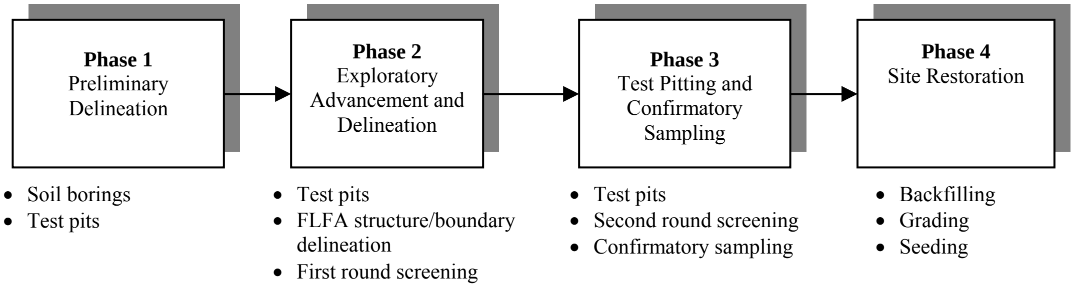
Analyte			Sample ID Sample Date	SPG3SE1 1/13/95		
	i-RBC	**r-RBC**	**Background**	Result	Lab Q	Val Q
Explosives (mg/kg)	None detected					
Metals (mg/kg)						
Arsenic	1.9	0.43	15.8	**17.4**	J	
Barium	20000	1600	209	**700**	J	
Beryllium	200	16	1.02	**4.2**	J	
Chromium	310	23	65.3	62.7	J	
Lead	800	400	26.8	**550**	J	
Mercury	31	2.3	0.13	**0.13**	J	
Nickel	2000	160	62.8	52.9	J	
Silver	510	39	na	0.22	J	
Misc. (mg/kg)						
Total organic carbon	na	na	na	33740		
Total organic halides	na	na	na	240		

2.6.3 RCRA Facility Investigation, ICF Kaiser Engineers, 1998

An RFI was performed by ICF Kaiser Engineers (ICF KE) to delineate the extent of lead-contaminated soil associated with the FLFA. Several assumptions guided FLFA activities, including:

- Lead contamination associated with the furnace was limited to the FLFA boundaries.
- Lead was the principal contaminant of concern at the area.

A phased-focused approach was selected to investigate lead contamination at the FLFA and to ensure that project schedules and objectives were met. Four phases representing critical process junctures associated with the site conceptual model were identified as follows:



2.6.3.1 Phase 1: Preliminary Delineation

The purpose of this activity was to assess (1) the lateral and vertical extent of lead contamination at the FLFA, and (2) the appropriate test pit dimensions necessary to remove the affected soil. Site activities conducted in support of this phase included:

- Shallow and deep subsurface soil sampling.
- Preliminary soil and debris were taken out for additional subsurface sampling.

Seven soil borings (LFSB1 through LFSB7) were advanced to delineate the lateral and vertical extent of lead contamination (**Figure 2-8**). Samples were analyzed for lead content; the results are presented in **Table 2-6a**. As shown in **Table 2-6a**, lead concentrations were detected above the residential screening level in three of the twelve preliminary delineation samples.

Preliminary soil and debris test pitting was then performed. Areas of soil and debris were taken out, which uncovered remnants of the FLFA structures and a large piece of lead slag. The preliminary delineation and test pit results demonstrated that:

- Lead concentrations exceeding the residential screening criterion were found at 0-2 ft bgs (two of four samples at this depth interval) and at the 4-6 ft bgs (one of three samples collected between 2 and 7 ft bgs). Samples collected at intervals below 7 ft bgs had lead concentrations less than the background concentration.
- Additional (unknown) FLFA structures existed besides the exposed lower retaining wall.
- Soil and debris test pitting was necessary to further enhance the site conceptual model and access the subsurface soil for lead field screening.

Table 2-6a
Former Lead Furnace Area - RFI Preliminary Soil Delineation Results - 1998

Sample	Sample Depth (ft)	Lead (mg/kg)
LFSB1A	0-1	**128**
LFSB1B	10-12	18
LFSB2A	0-2	**580**
LFSB2B	6-7	10.2
LFSB3A	0-2	**51.1**
LFSB3B	12-14	23.4
LFSB4A	8-10	15
LFSB5A	4-6	**2070**
LFSB5B	8-10	22.4
LFSB6A	2-4	**27.5**
LFSB6B	10-12	10
LFSB7A	0-2	**943**

Table 2-6b
Former Lead Furnace Area - RFI Soil Confirmation Results - 1998

Sample	Associated Screening Sample	Sample Depth (ft)	Lead (mg/kg)
LFTP1	SS11	5-6	15.3
LFTP2	SS1	4-5	**29.2**
LFTP3	SS3	6-8	10.8
LFTP4	SS7	5-7	**103**
LFTP5	SS9/SS10	5-7	12.8
LFTP6	na	8-10	12.5
LFTP7	na	8-10	11
LFTP8	SS5	5-6	**866**

Table 2-6c
Former Lead Furnace Area - RFI Boundary Delineation Soil Boring Results - 1998

Sample	Sample Depth (ft)	Lead (mg/kg)	TCLP Lead (µg/L)
LFSB8A	0.5-1	**86.9**	507
LFSB9A	0.5-1	**189**	NA
LFSB10A	0.5-1	**279**	NA
LFSB10B	2-2.5	**326**	NA
LFSB11A	0.5-1	**179**	NA

2.6.3.2 Phase 2: Exploratory Advancement and Delineation

The purpose of this phase was to (1) further enhance the CSM by delineating FLFA structures, (2) identify visible contamination and debris related to FLFA activities, and (3) to qualitatively define the presence of lead within FLFA-related soil. Site activities conducted in support of this phase included:

- Test pitting.
- On-site lead screening.

Lead field-screening was used to refine the conceptual model as test pitting progressed, to avoid taking out uncontaminated soil and to track the subsurface location of contaminants.

The exploratory advancement and delineation results demonstrated that:

- Lead contamination existed above and north of the foundation.
- Additional test pitting and lead screening were required to adequately characterize the extent of lead contamination.

2.6.3.3 Phase 3: Test Pitting and Confirmatory Sampling

The purpose of this phase was to quantitatively verify the extent of lead-contaminated soil, following Phase 2 screening and test pit activities. Site activities conducted in support of this phase included:

- Test pitting.
- On-site lead screening (second round).
- Confirmatory sampling.

FLFA structures, remaining debris, and soil with lead concentrations exceeding the residential screening criterion (as indicated during Phase 2 field screening) were taken out during this phase. Test pitting was required to adequately characterize the extent of FLFA-related lead contamination.

Eight confirmation samples (LFTP1 through LFTP8) were collected for laboratory analysis from the bottom and sidewalls of the test pit to verify that soil with lead concentrations exceeding the residential screening level had been taken out (**Figure 2-8**). The results from this sampling are presented in **Table 2-6b**. Results demonstrated that the samples exhibited lead concentrations below the residential screening level, except LFTP8 (866 mg/kg), which was collected from the northern side wall of the excavation.

In response to the elevated lead detection in confirmation sample LFTP8, four soil borings (LFSB8, LFSB9, LFSB10, and LFSB11) were advanced to the north of the excavation to assess whether elevated lead concentrations existed beyond the FLFA footprint (**Figure 2-8**). The samples were analyzed for lead content; the results are presented in **Table 2-6c**. Lead concentrations were reported below the residential screening criterion (400 mg/kg). Based on these results, it was concluded that the lead-containing soil (as indicated by sample LFTP8), was primarily present at the same horizon as the FLFA structures and pinches out at the bedrock surface north of the excavated area. Surface and near surface samples collected outside the excavated area (LFSB8 through LFSB11) contained lead at concentrations below the residential screening level and approximately one-half the concentration detected in LFTP8. Conclusions from this phase were:

- Lead-contaminated soil was taken out from areas impacted by lead furnace activities.
- Additional low concentrations of lead exist beyond the FLFA footprint and may be present at these locations due to other sources and the extensive filling and reworking of soil in the vicinity of the FLFA.

2.6.3.4 Phase 4: Site Restoration

The objective of this phase was to restore the site to an aesthetic state, natural with the local surroundings. Activities conducted in support of this phase included backfilling, grading, and seeding.

Following the completion of FLFA investigation activities, the test pit area was backfilled with highly compactable clay, and graded to a slope less than 45 degrees. The slope terminated approximately 7 ft from the edge of the asphalt road located east of the site. A layer of topsoil was added and the slope was seeded to complement the local flora and fauna and maintain slope stability.

2.6.4 RCRA Facility Investigation, Shaw, 2002

Additional samples were collected by Shaw during the 2002 RFI to further delineate lead-containing soil and characterize site media for previously untested parameters. The draft RFI report was submitted to the Army in August 2005, but was never finalized. This assessment indicated that VOCs, SVOCs, pesticides, herbicides, and explosives compounds did not exceed industrial (or residential) screening levels. Metals (predominantly lead), dioxins/furans, and PCBs, predominantly in surface soil, are the constituents of concern at the FLFA based on exceedances of residential screening criteria. Results from the 2002 sampling are presented in **Tables 2-7 and 2-8** (dioxin/furan results). The relatively lower concentrations of lead (maximum of 3,150 mg/kg) detected in the 2002 Investigation as compared to a previous lead concentration of 100,000 mg/kg (source taken out) and the lack of elevated concentrations in subsurface soil indicate that the major source area is no longer present. The extensive reworking of soil in the area, and the close association with SWMU 17A, has lead to a mix of constituents in surface soil in the area from both sites. Metals in the soil are likely the result of operations at both sites. Organic constituents (dioxins/furans and PCBs) are likely due to burning operations at the adjacent SWMU 17A.

The 2002 Investigation did not include a groundwater component and indicated that areas of lead-containing soil above the residential screening level had not been completely bound. The additional investigation in 2007 (*Section 3.0*) was performed to fill these data gaps.

Table 2-7
Analytes Detected in FLFA Soil - 2002 Investigation
Page 1 of 6

Analyte			Sample ID	LFSS01					LFSS02					LFSS03					LFSB12A					LFSB12B					LFSB12C				
			Sample Date	6/26/02					6/26/02					6/26/02					6/26/02					6/26/02					6/26/02				
			Sample Depth	0-0.5					0-0.5					0-0.5					0-0.5					2-4					4-5.4				
	i-RBC	r-RBC	Background	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)																																	
Toluene	8200000	630000	na	5.7	U		0.37	5.7	5.2	U		0.34	5.2	0.77	J	B	0.53	8.1	5.1	U		0.33	5.1	6.6	U		0.43	6.6	5.5	U		0.36	5.5
PAHs (ug/kg)																																	
2-Methylnaphthalene	410000	31000	na	4.2			0.59	1.8	9			0.59	1.8	46			0.58	1.7	62			0.58	1.7	2.2	U		0.75	2.2	2.1	U		0.7	2.1
Acenaphthene	6100000	470000	na	1.4	J	B	0.97	1.8	1.2	J	B	0.97	1.8	1.5	J	B	0.96	1.7	1.7	U		0.96	1.7	2.2	U		1.2	2.2	2.1	U		1.2	2.1
Acenaphthylene	3100000	230000	na	0.76	J	J	0.23	1.8	1.8	U		0.23	1.8	2.6			0.23	1.7	1.1	J	J	0.23	1.7	2.2	U		0.3	2.2	2.1	U		0.28	2.1
Anthracene	31000000	2300000	na	3.3			0.19	1.8	2.2			0.19	1.8	5.6			0.19	1.7	1.9			0.19	1.7	2.2	U		0.25	2.2	2.1	U		0.23	2.1
Benz(a)anthracene	3900	220	na	24			0.23	1.8	12			0.23	1.8	24			0.23	1.7	11			0.23	1.7	2.2	U		0.3	2.2	2.1	U		0.28	2.1
Benzo(a)pyrene	390	22	na	25			0.2	1.8	11			0.2	1.8	28			0.19	1.7	9.7			0.19	1.7	2.2	U		0.25	2.2	2.1	U		0.23	2.1
Benzo(b)fluoranthene	3900	220	na	44			0.33	1.8	18			0.33	1.8	67			0.33	1.7	21			0.33	1.7	2.2	U		0.43	2.2	2.1	U		0.4	2.1
Benzo(g,h,i)perylene	3100000	230000	na	17		L	0.62	1.8	4.8		L	0.62	1.8	25		L	0.61	1.7	5.9		L	0.61	1.7	2.2	U	UL	0.79	2.2	2.1	U	UL	0.73	2.1
Benzo(k)fluoranthene	39000	2200	na	16			0.31	1.8	7.4			0.31	1.8	15			0.3	1.7	5.9			0.3	1.7	2.2	U		0.39	2.2	2.1	U		0.36	2.1
Chrysene	390000	22000	na	26			0.28	1.8	12			0.28	1.8	37			0.28	1.7	14			0.28	1.7	2.2	U		0.36	2.2	2.1	U		0.33	2.1
Dibenz(a,h)anthracene	390	22	na	3.4		J	0.6	1.8	1.8	U		0.6	1.8	3.5		J	0.59	1.7	1.7	U		0.59	1.7	2.2	U		0.76	2.2	2.1	U		0.71	2.1
Fluoranthene	4100000	310000	na	41			0.3	1.8	18			0.3	1.8	33			0.3	1.7	18			0.3	1.7	2.2	U		0.39	2.2	2.1	U		0.36	2.1
Fluorene	4100000	310000	na	1.3	J	J	0.46	1.8	1.2	J	J	0.47	1.8	4.4			0.46	1.7	1.4	J	J	0.46	1.7	2.2	U		0.59	2.2	2.1	U		0.55	2.1
Indeno(1,2,3-cd)pyrene	3900	220	na	20			0.56	1.8	6.3			0.56	1.8	26			0.55	1.7	6.8			0.55	1.7	2.2	U		0.72	2.2	2.1	U		0.67	2.1
Naphthalene	2000000	160000	na	3		B	0.68	1.8	5.4		B	0.68	1.8	34			0.67	1.7	22			0.67	1.7	2.2	U		0.86	2.2	2.1	U		0.8	2.1
Phenanthrene	3100000	230000	na	19			0.27	1.8	17			0.27	1.8	55			0.26	1.7	28			0.27	1.7	2.2	U		0.34	2.2	2.1	U		0.32	2.1
Pyrene	3100000	230000	na	40			0.39	1.8	19			0.4	1.8	37			0.39	1.7	22			0.39	1.7	2.2	U		0.5	2.2	2.1	U		0.47	2.1
SVOCs (ug/kg)																																	
1,2,4-Trichlorobenzene	1000000	78000	na	170	U		7.2	170	170	U		7.2	170	170	U		7.1	170	170	U		7.1	170	220	U		9.1	220	200	U		8.5	200
1,2-Dichlorobenzene	9200000	700000	na	170	U		4.9	170	170	U		5	170	170	U		4.9	170	170	U		4.9	170	220	U		6.3	220	200	U		5.9	200
1,3-Dichlorobenzene	310000	23000	na	170	U		5.4	170	170	U		5.4	170	170	U		5.3	170	170	U		5.3	170	220	U		6.9	220	200	U		6.4	200
1,4-Dichlorobenzene	120000	27000	na	170	U		5.9	170	170	U		6	170	170	U		5.8	170	170	U		5.9	170	220	U		7.6	220	200	U		7.1	200
2,4,5-Trichlorophenol	10000000	780000	na	170	U		6.3	170	170	U		6.3	170	170	U		6.2	170	170	U		6.2	170	220	U		8.1	220	200	U		7.5	200
2,4,6-Trichlorophenol	102000	7800	na	170	U		4.9	170	170	U		5	170	170	U		4.9	170	170	U		4.9	170	220	U		6.3	220	200	U		5.9	200
2,4-Dichlorophenol	310000	23000	na	170	U		4.1	170	170	U		4.1	170	170	U		4	170	170	U		4	170	220	U		5.2	220	200	U		4.9	200
2,4-Dinitrotoluene	200000	16000	na	13	J	J	5.9	170	7.6	J	J	5.9	170	36	J	J	5.8	170	7.2	J	J	5.8	170	220	U		7.5	220	200	U		7	200
2-Chloronaphthalene	8200000	630000	na	170	U		4.4	170	170	U		4.5	170	170	U		4.4	170	170	U		4.4	170	220	U		5.7	220	200	U		5.3	200
2-Chlorophenol	510000	39000	na	170	U		4.1	170	170	U		4.2	170	170	U		4.1	170	170	U		4.1	170	220	U		5.3	220	200	U		4.9	200
2-Methylnaphthalene	410000	31000	na	170	U		6.6	170	170	U		6.7	170	69	J	J	6.6	170	170	U		6.6	170	220	U		8.5	220	200	U		7.9	200
2-Methylphenol	5100000	390000	na	170	U	UL	7	170	170	U	UL	7	170	170	U	UL	6.9	170	170	U	UL	6.9	170	220	U	UL	9	220	200	U	UL	8.4	200
2-Nitrophenol	na	na	na	170	U		5.7	170	170	U		5.8	170	170	U		5.7	170	170	U		5.7	170	220	U		7.3	220	200	U		6.8	200
4-Chloro-3-methylphenol	na	na	na	170	U		8.3	170	170	U		8.3	170	170	U		8.2	170	170	U		8.2	170	220	U		11	220	200	U		9.9	200
4-Chlorophenyl phenyl ether	na	na	na	170	U		5.4	170	170	U		5.5	170	170	U		5.4	170	170	U		5.4	170	220	U		7	220	200	U		6.5	200
4-Methylphenol	510000	39000	na	170	U	UL	6.1	170	170	U	UL	6.1	170	170	U	UL	6	170	170	U	UL	6.1	170	220	U	UL	7.8	220	200	U	UL	7.3	200
Acenaphthene	6100000	470000	na	170	U		4.8	170	170	U		4.8	170	170	U		4.8	170	170	U		4.8	170	220	U		6.2	220	200	U		5.7	200
Acenaphthylene	3100000	230000	na	170	U		4.7	170	170	U		4.7	170	170	U		4.6	170	170	U		4.6	170	220	U		6	220	200	U		5.6	200
Benz(a)anthracene	3900	220	na	30	J	J	5	170	14	J	J	5	170	32	J	J	4.9	170	13	J	J	4.9	170	220	U		6.4	220	13	J	J	5.9	200
Benzo(a)pyrene	390	22	na	27	J	J	4.3	170	11	J	J	4.3	170	39	J	J	4.2	170	8.1	J	J	4.2	170	220	U		5.5	220	200	U		5.1	200
Benzo(b)fluoranthene	3900	220	na	42	J	J	3.7	170	17	J	J	3.7	170	53	J	J	3.6	170	13	J	J	3.6	170	220	U		4.7	220	200	U		4.4	200
Benzo(g,h,i)perylene	3100000	230000	na	30	J	J	4.9	170	170	U		4.9	170	50	J	J	4.8	170	10	J	J	4.8	170	220	U		6.2	220	200	U		5.8	200
Benzo(k)fluoranthene	39000	2200	na	15	J	J	4.9	170	7.1	J	J	4.9	170	19	J	J	4.9	170	5	J	J	4.9	170	220	U		6.3	220	200	U		5.9	200
bis(2-Chloroethoxy)methane	na	na	na	170	U		5.3	170	170	U		5.3	170	170	U		5.2	170	170	U		5.3	170	220	U		6.8	220	200	U		6.3	200
bis(2-Chloroethyl)ether	2600	580	na	170	U		3.9	170	170	U		3.9	170	170	U		3.9	170	170	U		3.9	170	220	U		5	220	200	U		4.7	200
bis(2-Ethylhexyl)phthalate	200000	46000	na	30	J	B	12	170	27	J	B	12	170	32	J	B	11	170	27	J	B	12	170	18	J	B	15	220	18	J	B	14	200
bis(Chloroisopropyl)ether	41000	9100	na	170	U		3.9	170	170	U		3.9	170	170	U		3.8	170	170	U		3.9	170	220	U		5	220	200	U		4.6	200
Butylbenzylphthalate	20000000	1600000	na	170	U		6.8	170	170	U		6.8	170	14	J	B	6.7	170	170	U		6.7	170	8.8	J	B	8.7	220	200	U		8.1	200
Chrysene	390000	22000	na	33	J	J	4	170	10	J	J	4	170	40	J	J	4	170	8.9	J	J	4	170	220	U		5.1	220	8.8	J	J	4.8	200
Dibenzofuran	100000	7800	na	170	U		5	170	170	U		5	170	13	J	J	4.9	170	170	U		4.9	170	220	U		6.3	220	200	U		5.9	200
Diethylphthalate	82000000	6300000	na	10	J	B	5	170	170	U		5.1	170	170	U		5	170	170	U		5	170	220	U		6.4	220	200	U		6	200
Di-n-butylphthalate	10000000	780000	na	170	U		50	170	170	U		50	170	160	J	B	50	170	170	U		50	170	220	U		64	220	200	U		60	200
Di-n-octylphthalate	na	na	na	170	U		7.8	170	170	U		7.8	170	170	U		7.7	170	170	U		7.7	170	220	U		9.9	220	200	U		9.2	200
Fluoranthene	4100000	310000	na	58	J	J	5.7	170	9.4	J	J	5.7	170	38	J	J	5.6	170	16	J	J	5.6	170	220	U		7.3	220	200	U		6.8	200
Fluorene	4100000	310000	na	170	U		5.7	170	170	U		5.7	170	170	U		5.6	170	170	U		5.6	170	220	U		7.2	220	200	U		6.7	200
Hexachlorobenzene	1800	400	na	170	U		6.5	170	170	U		6.5	170	170	U		6.4	170	170	U		6.4	170	220	U		8.2	220	200	U		7.7	200
Hexachlorobutadiene	37000	7800	na	170	U		5.8	170	170	U		5.8	170	170	U		5.7	170	170	U		5.7	170	220	U		7.4	220	200	U		6.9	200
Hexachloroethane	102000	7800	na	170	U		4.6	170	170	U		4.6	170	170	U		4.6	170	170	U		4.6	170	220	U		5.9	220	200	U		5.5	200
Indeno(1,2,3-cd)pyrene	3900	220	na	32	J	J	6.7	170	15	J	J	6.7	170	41	J	J	6.6	170	9.4	J	J	6.6	170	220	U		8.5	220	200	U		8	200
Isophorone	3000000	670000	na	170	U		4.3	170	170	U		4.3	170	170	U		4.3	170	170	U		4.3	170	220	U		5.5	220	200	U		5.2	200
Naphthalene	2000000	160000	na	170	U		6.4	170	170	U		6.4	170	53	J	J	6.3	170	170	U		6.3	170	220	U		8.1	220	200	U		7.6	200
Nitrobenzene	51000	3900	na	170	U		8.5	170	170	U		8.6	170	170	U		8.4	170	170	U		8.5	170	220	U		11	220	200	U		10	200
N-nitrosodiphenylamine	580000	130000	na	170	U		8.2	170	170	U		8.3	170	150	J	J	8.1	170	170	U		8.1	170	220	U		11	220	200	U		9.8	200
Phenanthrene	3100000	230000	na	27	J	J	5.4	170	12	J	J	5.4	170	57	J	J	5.3	170	9.3	J	J	5.4	170	220	U		6.9	220	200	U		6.4	200
Pyrene	3100000	230000	na	47	J	J	5.3	170	8.2	J	J	5.3	170	38	J	J	5.2	170	17	J	J	5.2	170	220	U		6.8	220	12	J	J	6.3	200

Table 2-7
Analytes Detected in FLFA Soil - 2002 Investigation
Page 2 of 6

Analyte			Sample ID	LFSS01					LFSS02					LFSS03					LFSB12A					LFSB12B					LFSB12C				
			Sample Date	6/26/02					6/26/02					6/26/02					6/26/02					6/26/02					6/26/02				
			Sample Depth	0-0.5					0-0.5					0-0.5					0-0.5					2-4					4-5.4				
	i-RBC	r-RBC	Background	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
Pesticides (ug/kg)																																	
4,4'-DDD	12000	2700	na	NT					NT					0.863			0.143	0.679	0.423	J	J	0.144	0.68	NT					NT				
4,4'-DDE	8400	1900	na	NT					NT					2.32			0.142	0.679	0.83		B	0.143	0.68	NT					NT				
4,4'-DDT	8400	1900	na	NT					NT					83.2			2.4	6.79	15.4			0.241	0.68	NT					NT				
delta-BHC	na	na	na	NT					NT					0.679	U		0.118	0.679	0.495	BJ	B	0.118	0.68	NT					NT				
Endosulfan II	610000	47000	na	NT					NT					19.9			0.242	0.679	4.2			0.243	0.68	NT					NT				
Endrin aldehyde	na	na	na	NT					NT					33.4			0.343	0.679	6.3			0.344	0.68	NT					NT				
Endrin ketone	na	na	na	NT					NT					6.79	U		5.47	6.79	0.68	U		0.548	0.68	NT					NT				
gamma-Chlordane	8200	1800	na	NT					NT					0.679	U		0.158	0.679	0.68	U		0.158	0.68	NT					NT				
Methoxychlor	510000	39000	na	NT					NT					0.679	U		0.518	0.679	0.68	U		0.519	0.68	NT					NT				
PCBs (mg/kg)																																	
PCB-1248	1.4	0.32	na	0.0343	U		0.0163	0.0343	0.0345	U		0.0164	0.0345	0.0339	U		0.0161	0.0339	0.0339	U		0.0161	0.0339	0.0439	U		0.0208	0.0439	0.0409	U		0.0194	0.0409
PCB-1254	1.4	0.16	na	0.138			0.0101	0.0343	0.0404			0.0102	0.0345	1.58			0.01	0.0339	0.129			0.01	0.0339	0.0439	U		0.013	0.0439	0.0409	U		0.0121	0.0409
Explosives (mg/kg)																																	
2,4-Dinitrotoluene	200	16	na	0.062	J	J	0.0163	0.2	0.2	U		0.0163	0.2	0.12	J	J	0.0163	0.2	0.2	U		0.0163	0.2	0.2	U		0.0163	0.2	0.2	U		0.0163	0.2
Herbicides (ug/kg)	None detected																																
Metals (mg/kg)																																	
Aluminum	100000	7800	40041	24000			5.7	20.6	22300			5.7	20.7	19600			5.6	20.3	17400			5.6	20.4	31600			7.3	26.4	37700			6.8	24.5
Antimony	41	3.1	na	0.47	B	J	0.17	0.515	0.518	U	UL	0.17	0.518	24		J	0.17	0.509	0.43	B	J	0.17	0.51	0.22	B	B	0.22	0.659	0.613	U	UL	0.21	0.613
Arsenic	1.9	0.43	15.8	7.4		J	0.36	0.515	3.02		J	0.36	0.518	**19.4**		**J**	0.36	0.509	3.12		J	0.36	0.51	3.49		J	0.46	0.659	1.39		J	0.43	0.613
Barium	20000	1600	209	62.5			0.34	2.06	58.9			0.35	2.07	**2630**			0.34	2.03	59.3			0.34	2.04	74.4			0.44	2.64	102			0.41	2.45
Beryllium	200	16	1.02	**1.18**			0.0356	0.515	0.4	B	J	0.0357	0.518	1.01			0.0351	0.509	**1.25**			0.0352	0.51	**1.96**			0.0455	0.659	**2.09**			0.0423	0.613
Cadmium	51	3.9	0.69	0.177			0.049	0.103	0.072	B	J	0.049	0.104	**9.81**			0.048	0.102	0.111			0.048	0.102	0.132	U		0.063	0.132	0.123	U		0.058	0.123
Calcium	na	na	na	61600		J	2.9	10.3	4660		J	2.9	10.4	20300		J	2.8	10.2	21600		J	2.8	10.2	11200		J	3.7	13.2	23300		J	3.4	12.3
Chromium	310	23	65.3	59.8		J	0.39	1.03	33.1		J	0.39	1.04	**299**		**J**	0.38	1.02	31.1		J	0.38	1.02	43.2		J	0.49	1.32	41.5		J	0.46	1.23
Cobalt	na	na	72.3	7.83		J	0.83	5.15	3.7	B	J	0.84	5.18	22.5		J	0.82	5.09	19.7		J	0.83	5.1	9.65		J	1.1	6.59	9.2		J	0.99	6.13
Copper	4100	310	53.5	**521**		**J**	0.64	2.06	37.9		J	0.64	2.07	**1670**		**J**	0.63	2.03	**57.5**		**J**	0.63	2.04	29.5		J	0.81	2.64	23.7		J	0.76	2.45
Iron	72000	5500	50962	22800		J	3.5	5.15	25100		J	3.5	5.18	**61400**		**J**	3.4	5.09	22000		J	3.4	5.1	35700		J	4.4	6.59	39800		J	4.1	6.13
Lead	800	400	26.8	**50.9**			0.031	0.309	**89.3**		**J**	3.8	10.4	**3150**		**J**	3.7	10.2	**60.7**			0.031	0.306	12.3			0.04	0.395	14.4			0.037	0.368
Magnesium	na	na	na	41600			2.4	10.3	2280			2.4	10.4	15500			2.4	10.2	20400			2.4	10.2	45500			3.1	13.2	51400			2.9	12.3
Manganese	2000	160	2543	277		J	0.058	1.03	183		J	0.058	1.04	1250		J	0.057	1.02	333		J	0.057	1.02	214		J	0.074	1.32	496		J	0.069	1.23
Mercury	31	2.3	0.13	0.0555			0.0204	0.0515	**0.141**			0.0205	0.0518	**0.875**			0.0201	0.0509	0.038	B	J	0.0202	0.051	0.031	B	J	0.0261	0.0659	0.035	B	J	0.0243	0.0613
Nickel	2000	160	62.8	18.8		J	0.94	4.12	8.44		J	0.95	4.14	**121**		**J**	0.93	4.07	18.2		J	0.93	4.08	30.5		J	1.2	5.27	27.9		J	1.1	4.91
Potassium	na	na	na	4400			34	309	883			35	311	3260			34	305	2310			34	306	8670			44	395	4200			41	368
Silver	510	39	na	1.03	U		0.51	1.03	1.04	U		0.51	1.04	44.4		J	0.5	1.02	1.02	U		0.5	1.02	1.32	U		0.65	1.32	1.23	U		0.6	1.23
Sodium	na	na	na	58.8			3.9	20.6	61.9			3.9	20.7	996			3.8	20.3	39.5			3.8	20.4	75.7			4.9	26.4	129			4.6	24.5
Thallium	7.2	0.55	2.11	0.361			0.031	0.309	0.16	B	J	0.031	0.311	0.15	B	J	0.031	0.305	0.22	B	J	0.031	0.306	0.29	B	J	0.04	0.395	0.25	B	J	0.037	0.368
Vanadium	102	7.8	108	39.3		J	0.6	5.15	48.4		J	0.6	5.18	35		J	0.59	5.09	41.1		J	0.59	5.1	62.1		J	0.76	6.59	66		J	0.71	6.13
Zinc	31000	2300	202	**232**		**J**	0.37	2.06	63.6		J	0.37	2.07	**5080**		**J**	0.36	2.03	115		J	0.37	2.04	56.4		J	0.47	2.64	50.7		J	0.44	2.45
Misc.																																	
Total Organic Carbon (mg/kg)	na	na	na	NT					NT					NT					14500			172	1020	NT					3740			207	1230
pH	na	na	na	NT					NT					NT					7.57		J	+/-0.1	+/-0.1	NT					7.56		J	+/-0.1	+/-0.1

**Refer to legend immediately following this table for a list of definitions and table notes

Table 2-7
Analytes Detected in FLFA Soil - 2002 Investigation
Page 3 of 6

Analyte			Sample ID Sample Date Sample Depth	LFSB13A 6/26/02 8.3-9					LFSB14A 6/26/02 5.5-7					LFSB14B 6/26/02 7-8.8					LFSB15A 6/26/02 0-0.5					LFSB15B 6/26/02 2-4					LFSB15C 6/26/02 4-6				
	i-RBC	r-RBC	Background	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)																																	
Toluene	8200000	630000	na	6.5	U		0.42	6.5	5.3	U		0.34	5.3	6.5	U		0.42	6.5	12	U		0.78	12	5.7	U		0.37	5.7	6.4	U		0.41	6.4
PAHs (ug/kg)																																	
2-Methylnaphthalene	410000	31000	na	2.4		B	0.83	2.4	1	J	B	0.67	2	2.2	U		0.74	2.2	8.9			0.69	2	2.1	U		0.72	2.1	1.8	J	B	0.73	2.2
Acenaphthene	6100000	470000	na	1.7	J	B	1.4	2.4	2	U		1.1	2	2.2	U		1.2	2.2	2		B	1.1	2	2.1	U		1.2	2.1	1.3	J	B	1.2	2.2
Acenaphthylene	3100000	230000	na	1.5	J	J	0.32	2.4	2	U		0.26	2	2.2	U		0.29	2.2	1.2	J	J	0.27	2	2.1	U		0.28	2.1	0.98	J	J	0.29	2.2
Anthracene	31000000	2300000	na	2.4	U		0.27	2.4	2	U		0.22	2	2.2	U		0.24	2.2	3.4			0.22	2	2.1	U		0.23	2.1	0.93	J	J	0.24	2.2
Benz(a)anthracene	3900	220	na	2.4	U		0.32	2.4	2	U		0.26	2	2.2	U		0.29	2.2	14			0.27	2	2.1	U		0.28	2.1	2.2	U		0.29	2.2
Benzo(a)pyrene	390	22	na	2.4	U		0.27	2.4	2	U		0.22	2	2.2	U		0.25	2.2	15			0.23	2	2.1	U		0.24	2.1	2.2	U		0.24	2.2
Benzo(b)fluoranthene	3900	220	na	2.4	U		0.47	2.4	2	U		0.38	2	2.2	U		0.42	2.2	27			0.39	2	2.1	U		0.41	2.1	2.2	U		0.41	2.2
Benzo(g,h,i)perylene	3100000	230000	na	2.4	U	UL	0.86	2.4	2	U	UL	0.7	2	2.2	U	UL	0.78	2.2	7.7		L	0.72	2	2.1	U	UL	0.75	2.1	2.2	U	UL	0.76	2.2
Benzo(k)fluoranthene	39000	2200	na	2.4	U		0.43	2.4	2	U		0.35	2	2.2	U		0.38	2.2	9.1			0.35	2	2.1	U		0.37	2.1	2.2	U		0.38	2.2
Chrysene	390000	22000	na	2.4	U		0.39	2.4	2	U		0.32	2	2.2	U		0.35	2.2	17			0.32	2	2.1	U		0.34	2.1	2.2	U		0.35	2.2
Dibenz(a,h)anthracene	390	22	na	2.4	U		0.83	2.4	2	U		0.68	2	2.2	U		0.75	2.2	2.7		J	0.69	2	2.1	U		0.73	2.1	2.2	U		0.74	2.2
Fluoranthene	4100000	310000	na	2.4	U		0.42	2.4	2	U		0.34	2	2.2	U		0.38	2.2	25			0.35	2	2.1	U		0.37	2.1	2.2	U		0.37	2.2
Fluorene	4100000	310000	na	1.2	J	J	0.65	2.4	0.86	J	J	0.53	2	2.2	U		0.58	2.2	2.6			0.54	2	2.1	U		0.57	2.1	1.3	J	J	0.57	2.2
Indeno(1,2,3-cd)pyrene	3900	220	na	2.4	U		0.78	2.4	2	U		0.64	2	2.2	U		0.71	2.2	9.5			0.65	2	2.1	U		0.69	2.1	2.2	U		0.69	2.2
Naphthalene	2000000	160000	na	1.5	J	B	0.95	2.4	0.9	J	B	0.77	2	2.2	U		0.85	2.2	7.4			0.79	2	2.1	U		0.83	2.1	1.2	J	B	0.84	2.2
Phenanthrene	3100000	230000	na	2.4	U		0.37	2.4	2	U		0.3	2	2.2	U		0.34	2.2	23			0.31	2	2.1	U		0.33	2.1	1.1	J	J	0.33	2.2
Pyrene	3100000	230000	na	2.4	U		0.55	2.4	2	U		0.45	2	2.2	U		0.5	2.2	23			0.46	2	2.1	U		0.48	2.1	2.2	U		0.49	2.2
SVOCs (ug/kg)																																	
1,2,4-Trichlorobenzene	1000000	78000	na	240	U		10	240	200	U		8.1	200	220	U		9	220	200	U		8.3	200	210	U		8.8	210	210	U		8.8	210
1,2-Dichlorobenzene	9200000	700000	na	240	U		6.9	240	200	U		5.6	200	220	U		6.2	220	200	U		5.7	200	210	U		6	210	210	U		6.1	210
1,3-Dichlorobenzene	310000	23000	na	240	U		7.5	240	200	U		6.1	200	220	U		6.8	220	200	U		6.3	200	210	U		6.6	210	210	U		6.7	210
1,4-Dichlorobenzene	120000	27000	na	240	U		8.3	240	200	U		6.7	200	220	U		7.5	220	200	U		6.9	200	210	U		7.3	210	210	U		7.3	210
2,4,5-Trichlorophenol	10000000	780000	na	240	U		8.8	240	200	U		7.2	200	220	U		7.9	220	200	U		7.3	200	210	U		7.7	210	210	U		7.8	210
2,4,6-Trichlorophenol	102000	7800	na	240	U		6.9	240	200	U		5.6	200	220	U		6.2	220	200	U		5.7	200	210	U		6.1	210	210	U		6.1	210
2,4-Dichlorophenol	310000	23000	na	240	U		5.7	240	200	U		4.6	200	220	U		5.1	220	200	U		4.8	200	210	U		5	210	210	U		5.1	210
2,4-Dinitrotoluene	200000	16000	na	240	U		8.2	240	200	U		6.7	200	220	U		7.4	220	16	J	J	6.8	200	210	U		7.2	210	210	U		7.2	210
2-Chloronaphthalene	8200000	630000	na	240	U		6.2	240	200	U		5	200	220	U		5.6	220	200	U		5.1	200	210	U		5.4	210	210	U		5.5	210
2-Chlorophenol	510000	39000	na	240	U		5.8	240	200	U		4.7	200	220	U		5.2	220	200	U		4.8	200	210	U		5.1	210	210	U		5.1	210
2-Methylnaphthalene	410000	31000	na	240	U		9.3	240	200	U		7.5	200	220	U		8.4	220	14	J	J	7.7	200	210	U		8.1	210	210	U		8.2	210
2-Methylphenol	5100000	390000	na	240	U	UL	9.8	240	200	U	UL	8	200	220	U	UL	8.8	220	200	U	UL	8.2	200	210	U	UL	8.6	210	210	U	UL	8.7	210
2-Nitrophenol	na	na	na	240	U		8	240	200	U		6.5	200	220	U		7.2	220	200	U		6.7	200	210	U		7	210	210	U		7.1	210
4-Chloro-3-methylphenol	na	na	na	240	U		12	240	200	U		9.4	200	220	U		10	220	200	U		9.6	200	210	U		10	210	210	U		10	210
4-Chlorophenyl phenyl ether	na	na	na	240	U		7.6	240	200	U		6.2	200	220	U		6.8	220	200	U		6.3	200	210	U		6.7	210	210	U		6.7	210
4-Methylphenol	510000	39000	na	240	U	UL	8.6	240	200	U	UL	7	200	220	U	UL	7.7	220	200	U	UL	7.1	200	210	U	UL	7.5	210	210	U	UL	7.6	210
Acenaphthene	6100000	470000	na	240	U		6.7	240	200	U		5.5	200	220	U		6.1	220	200	U		5.6	200	210	U		5.9	210	210	U		5.9	210
Acenaphthylene	3100000	230000	na	240	U		6.5	240	200	U		5.3	200	220	U		5.9	220	200	U		5.4	200	210	U		5.7	210	210	U		5.8	210
Benz(a)anthracene	3900	220	na	240	U		7	240	200	U		5.7	200	220	U		6.3	220	20	J	J	5.8	200	210	U		6.1	210	210	U		6.2	210
Benzo(a)pyrene	390	22	na	240	U		6	240	200	U		4.9	200	220	U		5.4	220	18	J	J	5	200	210	U		5.2	210	210	U		5.3	210
Benzo(b)fluoranthene	3900	220	na	240	U		5.2	240	200	U		4.2	200	220	U		4.6	220	30	J	J	4.3	200	210	U		4.5	210	210	U		4.6	210
Benzo(g,h,i)perylene	3100000	230000	na	240	U		6.8	240	200	U		5.6	200	220	U		6.1	220	13	J	J	5.7	200	210	U		6	210	210	U		6	210
Benzo(k)fluoranthene	39000	2200	na	240	U		6.9	240	200	U		5.6	200	220	U		6.2	220	8.7	J	J	5.7	200	210	U		6	210	210	U		6.1	210
bis(2-Chloroethoxy)methane	na	na	na	240	U		7.4	240	200	U		6	200	220	U		6.7	220	200	U		6.2	200	210	U		6.5	210	210	U		6.6	210
bis(2-Chloroethyl)ether	2600	580	na	240	U		5.5	240	200	U		4.4	200	220	U		4.9	220	200	U		4.5	200	210	U		4.8	210	210	U		4.8	210
bis(2-Ethylhexyl)phthalate	200000	46000	na	17	J	B	16	240	13	J	B	13	200	35	J	B	15	220	68	J	B	14	200	23	J	B	14	210	210	U		14	210
bis(Chloroisopropyl)ether	41000	9100	na	240	U		5.4	240	200	U		4.4	200	220	U		4.9	220	200	U		4.5	200	210	U		4.8	210	210	U		4.8	210
Butylbenzylphthalate	20000000	1600000	na	240	U		9.5	240	200	U		7.7	200	14	J	B	8.5	220	200	U		7.9	200	210	U		8.3	210	210	U		8.4	210
Chrysene	390000	22000	na	240	U		5.6	240	200	U		4.6	200	220	U		5	220	23	J	J	4.7	200	210	U		4.9	210	210	U		5	210
Dibenzofuran	100000	7800	na	240	U		6.9	240	200	U		5.6	200	220	U		6.2	220	200	U		5.8	200	210	U		6.1	210	210	U		6.1	210
Diethylphthalate	82000000	6300000	na	240	U		7	240	200	U		5.7	200	220	U		6.3	220	9.1	J	B	5.8	200	210	U		6.2	210	210	U		6.2	210
Di-n-butylphthalate	10000000	780000	na	240	U		70	240	200	U		57	200	220	U		63	220	200	U		58	200	210	U		61	210	210	U		62	210
Di-n-octylphthalate	na	na	na	240	U		11	240	200	U		8.8	200	220	U		9.8	220	200	U		9	200	210	U		9.5	210	210	U		9.6	210
Fluoranthene	4100000	310000	na	240	U		8	240	200	U		6.5	200	220	U		7.2	220	30	J	J	6.6	200	210	U		7	210	210	U		7	210
Fluorene	4100000	310000	na	240	U		7.9	240	200	U		6.4	200	220	U		7.1	220	200	U		6.6	200	210	U		6.9	210	210	U		7	210
Hexachlorobenzene	1800	400	na	240	U		9	240	200	U		7.3	200	220	U		8.1	220	20	J	J	7.5	200	210	U		7.9	210	210	U		8	210
Hexachlorobutadiene	37000	7800	na	240	U		8.1	240	200	U		6.6	200	220	U		7.3	220	200	U		6.7	200	210	U		7.1	210	210	U		7.2	210
Hexachloroethane	102000	7800	na	240	U		6.5	240	200	U		5.2	200	220	U		5.8	220	200	U		5.4	200	210	U		5.6	210	210	U		5.7	210
Indeno(1,2,3-cd)pyrene	3900	220	na	240	U		9.3	240	200	U		7.6	200	220	U		8.4	220	11	J	J	7.8	200	210	U		8.2	210	210	U		8.3	210
Isophorone	3000000	670000	na	240	U		6.1	240	200	U		4.9	200	220	U		5.4	220	200	U		5	200	210	U		5.3	210	210	U		5.4	210
Naphthalene	2000000	160000	na	240	U		8.9	240	200	U		7.2	200	220	U		8	220	14	J	J	7.4	200	210	U		7.8	210	210	U		7.8	210
Nitrobenzene	51000	3900	na	240	U		12	240	200	U		9.7	200	220	U		11	220	200	U		9.9	200	210	U		10	210	210	U		11	210
N-nitrosodiphenylamine	580000	130000	na	240	U		12	240	200	U		9.4	200	220	U		10	220	200	U		9.6	200	210	U		10	210	210	U		10	210
Phenanthrene	3100000	230000	na	240	U		7.6	240	200	U		6.1	200	220	U		6.8	220	28	J	J	6.3	200	210	U		6.6	210	210	U		6.7	210
Pyrene	3100000	230000	na	240	U		7.4	240	200	U		6	200	220	U		6.7	220	23	J	J	6.2	200	210	U		6.5	210	210	U		6.6	210

Table 2-7
Analytes Detected in FLFA Soil - 2002 Investigation
Page 4 of 6

Analyte			Sample ID Sample Date Sample Depth	LFSB13A 6/26/02 8.3-9					LFSB14A 6/26/02 5.5-7					LFSB14B 6/26/02 7-8.8					LFSB15A 6/26/02 0-0.5					LFSB15B 6/26/02 2-4					LFSB15C 6/26/02 4-6				
	i-RBC	r-RBC	Background	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
Pesticides (ug/kg)																																	
4,4'-DDD	12000	2700	na	NT					NT					NT					5.93			0.169	0.799	NT					NT				
4,4'-DDE	8400	1900	na	NT					NT					NT					49.3			1.68	7.99	NT					NT				
4,4'-DDT	8400	1900	na	NT					NT					NT					45.6			2.83	7.99	NT					NT				
delta-BHC	na	na	na	NT					NT					NT					0.799	U		0.139	0.799	NT					NT				
Endosulfan II	610000	47000	na	NT					NT					NT					1.23			0.285	0.799	NT					NT				
Endrin aldehyde	na	na	na	NT					NT					NT					1.87			0.404	0.799	NT					NT				
Endrin ketone	na	na	na	NT					NT					NT					4.46			0.644	0.799	NT					NT				
gamma-Chlordane	8200	1800	na	NT					NT					NT					2.81			0.186	0.799	NT					NT				
Methoxychlor	510000	39000	na	NT					NT					NT					0.728	J	J	0.61	0.799	NT					NT				
PCBs (mg/kg)																																	
PCB-1248	1.4	0.32	na	0.048	U		0.0228	0.048	1.42			0.0185	0.039	0.0432	U		0.0205	0.0432	0.0399	U		0.0189	0.0399	0.042	U		0.0199	0.042	0.0424	U		0.0201	0.0424
PCB-1254	1.4	0.16	na	0.048	U		0.0142	0.048	0.039	U		0.0115	0.039	0.0432	U		0.0127	0.0432	0.335			0.0118	0.0399	0.042	U		0.0124	0.042	0.0424	U		0.0125	0.0424
Explosives (mg/kg)																																	
2,4-Dinitrotoluene	200	16	na	0.2	U		0.0163	0.2	0.2	U		0.0163	0.2	0.2	U		0.0163	0.2	0.4	U		0.0326	0.4	0.2	U		0.0163	0.2	0.2	U		0.0163	0.2
Herbicides (ug/kg)	None detected																																
Metals (mg/kg)																																	
Aluminum	100000	7800	40041	20300			8	28.8	22500			6.5	23.4	38300			7.2	25.9	**47800**			6.6	24	18500			7	25.2	29300			7	25.5
Antimony	41	3.1	na	0.27	B	B	0.24	0.72	0.585	U	UL	0.2	0.585	0.649	U	UL	0.22	0.649	47.6		J	0.2	0.599	0.631	U	UL	0.21	0.631	0.29	B	B	0.21	0.637
Arsenic	1.9	0.43	15.8	2.82		J	0.5	0.72	2.79		J	0.41	0.585	1.52		J	0.45	0.649	**26.2**		**J**	0.42	0.599	2.09		J	0.44	0.631	1.59		J	0.45	0.637
Barium	20000	1600	209	59			0.48	2.88	51.6			0.39	2.34	72.7			0.43	2.59	**2300**			0.4	2.4	46			0.42	2.52	71			0.43	2.55
Beryllium	200	16	1.02	**2.02**			0.0497	0.72	**1.49**			0.0404	0.585	**2.36**			0.0447	0.649	0.726			0.0413	0.599	**1.34**			0.0435	0.631	**1.84**			0.0439	0.637
Cadmium	51	3.9	0.69	0.08	B	B	0.068	0.144	0.117	U		0.056	0.117	0.13	U		0.062	0.13	**19.8**			0.057	0.12	0.126	U		0.06	0.126	0.127	U		0.061	0.127
Calcium	na	na	na	7460		J	4	14.4	8220		J	3.3	11.7	11800		J	3.6	13	18000		J	3.3	12	488		J	3.5	12.6	1910		J	3.6	12.7
Chromium	310	23	65.3	26.6		J	0.54	1.44	35.1		J	0.44	1.17	44.1		J	0.49	1.3	**281**		**J**	0.45	1.2	30.9		J	0.47	1.26	45.9		J	0.48	1.27
Cobalt	na	na	72.3	7.65		J	1.2	7.2	12.5		J	0.95	5.85	8.63		J	1.1	6.49	47		J	0.97	5.99	9.81		J	1	6.31	10.8		J	1	6.37
Copper	4100	310	53.5	26.4		J	0.89	2.88	21.1		J	0.72	2.34	32.6		J	0.8	2.59	**2890**		**J**	0.74	2.4	18.9		J	0.78	2.52	36.7		J	0.79	2.55
Iron	72000	5500	50962	33100		J	4.8	7.2	29200		J	3.9	5.85	42500		J	4.4	6.49	**99900**		**J**	4	5.99	24600		J	4.2	6.31	30700		J	4.3	6.37
Lead	800	400	26.8	14.6			0.044	0.432	25.1			0.035	0.351	11.9			0.039	0.389	**1650**		**J**	4.4	12	13.2			0.038	0.378	26.6			0.039	0.382
Magnesium	na	na	na	7940			3.4	14.4	15200			2.8	11.7	33700			3.1	13	7510			2.8	12	12300			3	12.6	40900			3	12.7
Manganese	2000	160	2543	373		J	0.081	1.44	263		J	0.066	1.17	298		J	0.073	1.3	2230		J	0.067	1.2	285		J	0.071	1.26	358		J	0.071	1.27
Mercury	31	2.3	0.13	0.121			0.0285	0.072	0.036	B	J	0.0232	0.0585	**0.135**			0.0257	0.0649	**2.11**			0.0237	0.0599	0.039	B	J	0.025	0.0631	0.05	B	J	0.0252	0.0637
Nickel	2000	160	62.8	28.9		J	1.3	5.76	26.1		J	1.1	4.68	36.4		J	1.2	5.19	**404**		**J**	1.1	4.79	23.3		J	1.2	5.04	36.4		J	1.2	5.1
Potassium	na	na	na	2020			48	432	1770			39	351	4540			43	389	2870			40	359	2810			42	378	7210			43	382
Silver	510	39	na	1.44	U		0.71	1.44	1.17	U		0.58	1.17	1.3	U		0.64	1.3	18.9		J	0.59	1.2	1.26	U		0.62	1.26	0.95	B	J	0.63	1.27
Sodium	na	na	na	24	B	B	5.4	28.8	39.7			4.4	23.4	77.4			4.8	25.9	2460			4.5	24	27		B	4.7	25.2	131			4.8	25.5
Thallium	7.2	0.55	2.11	0.27	B	J	0.043	0.432	0.21	B	J	0.035	0.351	0.26	B	J	0.039	0.389	0.099	B	J	0.036	0.359	0.22	B	J	0.038	0.378	0.23	B	J	0.038	0.382
Vanadium	102	7.8	108	47.8		J	0.83	7.2	47.5		J	0.68	5.85	69.5		J	0.75	6.49	31		J	0.69	5.99	43.7		J	0.73	6.31	52.9		J	0.74	6.37
Zinc	31000	2300	202	75.1		J	0.52	2.88	40		J	0.42	2.34	55		J	0.46	2.59	**5600**		**J**	0.43	2.4	39.7		J	0.45	2.52	80.7		J	0.46	2.55
Misc.																																	
Total Organic Carbon (mg/kg)	na	na	na	NT					NT					NT					NT					NT					NT				
pH	na	na	na	NT					NT					NT					NT					NT					NT				

**Refer to legend immediately following this table for a list of definitions and table notes

Table 2-7
Analytes Detected in FLFA Soil - 2002 Investigation
Page 5 of 6

Analyte			Sample ID Sample Date Sample Depth	LFSB16A 6/26/02 0-0.5					LFSB16B 6/26/02 1-3					LFSB16C 6/26/02 3-5					LFSB17A 6/26/02 0-0.5					LFSB17B 6/26/02 1-3				
	i-RBC	r-RBC	Background	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)																												
Toluene	8200000	630000	na	NT					NT					NT					NT					NT				
PAHs (ug/kg)																												
2-Methylnaphthalene	410000	31000	na	NT					NT					NT					NT					NT				
Acenaphthene	6100000	470000	na	NT					NT					NT					NT					NT				
Acenaphthylene	3100000	230000	na	NT					NT					NT					NT					NT				
Anthracene	31000000	2300000	na	NT					NT					NT					NT					NT				
Benz(a)anthracene	3900	220	na	NT					NT					NT					NT					NT				
Benzo(a)pyrene	390	22	na	NT					NT					NT					NT					NT				
Benzo(b)fluoranthene	3900	220	na	NT					NT					NT					NT					NT				
Benzo(g,h,i)perylene	3100000	230000	na	NT					NT					NT					NT					NT				
Benzo(k)fluoranthene	39000	2200	na	NT					NT					NT					NT					NT				
Chrysene	390000	22000	na	NT					NT					NT					NT					NT				
Dibenz(a,h)anthracene	390	22	na	NT					NT					NT					NT					NT				
Fluoranthene	4100000	310000	na	NT					NT					NT					NT					NT				
Fluorene	4100000	310000	na	NT					NT					NT					NT					NT				
Indeno(1,2,3-cd)pyrene	3900	220	na	NT					NT					NT					NT					NT				
Naphthalene	2000000	160000	na	NT					NT					NT					NT					NT				
Phenanthrene	3100000	230000	na	NT					NT					NT					NT					NT				
Pyrene	3100000	230000	na	NT					NT					NT					NT					NT				
SVOCs (ug/kg)																												
1,2,4-Trichlorobenzene	1000000	78000	na	200	U		*8.4*	*200*	31	J	J	*8.8*	*210*	220	U		*9.2*	*220*	12	J	J	*7.6*	*180*	200	U		*8.4*	*200*
1,2-Dichlorobenzene	9200000	700000	na	200	U		*5.8*	*200*	30	J	J	*6.1*	*210*	220	U		*6.3*	*220*	180	U		*5.2*	*180*	200	U		*5.8*	*200*
1,3-Dichlorobenzene	310000	23000	na	200	U		*6.4*	*200*	32	J	J	*6.6*	*210*	220	U		*6.9*	*220*	12	J	J	*5.7*	*180*	200	U		*6.3*	*200*
1,4-Dichlorobenzene	120000	27000	na	200	U		*7*	*200*	34	J	J	*7.3*	*210*	220	U		*7.6*	*220*	13	J	J	*6.3*	*180*	200	U		*7*	*200*
2,4,5-Trichlorophenol	10000000	780000	na	200	U		*7.4*	*200*	12	J	J	*7.7*	*210*	220	U		*8.1*	*220*	180	U		*6.7*	*180*	200	U		*7.4*	*200*
2,4,6-Trichlorophenol	102000	7800	na	200	U		*5.8*	*200*	18	J	J	*6.1*	*210*	220	U		*6.4*	*220*	180	U		*5.2*	*180*	200	U		*5.8*	*200*
2,4-Dichlorophenol	310000	23000	na	200	U		*4.8*	*200*	22	J	J	*5*	*210*	220	U		*5.3*	*220*	180	U		*4.3*	*180*	200	U		*4.8*	*200*
2,4-Dinitrotoluene	200000	16000	na	200	U		*6.9*	*200*	210	U		*7.2*	*210*	220	U		*7.5*	*220*	180	U		*6.2*	*180*	200	U		*6.9*	*200*
2-Chloronaphthalene	8200000	630000	na	200	U		*5.2*	*200*	20	J	J	*5.4*	*210*	220	U		*5.7*	*220*	8	J	J	*4.7*	*180*	200	U		*5.2*	*200*
2-Chlorophenol	510000	39000	na	200	U		*4.9*	*200*	25	J	J	*5.1*	*210*	220	U		*5.3*	*220*	8.2	J	J	*4.4*	*180*	200	U		*4.9*	*200*
2-Methylnaphthalene	410000	31000	na	200	U		*7.8*	*200*	23	J	J	*8.2*	*210*	220	U		*8.5*	*220*	12	J	J	*7*	*180*	200	U		*7.8*	*200*
2-Methylphenol	5100000	390000	na	200	U	UL	*8.3*	*200*	21	J	B	*8.6*	*210*	220	U	UL	*9*	*220*	180	U	UL	*7.4*	*180*	200	U	UL	*8.2*	*200*
2-Nitrophenol	na	na	na	200	U		*6.8*	*200*	26	J	J	*7*	*210*	220	U		*7.4*	*220*	11	J	J	*6.1*	*180*	200	U		*6.7*	*200*
4-Chloro-3-methylphenol	na	na	na	200	U		*9.8*	*200*	14	J	J	*10*	*210*	220	U		*11*	*220*	180	U		*8.8*	*180*	200	U		*9.7*	*200*
4-Chlorophenyl phenyl ether	na	na	na	200	U		*6.4*	*200*	12	J	J	*6.7*	*210*	220	U		*7*	*220*	180	U		*5.8*	*180*	200	U		*6.4*	*200*
4-Methylphenol	510000	39000	na	200	U	UL	*7.2*	*200*	19	J	B	*7.5*	*210*	220	U	UL	*7.9*	*220*	180	U	UL	*6.5*	*180*	200	U	UL	*7.2*	*200*
Acenaphthene	6100000	470000	na	200	U		*5.7*	*200*	13	J	J	*5.9*	*210*	220	U		*6.2*	*220*	180	U		*5.1*	*180*	200	U		*5.7*	*200*
Acenaphthylene	3100000	230000	na	200	U		*5.5*	*200*	13	J	J	*5.7*	*210*	220	U		*6*	*220*	180	U		*4.9*	*180*	200	U		*5.5*	*200*
Benz(a)anthracene	3900	220	na	7.9	J	J	*5.9*	*200*	210	U		*6.1*	*210*	220	U		*6.4*	*220*	17	J	J	*5.3*	*180*	10	J	J	*5.9*	*200*
Benzo(a)pyrene	390	22	na	200	U		*5.1*	*200*	210	U		*5.3*	*210*	220	U		*5.5*	*220*	22	J	J	*4.5*	*180*	200	U		*5*	*200*
Benzo(b)fluoranthene	3900	220	na	200	U		*4.3*	*200*	210	U		*4.5*	*210*	220	U		*4.7*	*220*	25	J	J	*3.9*	*180*	200	U		*4.3*	*200*
Benzo(g,h,i)perylene	3100000	230000	na	200	U		*5.8*	*200*	210	U		*6*	*210*	220	U		*6.3*	*220*	16	J	J	*5.2*	*180*	200	U		*5.7*	*200*
Benzo(k)fluoranthene	39000	2200	na	200	U		*5.8*	*200*	210	U		*6.1*	*210*	220	U		*6.3*	*220*	7.1	J	J	*5.2*	*180*	200	U		*5.8*	*200*
bis(2-Chloroethoxy)methane	na	na	na	200	U		*6.3*	*200*	13	J	J	*6.5*	*210*	220	U		*6.8*	*220*	180	U		*5.6*	*180*	200	U		*6.2*	*200*
bis(2-Chloroethyl)ether	2600	580	na	200	U		*4.6*	*200*	19	J	J	*4.8*	*210*	220	U		*5*	*220*	180	U		*4.1*	*180*	200	U		*4.6*	*200*
bis(2-Ethylhexyl)phthalate	200000	46000	na	15	J	B	*14*	*200*	210	U		*14*	*210*	220	U		*15*	*220*	36	J	B	*12*	*180*	34	J	B	*14*	*200*
bis(Chloroisopropyl)ether	41000	9100	na	200	U		*4.6*	*200*	21	J	J	*4.8*	*210*	220	U		*5*	*220*	8.8	J	J	*4.1*	*180*	200	U		*4.6*	*200*
Butylbenzylphthalate	20000000	1600000	na	200	U		*8*	*200*	210	U		*8.3*	*210*	220	U		*8.7*	*220*	180	U		*7.2*	*180*	17	J	B	*8*	*200*
Chrysene	390000	22000	na	200	U		*4.7*	*200*	210	U		*4.9*	*210*	220	U		*5.2*	*220*	21	J	J	*4.2*	*180*	200	U		*4.7*	*200*
Dibenzofuran	100000	7800	na	200	U		*5.8*	*200*	14	J	J	*6.1*	*210*	220	U		*6.4*	*220*	180	U		*5.2*	*180*	200	U		*5.8*	*200*
Diethylphthalate	82000000	6300000	na	200	U		*5.9*	*200*	210	U		*6.2*	*210*	220	U		*6.5*	*220*	180	U		*5.3*	*180*	200	U		*5.9*	*200*
Di-n-butylphthalate	10000000	780000	na	200	U		*59*	*200*	210	U		*62*	*210*	220	U		*65*	*220*	180	U		*53*	*180*	200	U		*59*	*200*
Di-n-octylphthalate	na	na	na	200	U		*9.1*	*200*	210	U		*9.5*	*210*	220	U		*10*	*220*	20	J	J	*8.2*	*180*	200	U		*9.1*	*200*
Fluoranthene	4100000	310000	na	200	U		*6.7*	*200*	210	U		*7*	*210*	220	U		*7.3*	*220*	21	J	J	*6*	*180*	200	U		*6.7*	*200*
Fluorene	4100000	310000	na	200	U		*6.7*	*200*	9	J	J	*7*	*210*	220	U		*7.3*	*220*	180	U		*6*	*180*	200	U		*6.7*	*200*
Hexachlorobenzene	1800	400	na	200	U		*7.6*	*200*	210	U		*7.9*	*210*	220	U		*8.3*	*220*	180	U		*6.8*	*180*	200	U		*7.6*	*200*
Hexachlorobutadiene	37000	7800	na	200	U		*6.8*	*200*	30	J	J	*7.1*	*210*	220	U		*7.5*	*220*	10	J	J	*6.1*	*180*	200	U		*6.8*	*200*
Hexachloroethane	102000	7800	na	200	U		*5.4*	*200*	13	J	J	*5.7*	*210*	220	U		*5.9*	*220*	180	U		*4.9*	*180*	200	U		*5.4*	*200*
Indeno(1,2,3-cd)pyrene	3900	220	na	200	U		*7.9*	*200*	210	U		*8.2*	*210*	220	U		*8.6*	*220*	15	J	J	*7.1*	*180*	200	U		*7.8*	*200*
Isophorone	3000000	670000	na	200	U		*5.1*	*200*	10	J	J	*5.3*	*210*	220	U		*5.6*	*220*	7.4	J	J	*4.6*	*180*	200	U		*5.1*	*200*
Naphthalene	2000000	160000	na	200	U		*7.5*	*200*	24	J	J	*7.8*	*210*	220	U		*8.2*	*220*	12	J	J	*6.7*	*180*	200	U		*7.5*	*200*
Nitrobenzene	51000	3900	na	200	U		*10*	*200*	35	J	J	*10*	*210*	220	U		*11*	*220*	180	U		*9*	*180*	200	U		*10*	*200*
N-nitrosodiphenylamine	580000	130000	na	200	U		*9.7*	*200*	210	U		*10*	*210*	220	U		*11*	*220*	180	U		*8.7*	*180*	200	U		*9.7*	*200*
Phenanthrene	3100000	230000	na	200	U		*6.4*	*200*	210	U		*6.6*	*210*	220	U		*7*	*220*	14	J	J	*5.7*	*180*	200	U		*6.4*	*200*
Pyrene	3100000	230000	na	200	U		*6.3*	*200*	210	U		*6.5*	*210*	220	U		*6.8*	*220*	32	J	J	*5.6*	*180*	200	U		*6.2*	*200*

Table 2-7
Analytes Detected in FLFA Soil - 2002 Investigation
Page 6 of 6

Analyte			Sample ID	LFSB16A					LFSB16B					LFSB16C					LFSB17A					LFSB17B				
			Sample Date	6/26/02					6/26/02					6/26/02					6/26/02					6/26/02				
			Sample Depth	0-0.5					1-3					3-5					0-0.5					1-3				
	i-RBC	r-RBC	Background	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
Pesticides (ug/kg)																												
4,4'-DDD	12000	2700	na	NT					NT					NT					NT					NT				
4,4'-DDE	8400	1900	na	NT					NT					NT					NT					NT				
4,4'-DDT	8400	1900	na	NT					NT					NT					NT					NT				
delta-BHC	na	na	na	NT					NT					NT					NT					NT				
Endosulfan II	610000	47000	na	NT					NT					NT					NT					NT				
Endrin aldehyde	na	na	na	NT					NT					NT					NT					NT				
Endrin ketone	na	na	na	NT					NT					NT					NT					NT				
gamma-Chlordane	8200	1800	na	NT					NT					NT					NT					NT				
Methoxychlor	510000	39000	na	NT					NT					NT					NT					NT				
PCBs (mg/kg)																												
PCB-1248	1.4	0.32	na	NT					NT					NT					NT					NT				
PCB-1254	1.4	0.16	na	NT					NT					NT					NT					NT				
Explosives (mg/kg)																												
2,4-Dinitrotoluene	200	16	na	NT					NT					NT					NT					NT				
Herbicides (ug/kg)	None detected																											
Metals (mg/kg)																												
Aluminum	100000	7800	40041	26600			*6.7*	*24.3*	25800			*7*	*25.3*	**47900**			*7.3*	*26.5*	13800			*6*	*21.8*	20900			*6.7*	*24.2*
Antimony	41	3.1	na	0.38	B	B	*0.2*	*0.608*	0.633	U	UL	*0.21*	*0.633*	0.662	U	UL	*0.22*	*0.662*	1.73		J	*0.18*	*0.545*	0.605	U	UL	*0.2*	*0.605*
Arsenic	1.9	0.43	15.8	1.96		J	*0.42*	*0.608*	5.45		J	*0.44*	*0.633*	4.27		J	*0.46*	*0.662*	2.22		J	*0.38*	*0.545*	1.79		J	*0.42*	*0.605*
Barium	20000	1600	209	73.8			*0.41*	*2.43*	69.3			*0.42*	*2.53*	104			*0.44*	*2.65*	52.5			*0.36*	*2.18*	25.3			*0.4*	*2.42*
Beryllium	200	16	1.02	0.946			*0.0419*	*0.608*	**1.72**			*0.0437*	*0.633*	**3**			*0.0457*	*0.662*	0.588			*0.0376*	*0.545*	**1.06**			*0.0418*	*0.605*
Cadmium	51	3.9	0.69	0.122	U		*0.058*	*0.122*	0.127	U		*0.06*	*0.127*	0.132	U		*0.063*	*0.132*	0.11	B	J	*0.052*	*0.109*	0.121	U		*0.058*	*0.121*
Calcium	na	na	na	2050		J	*3.4*	*12.2*	1280		J	*3.5*	*12.7*	1830		J	*3.7*	*13.2*	12100		J	*3*	*10.9*	55700		J	*3.4*	*12.1*
Chromium	310	23	65.3	28.4		J	*0.45*	*1.22*	32.5		J	*0.47*	*1.27*	58.5		J	*0.5*	*1.32*	24.3		J	*0.41*	*1.09*	35.5		J	*0.45*	*1.21*
Cobalt	na	na	72.3	20.5		J	*0.98*	*6.08*	12.5		J	*1*	*6.33*	9.26		J	*1.1*	*6.62*	6.88		J	*0.88*	*5.45*	9.24		J	*0.98*	*6.05*
Copper	4100	310	53.5	23.6		J	*0.75*	*2.43*	23.6		J	*0.78*	*2.53*	35.2		J	*0.82*	*2.65*	39.3		J	*0.67*	*2.18*	10.8		J	*0.75*	*2.42*
Iron	72000	5500	50962	36200		J	*4.1*	*6.08*	30800		J	*4.3*	*6.33*	49100		J	*4.5*	*6.62*	15900		J	*3.7*	*5.45*	19600		J	*4.1*	*6.05*
Lead	800	400	26.8	23.8			*0.037*	*0.365*	22.1			*0.038*	*0.38*	16.5			*0.04*	*0.397*	**1670**		**J**	*4*	*10.9*	18.3			*0.037*	*0.363*
Magnesium	na	na	na	5030			*2.9*	*12.2*	11000			*3*	*12.7*	20300			*3.1*	*13.2*	13200			*2.6*	*10.9*	60400			*2.9*	*12.1*
Manganese	2000	160	2543	574		J	*0.068*	*1.22*	418		J	*0.071*	*1.27*	270		J	*0.074*	*1.32*	230		J	*0.061*	*1.09*	137		J	*0.068*	*1.21*
Mercury	31	2.3	0.13	0.047	B	J	*0.0241*	*0.0608*	0.0982			*0.0251*	*0.0633*	**0.15**			*0.0262*	*0.0662*	0.037	B	J	*0.0216*	*0.0545*	0.0605	U		*0.024*	*0.0605*
Nickel	2000	160	62.8	15.6		J	*1.1*	*4.86*	28.6		J	*1.2*	*5.06*	47.4		J	*1.2*	*5.3*	11.6		J	*1*	*4.36*	20.4		J	*1.1*	*4.84*
Potassium	na	na	na	2440			*41*	*365*	2520			*42*	*380*	5190			*44*	*397*	1960			*36*	*327*	7870			*40*	*363*
Silver	510	39	na	1.22	U		*0.6*	*1.22*	1.27	U		*0.62*	*1.27*	1.32	U		*0.65*	*1.32*	1.09	U		*0.54*	*1.09*	1.21	U		*0.6*	*1.21*
Sodium	na	na	na	44.2			*4.5*	*24.3*	29.2		B	*4.7*	*25.3*	47.1			*4.9*	*26.5*	52.9			*4.1*	*21.8*	104			*4.5*	*24.2*
Thallium	7.2	0.55	2.11	0.15	B	J	*0.037*	*0.365*	0.26	B	J	*0.038*	*0.38*	0.34	B	J	*0.04*	*0.397*	0.12	B	J	*0.033*	*0.327*	0.19	B	J	*0.036*	*0.363*
Vanadium	102	7.8	108	53.6		J	*0.7*	*6.08*	50		J	*0.73*	*6.33*	71.7		J	*0.77*	*6.62*	28.5		J	*0.63*	*5.45*	41		J	*0.7*	*6.05*
Zinc	31000	2300	202	52.2		J	*0.44*	*2.43*	50.6		J	*0.45*	*2.53*	64.2		J	*0.47*	*2.65*	87.4		J	*0.39*	*2.18*	26		J	*0.43*	*2.42*
Misc.																												
Total Organic Carbon (mg/kg)	na	na	na	NT					NT					NT					NT					NT				
pH	na	na	na	NT					NT					NT					NT					NT				

**Refer to legend immediately following this table for a list of definitions and table notes

Table 2-7
Legend

12	J	Shading and black font indicate an industrial RBC exceedance.
12	J	Bold outline indicates a residential RBC exceedance.
12	**J**	Bold, underlined font indicates a background 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 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 (October 2007).
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: Guidance Document (April 1999).
mg/kg = milligrams per kilogram (parts per million).
ng/kg = nanograms per kilogram (parts per trillion).
µg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers

B = (organics) Blank contamination. Value detected in sample and associated blank.
A (Dioxins) = B = (metals) Value <MRL and >MDL and is considered estimated.
E (metals) = Reported value is estimated because of the presence of interferences.
EMPC (Dioxins) = The ion-abundance ratio between the two characteristic PCDD/PCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).
J = (organics) Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.
X = (dioxins) Ion abundance ratio outside acceptable range. Value reported is EMPC.

Val Q = 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
N = presumptive evidence for tentatively identified compounds using a library search
U = analyte not detected
UJ = estimated concentration non-detect
UL = estimated concentration non-detect bias low

Table 2-8
Dioxins/Furans Detected in FLFA Soil - 2002 Investigation

Analyte			Sample ID	LFSS01					LFSS02					LFSS03					LFSB12A					LFSB12B					LFSB12C					LFSB13A				
			Sample Date	6/26/02					6/26/02					6/26/02					6/26/02					6/26/02					6/26/02					6/26/02				
			Sample Depth	0-0.5					0-0.5					0-0.5					0-0.5					2-4					4-5.4					8.3-9				
	i-RBC	r-RBC	Background	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	1.615		J	0.19	0.154	0.437		J	0.19	0.163	25.96		J	0.19	0.246	1.211		J	0.19	0.543	0.094	U		0.19	0.094	0.213	U		0.19	0.213	0.193	U		0.19	0.193
2,3,7,8-TCDD	19	4.3	na	1.366	X	J	0.13	0.072	0.368	X	J	0.13	0.076	12.07	X	J	0.13	0.024	0.165	U		0.13	0.165	0.254	U		0.13	0.254	0.272	U		0.13	0.272	0.27	U		0.13	0.27
1,2,3,7,8-PECDD	na	na	na	2.777		J	0.19	0.204	0.622		J	0.19	0.145	8.679		J	0.19	0.696	1.055	X	J	0.19	0.203	0.208	U		0.19	0.208	0.225	U		0.19	0.225	0.173	U		0.19	0.173
1,2,3,4,7,8-HXCDD	460	100	na	7.05		J	0.53	0.175	1.49		J	0.53	0.12	15.64		J	0.53	0.561	1.993			0.53	0.294	0.291	U		0.53	0.291	0.319	U		0.53	0.319	0.278	U		0.53	0.278
1,2,3,6,7,8-HXCDD	460	100	na	9.289		J	0.57	0.137	1.975		J	0.57	0.096	22.35		J	0.57	0.439	2.956			0.57	0.231	0.228	U		0.57	0.228	0.25	U		0.57	0.25	0.218	U		0.57	0.218
1,2,3,7,8,9-HXCDD	460	100	na	15.01		J	0.68	0.133	2.972		J	0.68	0.099	36.04		J	0.68	0.425	4.969			0.68	0.223	0.221	U		0.68	0.221	0.242	U		0.68	0.242	0.211	U		0.68	0.211
1,2,3,4,6,7,8-HPCDD	na	na	na	153		J	0.63	0.096	46.97		J	0.63	0.112	220.5		J	0.63	0.355	62.85			0.63	0.422	5.233			0.63	0.238	2.494	X	J	0.63	0.277	0.221	U		0.63	0.221
OCDD	na	na	na	873.4		J	6.86	0.134	2464	B	J	6.86	0.087	1313		J	6.86	0.21	1311			6.86	0.258	35.21			6.86	0.334	30.78			6.86	0.307	50.02			6.86	0.216
1,2,3,7,8-PECDF	na	na	na	1.013		J	0.28	0.211	0.32		J	0.28	0.067	18.52		J	0.28	0.57	0.719	X	J	0.28	0.161	0.262	U		0.28	0.262	0.161	U		0.28	0.161	0.13	U		0.28	0.13
2,3,4,7,8-PECDF	na	na	na	2.803		J	0.56	0.22	0.788		J	0.56	0.074	46.47		J	0.56	0.597	1.22			0.56	0.169	0.274	U		0.56	0.274	0.169	U		0.56	0.169	0.136	U		0.56	0.136
1,2,3,4,7,8-HXCDF	na	na	na	7.171		J	0.34	0.131	2.282		J	0.34	0.059	176.4		J	0.34	0.29	6.468			0.34	0.257	0.121	U		0.34	0.121	0.191	U		0.34	0.191	0.148	U		0.34	0.148
1,2,3,6,7,8-HXCDF	na	na	na	2.008		J	0.49	0.127	1.055		J	0.49	0.058	49.9	I	J	0.49	0.282	1.593	I	J	0.49	0.25	0.118	U		0.49	0.118	0.186	U		0.49	0.186	0.144	U		0.49	0.144
2,3,4,6,7,8-HXCDF	na	na	na	2.87		J	0.47	0.149	1.283		J	0.47	0.072	7.765		J	0.47	0.33	2.244			0.47	0.292	0.138	U		0.47	0.138	0.217	U		0.47	0.217	0.168	U		0.47	0.168
1,2,3,7,8,9-HXCDF	na	na	na	0.15	U	UJ	0.25	0.15	0.077	U	UJ	0.25	0.077	3.205		J	0.25	0.332	0.294	U		0.25	0.294	0.139	U		0.25	0.139	0.219	U		0.25	0.219	0.169	U		0.25	0.169
1,2,3,4,6,7,8-HPCDF	na	na	na	26.17		J	0.33	0.104	11.87		J	0.33	0.062	323.7		J	0.33	0.149	17.19			0.33	0.194	0.924			0.33	0.119	0.498	X	J	0.33	0.149	0.119	U		0.33	0.119
1,2,3,4,7,8,9-HPCDF	na	na	na	2.095		J	0.5	0.134	0.685		J	0.5	0.084	22.47		J	0.5	0.193	1.167			0.5	0.25	0.153	U		0.5	0.153	0.192	U		0.5	0.192	0.153	U		0.5	0.153
OCDF	na	na	na	49.59		J	0.79	0.163	17.93		J	0.79	0.07	181.7		J	0.79	0.231	29.75			0.79	0.354	3.081			0.79	0.532	0.394	U		0.79	0.394	0.274	U		0.79	0.274
TOTAL TCDD	na	na	na	1.463		J		0.072	0.076	U	UJ		0.076	4.198		J		0.024	1.913				0.165	0.254	U			0.254	0.272	U			0.272	0.27	U			0.27
TOTAL PECDD	na	na	na	14.59		J		0.204	0.622		J		0.145	19.81		J		0.696	0.393				0.203	0.208	U			0.208	0.225	U			0.225	0.173	U			0.173
TOTAL HXCDD	460	100	na	115.8		J		0.133	18.71		J		0.096	263.4		J		0.425	29.92				0.223	0.221	U			0.221	0.242	U			0.242	0.211	U			0.211
TOTAL HPCDD	na	na	na	312		J		0.096	94.32		J		0.112	415.3		J		0.355	141.7				0.422	5.233				0.238	2.044				0.277	1.138				0.221
TOTAL TCDF	na	na	na	27.09		J		0.194	6.861		J		0.073	314		J		0.203	15.68				0.242	0.094	U			0.094	0.213	U			0.213	0.193	U			0.193
TOTAL PECDF	na	na	na	22.15		J		0.211	3.947		J		0.067	305		J		0.57	11.33				0.161	0.262	U			0.262	0.161	U			0.161	0.13	U			0.13
TOTAL HXCDF	na	na	na	33.69		J		0.127	14.08		J		0.058	597.3		J		0.282	24.93				0.25	0.118	U			0.118	0.186	U			0.186	0.144	U			0.144
TOTAL HPCDF	na	na	na	61.85		J		0.104	24.98		J		0.062	444.8		J		0.149	20.39				0.194	0.924				0.119	0.149	U			0.149	0.119	U			0.119

**Refer to legend immediately following this table for a list of definitions and table notes

Analyte			Sample ID	LFSB14A					LFSB14B					LFSB15A					LFSB15B					LFSB15C					LFSB16A					LFSB17A				
			Sample Date	6/26/02					6/26/02					6/26/02					6/26/02					6/26/02					6/26/02					6/26/02				
			Sample Depth	5.5-7					7-8.8					0-0.5					2-4					4-6					0-0.5					0-0.5				
	i-RBC	r-RBC	Background	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	0.172	U		0.19	0.172	0.076	U		0.19	0.076	39.08		J	0.19	0.509	0.294	U		0.19	0.294	0.233	U	UJ	0.19	0.233	0.229	U	UJ	0.19	0.229	1.315		J	0.19	0.355
2,3,7,8-TCDD	19	4.3	na	0.166	U		0.13	0.166	0.23	U		0.13	0.23	5.232			0.13	0.144	0.369	U		0.13	0.369	0.291	U		0.13	0.291	0.166	U		0.13	0.166	0.041	U	UJ	0.13	0.041
1,2,3,7,8-PECDD	na	na	na	0.162	U		0.19	0.162	0.176	U		0.19	0.176	33.8			0.19	0.223	0.255	U		0.19	0.255	0.236	U		0.19	0.236	0.255	U		0.19	0.255	0.997		J	0.19	0.211
1,2,3,4,7,8-HXCDD	460	100	na	0.171	U		0.53	0.171	0.178	U		0.53	0.178	76.1			0.53	0.333	0.306	U		0.53	0.306	0.24	U		0.53	0.24	0.211	U		0.53	0.211	1.733		J	0.53	0.196
1,2,3,6,7,8-HXCDD	460	100	na	0.134	U		0.57	0.134	0.14	U		0.57	0.14	160.5			0.57	0.261	0.239	U		0.57	0.239	0.188	U		0.57	0.188	0.801			0.57	0.165	3.003		J	0.57	0.154
1,2,3,7,8,9-HXCDD	460	100	na	0.13	U		0.68	0.13	0.135	U		0.68	0.135	190.5			0.68	0.253	0.232	U		0.68	0.232	0.182	U		0.68	0.182	1.159	X	J	0.68	0.16	5.006		J	0.68	0.149
1,2,3,4,6,7,8-HPCDD	na	na	na	3.527			0.63	0.161	1.476			0.63	0.147	2967			0.63	0.347	3.588			0.63	0.235	3.429			0.63	0.135	22.77			0.63	0.288	63.5		J	0.63	0.152
OCDD	na	na	na	90.87			6.86	0.147	63.86		J	6.86	0.162	7298		J	6.86	0.31	730.4			6.86	0.237	57.36		J	6.86	0.227	1468			6.86	0.219	1420		J	6.86	0.146
1,2,3,7,8-PECDF	na	na	na	0.123	U		0.28	0.123	0.133	U		0.28	0.133	49.17			0.28	0.485	0.244	U		0.28	0.244	0.142	U		0.28	0.142	0.181	U		0.28	0.181	1.033		J	0.28	0.16
2,3,4,7,8-PECDF	na	na	na	0.128	U		0.56	0.128	0.139	U		0.56	0.139	124.9			0.56	0.507	0.255	U		0.56	0.255	0.148	U		0.56	0.148	0.189	U		0.56	0.189	1.599	X	J	0.56	0.168
1,2,3,4,7,8-HXCDF	na	na	na	0.095	U		0.34	0.095	0.103	U		0.34	0.103	756.9			0.34	0.46	0.122	U		0.34	0.122	1.981			0.34	0.109	1.2	X	J	0.34	0.144	5.912		J	0.34	0.12
1,2,3,6,7,8-HXCDF	na	na	na	0.093	U		0.49	0.093	0.1	U		0.49	0.1	168.1	I	J	0.49	0.447	0.119	U		0.49	0.119	0.683			0.49	0.106	0.141	U		0.49	0.141	1.749		J	0.49	0.117
2,3,4,6,7,8-HXCDF	na	na	na	0.109	U		0.47	0.109	0.117	U		0.47	0.117	287.5			0.47	0.523	0.139	U		0.47	0.139	0.977			0.47	0.124	0.165	U		0.47	0.165	2.404		J	0.47	0.137
1,2,3,7,8,9-HXCDF	na	na	na	0.109	U		0.25	0.109	0.118	U		0.25	0.118	11.22			0.25	0.527	0.14	U		0.25	0.14	0.125	U		0.25	0.125	0.166	U		0.25	0.166	0.138	U	UJ	0.25	0.138
1,2,3,4,6,7,8-HPCDF	na	na	na	1.217			0.33	0.099	0.265	X	J	0.33	0.076	1660			0.33	0.129	0.653			0.33	0.085	4.843			0.33	0.1	5.907			0.33	0.139	16.55		J	0.33	0.095
1,2,3,4,7,8,9-HPCDF	na	na	na	0.128	U		0.5	0.128	0.098	U		0.5	0.098	147.1			0.5	0.166	0.109	U		0.5	0.109	0.517			0.5	0.129	0.563	X	J	0.5	0.18	1.115		J	0.5	0.123
OCDF	na	na	na	11.47			0.79	0.257	0.96		J	0.79	0.174	1263		J	0.79	0.19	0.279	U		0.79	0.279	3.15		J	0.79	0.216	16.22			0.79	0.262	26.97		J	0.79	0.206
TOTAL TCDD	na	na	na	0.166	U			0.166	0.23	U			0.23	216.9				0.144	0.369	U			0.369	0.291	U			0.291	0.166	U			0.166	0.382		J		0.041
TOTAL PECDD	na	na	na	0.162	U			0.162	0.176	U			0.176	396.3				0.223	0.255	U			0.255	0.236	U			0.236	0.255	U			0.255	2.253		J		0.211
TOTAL HXCDD	460	100	na	0.13	U			0.13	0.135	U			0.135	1741				0.253	0.232	U			0.232	1.452				0.182	3.85				0.16	27.49		J		0.149
TOTAL HPCDD	na	na	na	6.197				0.161	2.839				0.147	6654				0.347	6.77				0.235	3.429				0.135	43.92				0.288	127.5		J		0.152
TOTAL TCDF	na	na	na	0.172	U			0.172	0.076	U			0.076	1048				0.483	0.294	U			0.294	2.463				0.22	0.239	U			0.239	23.59		J		0.182
TOTAL PECDF	na	na	na	0.123	U			0.123	0.133	U			0.133	1123				0.485	0.244	U			0.244	2.137				0.142	0.938				0.181	13.82		J		0.16
TOTAL HXCDF	na	na	na	0.396				0.093	0.1	U			0.1	2202				0.447	0.119	U			0.119	5.745				0.106	2.19				0.141	22.38		J		0.117
TOTAL HPCDF	na	na	na	4.908				0.099	0.076	U			0.076	2015				0.129	0.653				0.085	5.36				0.1	14.94				0.139	32.06		J		0.095

**Refer to legend immediately following this table for a list of definitions and table notes

Table 2-8
Legend

12	J	Shading and black font indicate an industrial RBC exceedance.
12	J	Bold outline indicates a residential RBC exceedance.
12	**J**	Bold, underlined font indicates a background 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 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 (October 2007).

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: Guidance Document (April 1999).

mg/kg = milligrams per kilogram (parts per million).

ng/kg = nanograms per kilogram (parts per trillion).

μg/kg = micrograms per kilogram (parts per billion).

NA = not applicable.

NT = analyte not tested.

Lab Q = Lab Data Qualifiers

B = (organics) Blank contamination. Value detected in sample and associated blank.

A (Dioxins) = B = (metals) Value <MRL and >MDL and is considered estimated.

E (metals) = Reported value is estimated because of the presence of interferences.

EMPC (Dioxins) = The ion-abundance ratio between the two characteristic PCDD/PCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).

J = (organics) Value <MRL and >MDL and is considered estimated.

U = Analyte not-detected at the method reporting limit.

X = (dioxins) Ion abundance ratio outside acceptable range. Value reported is EMPC.

Val Q = 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

N = presumptive evidence for tentatively identified compounds using a library search

U = analyte not detected

UJ = estimated concentration non-detect

UL = estimated concentration non-detect bias low

3.0 2007 INVESTIGATION ACTIVITIES

In order to complete the characterization of the FLFA, soil, groundwater, surface water, and sediment samples were collected by Shaw in 2007. Groundwater samples collected by URS Corporation (URS) at nearby (and downgradient) SWMU 40 were also used in the assessment. Details of these sampling activities are described in *Section 3.1* (Soil), *Section 3.2* (Surface Water/Sediment), and *Section 3.3* (Groundwater). A summary of the samples collected during the 2007 Investigations is presented in **Table 3-1**. Results from these investigations are presented in *Section 4.0*.

Table 3-1
2007 Investigations Samples and Analyses

Media	Sampling ID	Depth	Analytes
Surface Soil	Grid Locations 0E0-95E60	0-0.5 ft bgs	XRF Lead
	LFSS04-14	0-0.5 ft bgs	TAL metals, TCL PCBs, dioxins/furans
	LFSS015-21	0-0.5 ft bgs	TAL metals, TCL PCBs, dioxins/furans
Groundwater	LFMW01	mid-point of well screen	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, perchlorate
	17PZ1	mid-point of well screen	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, perchlorate
	17MW2	mid-point of well screen	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, perchlorate
	17MW3	mid-point of well screen	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, perchlorate
	40MW5	mid-point of well screen	TCL VOCs, SVOCs, pesticides/PCBs, explosives, TAL metals, perchlorate
	40MW6	mid-point of well screen	TCL VOCs, SVOCs, pesticides/PCBs, explosives, TAL metals, perchlorate
Surface Water	LFSW01	NA	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, perchlorate
Sediment	LFSD01	NA	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, perchlorate

* Refer to **Appendix A-1, Table A-1** for the preparation and analytical methodologies used.

3.1 Soil Sampling

Complete characterization of the site soil for lead, PCBs and dioxin/furans was a data gap identified after the 2002 Investigation that was addressed during the 2007 Investigation through an on-site X-ray fluorescence (XRF) survey combined with fixed-laboratory confirmation sampling.

3.1.1 XRF Survey

An XRF survey was performed to complete the delineation of lead in soil at the FLFA. Soil samples were screened for lead using dispersive XRF technology with an Innov-X Alpha Series model XRF analyzer following USEPA Method SW-846 6200. XRF analysis provides a field analytical method for analysis of lead in soil. The XRF detected lead concentrations in soil at the

FLFA down to 10 mg/kg. Samples were collected, stepping outward along grid lines, until sample concentrations were below 300 mg/kg. Because the XRF is a screening tool, 300 mg/kg was considered a conservative value to ensure that actual, laboratory confirmed concentrations were below the residential screening value (400 mg/kg) for lead.

All surface soil samples for lead screening were collected from under the vegetative mat using a decontaminated stainless steel shovel or stainless steel trowel. The samples were then prepared for analysis by removing the larger-grained and gravelly particles as well as any vegetative material and homogenized in a stainless steel bowl. The surface soil samples were analyzed by the XRF instrument for a read period of at least 30 seconds duration.

As presented in **Table 4-1** and illustrated on **Figure 4-1**, a total of 376 locations were screened using the XRF unit. Screening was stopped when an obstacle such as a tree, gravel/paved road, or the SWMU 17A burn pad was encountered. Once the limits of lead above the residential cleanup criteria were defined with the XRF, confirmation samples were collected at the perimeter of the delineated area and analyzed at a fixed-base laboratory. As shown in **Table 3-1** and **Figure 4-2**, eleven samples (LFSS04 through LFSS14) were collected to confirm the XRF results. Confirmation samples were analyzed for PCBs and dioxins/furans in addition to TAL metals, since these parameters were also elevated in site soil. XRF field screening results and confirmation sampling results are presented in *Section 4.0*.

3.1.2 Additional Soil Sampling

In addition to the confirmation samples described in the previous section, seven surface soil samples (LFSS15 through LFSS21) from within the established boundary of the FLFA were collected and analyzed for TAL metals, PCBs, and dioxins/furans to assess the soil for these constituents previously detected at elevated concentrations. These samples were collected from randomly picked XRF screening grid cells in accordance with systematic grid sampling strategy as defined in Standard Operating Procedure 30.7 of the MWP (URS, 2003). The locations of the samples are illustrated on **Figure 4-2**. Sample results are discussed in *Section 4.0*.

3.2 Surface Water/Sediment Sampling

Collocated surface water/sediment sample LFSW01/LFSD01 was collected from the spring (SPG 3) on the New River where a dye trace study (Engineering Science, 1994) indicated discharge from the FLFA/SWMU 17A sinkhole. These samples were collected to assess the fate and transport of FLFA constituents and evaluate whether these constituents are impacting the New River. Samples were analyzed for target compound list (TCL) VOCs, SVOCs, polynuclear aromatic hydrocarbons (PAHs), pest/PCBs, explosives, herbicides, TAL metals, dioxins/furans, and perchlorate (surface water only). The sampling location is illustrated on **Figure 4-3**. Sample results are discussed in *Section 4.0*.

3.3 Groundwater Sampling

Two groundwater investigations were conducted in the FLFA vicinity in August 2007. Shaw installed a monitoring well (LFMW01) in the sinkhole by the original furnace location to characterize groundwater at the site. Shaw collected groundwater samples from newly installed well LFMW01 and existing wells 17PZ1, 17MW2, and 17MW3. As shown in **Table 3-1**, samples from these wells were analyzed for TCL VOCs, SVOCs, PAHs, pest/PCBs, explosives, herbicides, TAL metals, dioxins/furans, and perchlorate.

URS installed two monitoring wells (40MW5 and 40MW6) at SWMUs 40/71 in a downgradient direction to the FLFA. URS collected groundwater samples from newly installed wells 40MW5 and 40MW6 and this data has been incorporated into the contamination and risk assessments. As shown in **Table 3-1**, samples from these wells were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, explosives, TAL metals (total and dissolved), and perchlorate.

Boring logs and well construction diagrams for the newly installed wells are presented in **Appendix B-1**. The well purging/field water quality measurements forms are included in **Appendix B-2**. Sample locations for both groundwater investigations are illustrated on **Figure 2-7**. Sample results are discussed in *Section 4.0*.

3.4 Survey and Global Positioning System Activities

3.4.1 Well Survey Activities

Newly installed monitoring well LFMW01 was surveyed for elevation and horizontal location coordinates. Its location was surveyed and located in the Virginia State Plane coordinate system by a licensed professional surveyor. Horizontal control was tied to the North American Datum of 1983 in survey feet. The vertical control was tied to the National Vertical Datum of 1929. Elevations for the natural ground surface and the top of well casings were surveyed to within ± 0.01 ft. Location coordinates were surveyed to within ± 1.0 foot.

Surveying accuracy was verified by loop closure and documented. Closure for the horizontal survey was less than 1.0 foot. The level loop for the survey was within 0.1 foot. Well location coordinates and elevations are presented in **Appendix C**.

3.4.2 Global Positioning Activities

Sample location coordinates and elevations were obtained using a Trimble GeoXH Global Positioning System. The GeoXH 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 North American Vertical Datum of 1988. Position information will be entered into the Environmental Restoration Information System database. Sample location coordinates and elevations are presented in **Appendix C**.

3.5 Quality Assurance

The accuracy and integrity of 2007 RFI data were ensured through the implementation of internal quality control (QC) measures in accordance with *MWP Addendum 019* (Shaw, 2007), as approved by USEPA Region III and the VDEQ. Quality assurance (QA) and 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 **Appendix A-2**. Chemical data validation reports and analytical data are provided in **Appendix A-3**.

3.6 Modifications to the Sampling Plan

No modifications were made to the proposed sampling effort at the FLFA from *MWP Addendum 019* (Shaw, 2007).

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 and groundwater at the FLFA. The distribution and concentrations of chemicals and parameter groups (i.e., VOCs, SVOCs, etc.) are evaluated for source locations, migration pathways, hotspots, and potential disposition areas.

Soil/Sediment Screening. Chemical results from soil and sediment samples are compared to adjusted USEPA Region III industrial and residential soil risk-based concentrations (RBCs) (USEPA, 2007a), as well as facility-wide background inorganic concentrations (IT, 2001), and other regulatory criteria. Industrial and residential RBCs were adjusted downward to a hazard index (HI) of 0.1 for non-carcinogenic compounds to ensure that chemicals with additive effects are not prematurely eliminated during screening.

Current (October 2007) RBC screening values and background 95% upper tolerance limits (UTLs) are presented for comparison in **Table 4-2** and summarized in **Table 4-3** and on **Figure 4-2** for soil. Sediment screening results are presented for comparison in **Table 4-6** and summarized on **Figure 4-3** for sediment. These comparisons are not for risk analysis (conducted in *Sections 6.0 and 7.0*), but to identify those chemicals of greatest concern for nature and extent characterization. Analytical results for inorganics in soil 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 soil that are below the background value allows site-specific constituents to be more clearly indicated on the tables and figures.

Surface Water/Groundwater Screening. Surface water and groundwater sampling results are compared to the 2006 Edition of the Drinking Water Standards and Health Advisories (i.e., MCLs and secondary MCLs) (USEPA, 2006) and adjusted tw-RBCs (USEPA, 2007a). Consistent with soil screening, tw-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. Surface water screening results are presented for comparison in **Table 4-5** and on **Figure 4-3**. Groundwater screening results are presented for comparison in **Table 4-7** and summarized in **Table 4-8** and on **Figure 4-4**.

4.1 RCRA Facility Investigation, Shaw, 2007

4.1.1 Soil

4.1.1.1 Soil Analytical Results – XRF Screening and Confirmation Sampling

<u>XRF Screening</u>. As described in *Section 3.1* and illustrated on **Figure 4-1**, a total of 376 soil locations were screened at the FLFA for lead using an XRF unit. Lead results obtained during XRF field screening and associated confirmation results from the off-site laboratory are presented in **Table 4-1** and illustrated on **Figures 4-1 and 4-2**.

As illustrated by the concentration of red dots (lead concentration > 400 mg/kg) on **Figure 4-1**, XRF field screening results indicate that three areas of elevated lead exist within the FLFA site boundary. Two of these areas are present west of the former location of the lead furnace and the third area is located north of where the lead furnace existed. As shown in **Table 4-1**, XRF lead concentrations ranged from 10 mg/kg (60E60) to 8,508 mg/kg (40E15).

LEGEND

●	Sample Location (XRF Result < 200 ppm)
●	Sample Location (XRF Result 200-400 ppm)
●	Sample Location (XRF Result > 400 ppm)
– – –	Dirt Road
———	Paved Road
☐	1998 RFI Excavation Boundary
☐	Former Lead Furnace Area Boundary

Notes:
1) Aerial photo, dated 25 May 2000, was obtained from the Army Topographic Engineering Center.

N

Scale:
0 37.5 75 150 Feet

U.S. Army Corps of Engineers

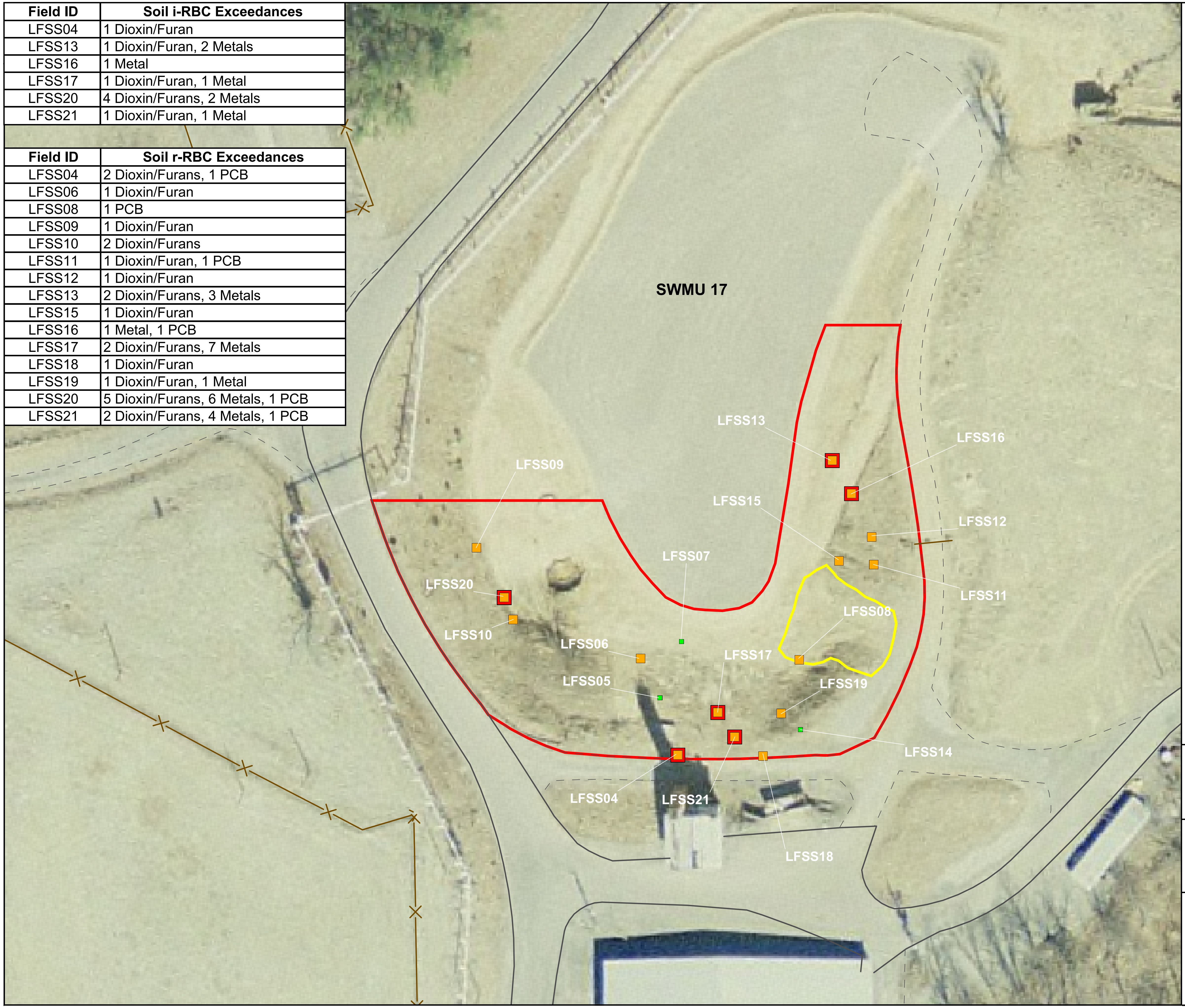
Shaw® Shaw Environmental, Inc.

FIGURE 4-1
Former Lead Furnace Area
XRF Results
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: RFAAP_Fig4-1_FLFA_XRF_Results.mxd (2/12/2008 11:13:43 AM)

Field ID	Soil i-RBC Exceedances
LFSS04	1 Dioxin/Furan
LFSS13	1 Dioxin/Furan, 2 Metals
LFSS16	1 Metal
LFSS17	1 Dioxin/Furan, 1 Metal
LFSS20	4 Dioxin/Furans, 2 Metals
LFSS21	1 Dioxin/Furan, 1 Metal

Field ID	Soil r-RBC Exceedances
LFSS04	2 Dioxin/Furans, 1 PCB
LFSS06	1 Dioxin/Furan
LFSS08	1 PCB
LFSS09	1 Dioxin/Furan
LFSS10	2 Dioxin/Furans
LFSS11	1 Dioxin/Furan, 1 PCB
LFSS12	1 Dioxin/Furan
LFSS13	2 Dioxin/Furans, 3 Metals
LFSS15	1 Dioxin/Furan
LFSS16	1 Metal, 1 PCB
LFSS17	2 Dioxin/Furans, 7 Metals
LFSS18	1 Dioxin/Furan
LFSS19	1 Dioxin/Furan, 1 Metal
LFSS20	5 Dioxin/Furans, 6 Metals, 1 PCB
LFSS21	2 Dioxin/Furans, 4 Metals, 1 PCB



LEGEND

🟩 Soil Sample Location Result
< r-RBC and < i-RBC

🟧 Soil Sample Location Result
>= r-RBC

🟥 Soil Sample Location Result
>= i-RBC

— Fence Line

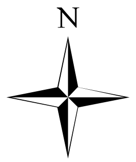
- - - Dirt Road

— Paved Road

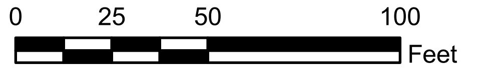
▭ 1998 RFI Excavation Boundary

▭ Former Lead Furnace Area Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) i-RBC and r-RBC values as of October 2007.



Scale:



U.S. Army Corps of Engineers

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FIGURE 4-2
Former Lead Furnace Area
2007 Investigation Soil Results
Radford Army Ammunition Plant
Radford, VA

ArcGIS File: RFAAP_Fig4-2_FLFA_2007_Soil_Results.mxd (2/12/2008 11:14:39 AM)

LEGEND

▲ Sediment Sample Location Result >= r-RBC

◀ - - Groundwater Flow Path Suggested by Engineering Science, Inc. (May 1994)

□ Former Lead Furnace Area Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) RBC values as of October 2007.
3) MCL values as of August 2006.

Field ID	Sediment r-RBC Exceedances
LFSD01	1 Dioxin/Furan, 1 PAH

Field ID	Surface Water Exceedances
LFSW01	No Exceedances

N

Scale:

0 400 800 1,600 Feet

U.S. Army Corps of Engineers

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FIGURE 4-3
Former Lead Furnace Area
2007 Investigation Surface Water
and Sediment Results
Radford Army Ammunition Plant
Radford, VA

ArcGIS File: RFAAP_Fig4-3_FLFA_2007_SWSD_Results.mxd (2/18/2008 10:48:22 AM)

LEGEND

● Groundwater Sample Location Result < MCL and < tw-RBC

● Groundwater Sample Location Result >= tw-RBC

● Groundwater Sample Location Result >= MCL

— Fence Line

- - Dirt Road

— Paved Road

▭ Former Lead Furnace Area Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) MCL values as of August 2006.
3) tw-RBC values as of October 2007.

Sample ID	Groundwater MCL Exceedances
17MW2	2 Metals
17PZ1	1 Metal
LFMW01	3 Metals

Sample ID	Groundwater tw-RBC Exceedances
17MW2	1 Metal, 2 VOCs, Perchlorate
17PZ1	1 Metal, 1 VOC
LFMW01	5 Metals, Perchlorate
40MW5	1 VOC
40MW6	1 VOC

Scale:

0 70 140 280 Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 4-4
Former Lead Furnace Area
2007 Investigation Groundwater Results

Radford Army Ammunition Plant
Radford, VA

ArcGIS File: RFAAP_Fig4-4_FLFA_2007_GW_Results.mxd (1/9/2008 11:28:52 AM)

Table 4-1
XRF Field Screening and Confirmation Sample Results for Lead at the FLFA
Page 1 of 4

XRF ID	XRF Reading	Conf. ID	Lab Result
0E0	424		
0E10	455		
0E20	584		
0E40	1025		
0E5	260		
0E50	1857		
0E55	1125		
0E60	30		
0E65	113		
0E70	96		
100E0	13		
100E10	13		
100E100	489		
100E105	535	LFSS16	1550
100E110	161		
100E115	81		
100E120	73		
100E130	59		
100E140	125		
100E145	90		
100E30	16		
100E50	276		
100E70	274		
100E75	3514		
100E80	1893		
100E90	427		
100W40	41		
100W50	76		
100W60	29		
100W90	52		
105E110	836		
105E115	57		
105E125	97		
105E130	125		
105E70	286		
105E85	7671		
105W50	82	LFSS10	86.2
105W55	33		
105W60	38		
105W65	60		
10E0	203		
10E10	1098		
10E20	1381	LFSS17	1660
10E40	3170		
10E5	367		
10E55	434		
10E60	54		
10W0	190		
10W10	152	LFSS04	118
10W20	239		
10W30	80		
10W35	75		
10W40	327		
10W45	107		
10W50	215		
10W55	1705		
10W60	111	LFSS07	51.1
10W70	172		
10W75	78		
110E0	20		
110E10	62		
110E110	561		
110E115	88		
110E125	1042		
110E130	43		
110E145	68		
110E150	53		
110E155	53		
110E30	15		
110E50	160		
110E65	165	LFSS11	372
110E70	390		
110E75	230		
110E80	146	LFSS12	241
110E85	54		
110E90	261		
110W0	159		
110W10	90		
110W100	44		
110W110	25		
110W120	48		
110W130	16		
110W20	66		
110W30	40		
110W40	62		
110W50	138		
110W55	1986		
110W60	700	LFSS20	36500
110W65	4908		
110W70	129		
110W80	176		
110W85	206		
110W90	233		
115E115	134		
115E120	135		
115E125	73		
115E130	31		
115E65	146		
115E70	194		
115E75	295		
115E85	95		
115W50	61		
115W55	94		
115W60	505		
115W65	556		
115W70	3801		
115W80	2785		
115W85	431		
115W90	1236		
120E0	85		
120E10	52		
120E100	113		
120E110	225		
120E125	47		
120E140	65		
120E145	19		
120E25	41		
120E30	381		

Table 4-1
XRF Field Screening and Confirmation Sample Results for Lead at the FLFA
Page 2 of 4

XRF ID	XRF Reading	Conf. ID	Lab Result
120E35	205		
120E40	98		
120E50	50		
120E70	259		
120E90	135		
120W100	98		
120W50	91		
120W55	111		
120W60	85		
120W65	191		
120W70	907		
120W75	405		
120W80	2599		
120W85	131		
120W90	732		
12590	276		
125E115	23		
125E120	85		
125E125	86		
125E75	48		
125W70	1090		
125W75	74		
125W80	407		
125W85	78		
130E0	117		
130E10	320		
130E110	14		
130E115	180		
130E120	1038		
130E125	22		
130E15	67		
130E20	233		
130E30	150		
130E5	160		
130E50	162		
130E65	132		
130E70	522		
130E75	108		
130E80	41		
130E90	72		
130W0	29		
130W100	204		
130W20	92		
130W30	113		
130W40	101		
130W50	73		
130W60	79		
130W70	109	LFSS09	126
130W75	73		
130W80	91		
130W90	89		
135E115	58		
135E120	175		
135E125	153		
135E65	50		
135E70	79		
135E75	81		
135E80	22		
140E0	247		
140E10	162		
140E30	145		
140E50	85		
140E70	86		
140E90	138		
150W0	181		
150W10	146		
150W20	47		
150W30	65		
150W40	102		
150W50	67		
150W60	28		
150W70	33		
150W80	26		
15E55	290		
15E60	298		
15W55	961		
15W60	70		
15W65	46		
160W0	50		
170W0	106		
170W10	87		
170W20	29		
170W30	270		
180W0	73		
20E0	37		
20E10	669	LFSS21	1230
20E30	924		
20E40	1288		
20E45	3398		
20E5	325		
20E50	31		
20E60	32		
20W0	94		
20W10	48		
20W20	52		
20W30	93	LFSS05	94.5
20W35	715		
20W40	25		
20W50	395		
20W60	342		
20W65	20		
20W70	44		
20W75	56		
20W80	139		
25E0	120		
25E5	146		
25W35	170		
25W40	347		
25W45	316		
25W65	48		
30E10	281		
30W0	169		
30W10	51		
30W20	36		

Table 4-1
XRF Field Screening and Confirmation Sample Results for Lead at the FLFA
Page 3 of 4

XRF ID	XRF Reading	Conf. ID	Lab Result
30W30	178		
30W40	122		
30W50	127	LFSS06	135
30W55	202		
30W60	909		
30W65	39		
30W70	17		
30W80	15		
30W85	113		
30W90	82		
35E60	210		
35E65	69		
35W55	46		
35W60	50		
35W65	92		
40E0	401	LFSS18	294
40E10	164		
40E15	8508		
40E45	3754		
40E5	151		
40E50	91		
40E55	22		
40E60	387		
40E65	29		
40W0	190		
40W10	40		
40W100	25		
40W20	99		
40W30	83		
40W40	101		
40W50	44		
40W60	11		
40W70	19		
40W80	16		
40W90	41		
40W95	39		
45E50	341		
45E55	156		
50E10	104		
50E15	123		
50E20	433	LFSS19	105
50E40	2273		
50E45	553		
50E50	113		
50E60	32		
50E70	70		
50W0	182		
50W10	43		
50W100	28		
50W110	18		
50W20	83		
50W30	47		
50W40	66		
50W50	65		
50W55	44		
50W60	105		
50W65	28		
50W70	19		
50W80	16		

XRF ID	XRF Reading	Conf. ID	Lab Result
50W90	52		
5E0	186		
5E5	428		
5E60	147		
5W60	59		
60E0	62		
60E10	38	LFSS14	35.9
60E20	99		
60E25	1183		
60E30	1736		
60E40	628		
60E45	28		
60E50	43	LFSS08	37.1
60E60	10		
60W90	20		
70E10	49		
70E20	139		
70E30	72		
70E40	25		
70E50	18		
70E60	38		
70E70	63		
70E80	128		
70E90	12		
70W0	241		
70W10	38		
70W110	26		
70W135	17		
70W20	67		
70W30	152		
70W40	56		
70W90	61		
75E80	151		
75E85	51		
75E90	31		
75E95	1395		
80E0	25		
80E10	33		
80E100	769		
80E105	361		
80E110	102		
80E50	20		
80E70	16		
80E80	186		
80E85	547		
80E90	7063		
80E95	526		
80W90	33		
85E105	160		
85E110	219		
85E70	25		
85E75	214		
85E80	86		
8E30	27		
90E0	18		
90E10	24		
90E100	389		
90E105	983		
90E110	296		

Table 4-1
XRF Field Screening and Confirmation Sample Results for Lead at the FLFA
Page 4 of 4

XRF ID	XRF Reading	Conf. ID	Lab Result
90E115	168		
90E120	153		
90E125	93	LFSS13	161
90E30	42		
90E50	23		
90E65	90		
90E70	334	LFSS15	186
90E75	173		
90E80	223		
90E85	302		
90E90	469		
90W0	68		
90W10	36		
90W110	15		
90W130	17		
90W20	19		
90W30	31		
90W40	27		
90W50	187		
90W60	92		
90W70	14		
90W75	25		
90W90	202		
95E110	382		
95E115	54		
95E60	111		

Lead Boundary Sampling. Eleven fixed-base laboratory samples (LFSS04 through LFSS14) were collected from the boundary of elevated lead, as determined by the XRF screening results. These samples were collected to ensure that the boundary of lead concentrations greater than 400 mg/kg had been accurately assessed and to determine whether PCBs and dioxins/furans were present outside of the areas where lead was present. Lead boundary sample locations LFSS04 through LFSS14 are shown on **Figure 4-2**. Detected results are presented in **Table 4-2** and summarized in **Table 4-3**.

PCBs. Two PCBs (Aroclor-1254 and Aroclor-1260) were detected in the samples. Concentrations of Aroclor-1254 exceeded residential screening levels in three samples (LFSS04, LFSS08, and LFSS11), but did not exceed industrial screening levels in any samples. Concentrations of Aroclor-1260 were below residential screening levels in all eleven samples.

TAL Metals. Twenty-three TAL metals were detected in the confirmation samples. Two metals (arsenic and copper) were detected at concentrations exceeding industrial screening levels both in one sample (LFSS13). Zinc was detected above its residential screening level (but below the industrial level) in the same sample (LFSS13). Lead concentrations were below residential screening levels in the samples, confirming the XRF results.

Dioxins/Furans. Seventeen dioxin/furan congeners were detected in the samples. Of these congeners that have an associated screening level, 2,3,7,8-TCDD concentrations exceeded residential (but below industrial) screening levels in three samples (LFSS04, LFSS10, and LFSS13). Total HXCDD exceeded its residential screening level in seven samples and the industrial screening level in two samples (LFSS04 and LFSS13).

Additional Delineation Sampling. Seven additional surface soil samples (LFSS15 through LFSS21) were collected from within the established boundary of the FLFA. These samples were collected to provide PCB and dioxin/furan data in the area of elevated lead, as determined by the XRF screening, and to provide additional correlation sampling for the XRF lead screening results. Samples were analyzed for TAL metals, PCBs, and dioxins/furans. Additional delineation sample locations LFSS15 through LFSS21 are shown on **Figure 4-2**. Detected results are presented in **Table 4-2** and summarized in **Table 4-3**.

PCBs. Two PCBs (Aroclor-1254 and Aroclor-1260) were detected in the samples. Concentrations of Aroclor-1254 exceeded residential screening levels in two samples (LFSS20 and LFSS21), but did not exceed industrial screening levels in any samples. Concentrations of Aroclor-1260 were above the residential screening level in one sample (LFSS16).

TAL Metals. Twenty-three TAL metals were detected in the additional delineation samples. Two metals (copper and lead) were detected at concentrations exceeding industrial screening levels in one and four samples, respectively. Nine metals (arsenic, barium, cadmium, chromium, copper, lead, silver, thallium, and zinc) were detected at concentrations exceeding residential screening levels.

Dioxins/Furans. Seventeen dioxin/furan congeners were detected in the samples. Of these congeners that have an associated screening level, 2,3,7,8-TCDD, 1,2,3,6,7,8-HXCDD, and 1,2,3,7,8,9-HXCDD concentrations exceeded industrial screening levels in one sample (LFSS20). Concentrations of 2,3,7,8-TCDD (three samples), 1,2,3,4,7,8-HXCDD (one sample), 1,2,3,6,7,8-HXCDD (one sample), and 1,2,3,7,8,9-HXCDD (one sample) exceeded residential

Table 4-2
Analytes Detected in FLFA Soil - 2007 Investigation
Page 1 of 6

Analyte			Sample ID Sample Date Sample Depth	**LFSS04** **8/2/07** **0-0.5**					**LFSS05** **8/2/07** **0-0.5**					**LFSS06** **8/2/07** **0-0.5**				
	i-RBC	**r-RBC**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PCBs (mg/kg)																		
PCB-1254	1.4	0.16	na	0.161	J	J	*0.021*	*0.042*	0.0285		J	*0.01*	*0.021*	0.0243		J	*0.0096*	*0.019*
PCB-1260	1.4	0.32	na	0.0568	J	J	*0.021*	*0.042*	0.021	U		*0.01*	*0.021*	0.019	U		*0.0096*	*0.019*
Metals (mg/kg)																		
Aluminum	100000	7800	40041	16300		J	*3*	*12*	17800		J	*2.8*	*12*	10200		J	*2.7*	*11*
Antimony	41	3.1	na	1	J	B	*0.24*	*3.7*	0.94	J	B	*0.22*	*3.5*	0.89	J	B	*0.21*	*3.4*
Arsenic	1.9	0.43	15.8	12.2		J	*0.24*	*0.5*	3.7		J	*0.23*	*0.47*	5.9		J	*0.22*	*0.45*
Barium	20000	1600	209	90		J	*0.31*	*12*	90.3		J	*0.29*	*12*	**253**	**C**	**J**	*0.28*	*11*
Beryllium	200	16	1.02	**1.5**		**B**	*0.12*	*0.62*	**1.6**		**B**	*0.12*	*0.58*	0.98		B	*0.11*	*0.56*
Cadmium	51	3.9	0.69	0.062	U	UL	*0.062*	*0.25*	0.59	U	UL	*0.59*	*1.2*	0.28	U	UL	*0.28*	*0.44*
Calcium	na	na	na	5420		J	*6.2*	*310*	4140		J	*5.9*	*290*	1520		J	*5.6*	*280*
Chromium	310	23	65.3	30.2		J	*0.087*	*0.62*	32.7		J	*0.082*	*0.59*	20.6		J	*0.078*	*0.56*
Cobalt	na	na	72.3	11.9		J	*0.068*	*3.1*	9.4		J	*0.064*	*2.9*	22.5		J	*0.061*	*2.8*
Copper	4100	310	53.5	**160**		**J**	*0.12*	*1.6*	**54.3**		**J**	*0.11*	*1.5*	**64.2**		**J**	*0.11*	*1.4*
Iron	72000	5500	50962	22300		J	*0.87*	*6.2*	21100		J	*0.82*	*5.9*	19600		J	*0.78*	*5.6*
Lead	800	400	26.8	**118**		**J**	*0.15*	*6.2*	**94.5**		**J**	*0.14*	*5.9*	**135**		**J**	*0.13*	*5.6*
Magnesium	na	na	na	4450		J	*6.2*	*310*	11000		J	*5.9*	*290*	4490		J	*5.6*	*280*
Manganese	2000	160	2543	435	C	J	*0.062*	*0.93*	360	C	J	*0.059*	*0.88*	2060		J	*0.56*	*8.4*
Mercury	31	2.3	0.13	**0.21**		**J**	*0.012*	*0.1*	**0.16**		**J**	*0.012*	*0.094*	0.081	J	J	*0.011*	*0.088*
Nickel	2000	160	62.8	16.4		J	*0.16*	*2.5*	19.3		J	*0.15*	*2.3*	12.8		J	*0.14*	*2.2*
Potassium	na	na	na	1920		J	*6.2*	*620*	2550		J	*5.9*	*590*	1440		J	*5.6*	*560*
Selenium	510	39	na	0.61	J	L	*0.28*	*6.2*	0.53	J	L	*0.26*	*5.9*	1.1	J	L	*0.25*	*5.6*
Silver	510	39	na	0.91		L	*0.087*	*0.62*	0.62		L	*0.082*	*0.59*	0.6		L	*0.078*	*0.56*
Sodium	na	na	na	465	J	L	*31*	*620*	328	J	L	*29*	*590*	307	J	L	*28*	*560*
Thallium	7.2	0.55	2.11	0.7	U	UL	*0.7*	*1.2*	0.66	U	UL	*0.66*	*1.2*	0.62	U	UL	*0.62*	*1*
Vanadium	102	7.8	108	44.6		J	*0.062*	*3.1*	44.8		J	*0.059*	*2.9*	32.7		J	*0.056*	*2.8*
Zinc	31000	2300	202	**290**	**C**	**J**	*0.31*	*1.2*	165		J	*0.29*	*1.2*	**327**	**C**	**J**	*0.28*	*1.1*
Dioxins/Furans (ng/kg)																		
2,3,7,8-TCDF	na	na	na	29.9					6.95					7.6				
2,3,7,8-TCDD	19	4.3	na	11					2.88					2.67				
1,2,3,7,8-PECDD	na	na	na	38.8	EMPC	J	*0.584*	*0.584*	3.54	J	J			5.17	J	J		
1,2,3,4,7,8-HXCDD	460	100	na	43.8					3.75	J	J			6.11				
1,2,3,6,7,8-HXCDD	460	100	na	85.6					8.13					9.98				
1,2,3,7,8,9-HXCDD	460	100	na	80.7					7.67					10.2				
1,2,3,4,6,7,8-HPCDD	na	na	na	1730					158					155				
OCDD	na	na	na	11500	E	J			5280	E	J			2670				
1,2,3,7,8-PECDF	na	na	na	26.1					3.42	J	J			6.31				
2,3,4,7,8-PECDF	na	na	na	45.3					7.92					8.67				
1,2,3,4,7,8-HXCDF	na	na	na	59.3					12.1					10.8				
1,2,3,6,7,8-HXCDF	na	na	na	47.7					7.36					7.82				
2,3,4,6,7,8-HXCDF	na	na	na	58					9.75					10.6				
1,2,3,7,8,9-HXCDF	na	na	na	15					2.73	J	J			2.79	J	J		
1,2,3,4,6,7,8-HPCDF	na	na	na	467					52.3					47.3				
1,2,3,4,7,8,9-HPCDF	na	na	na	33.3					4.06	J	J			3.52	J	J		
OCDF	na	na	na	1000					60.1					52				
TOTAL TCDD	na	na	na	166	EMPC	J			27.6	EMPC	J			40.4	EMPC	J		
TOTAL PECDD	na	na	na	347	Q, EMPC	J			46.1					73.3				
TOTAL HXCDD	460	100	na	828					80.6					113				
TOTAL HPCDD	na	na	na	3880					373					370				
TOTAL TCDF	na	na	na	408	Q, EMPC	J			77.5	EMPC	J			81.4	EMPC	J		
TOTAL PECDF	na	na	na	362	Q, EMPC	J			66.9	EMPC	J			73.2	EMPC	J		
TOTAL HXCDF	na	na	na	542					76.3	EMPC	J			86				
TOTAL HPCDF	na	na	na	1330					100					95.7	EMPC	J		

**Refer to legend immediately following this table for a list of definitions and table notes

Table 4-2
Analytes Detected in FLFA Soil - 2007 Investigation
Page 2 of 6

Analyte			Sample ID	**LFSS07**					**LFSS08**					**LFSS09**				
			Sample Date	**8/2/07**					**8/2/07**					**8/2/07**				
			Sample Depth	**0-0.5**					**0-0.5**					**0-0.5**				
	i-RBC	**r-RBC**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PCBs (mg/kg)																		
PCB-1254	1.4	0.16	na	0.0135	J	J	*0.009*	*0.018*	0.309			*0.043*	*0.087*	0.0453	J	J	*0.0098*	*0.02*
PCB-1260	1.4	0.32	na	0.018	U		*0.009*	*0.018*	0.087	U		*0.043*	*0.087*	0.0621	J	J	*0.0098*	*0.02*
Metals (mg/kg)																		
Aluminum	100000	7800	40041	14300		J	*2.7*	*11*	9770		J	*2.5*	*10*	16400		J	*2.9*	*12*
Antimony	41	3.1	na	0.34	J	B	*0.21*	*3.3*	0.42	J	B	*0.2*	*3.1*	1	J	B	*0.23*	*3.6*
Arsenic	1.9	0.43	15.8	1.9		J	*0.22*	*0.44*	2.6		J	*0.2*	*0.41*	5.1		J	*0.23*	*0.48*
Barium	20000	1600	209	79.9		J	*0.28*	*11*	65.1		J	*0.26*	*10*	70.6		J	*0.3*	*12*
Beryllium	200	16	1.02	0.8		B	*0.11*	*0.56*	0.9		B	*0.11*	*0.56*	**1.5**		**B**	*0.12*	*0.6*
Cadmium	51	3.9	0.69	0.55	U	UL	*0.55*	*0.88*	1	U	UL	*1*	*2.1*	1.2	U	UL	*1.2*	*2.4*
Calcium	na	na	na	5540		J	*5.5*	*280*	3740		J	*5.2*	*260*	1580		J	*6*	*300*
Chromium	310	23	65.3	18.5		J	*0.078*	*0.55*	13.1		J	*0.072*	*0.52*	35.7		J	*0.083*	*0.6*
Cobalt	na	na	72.3	8.7		J	*0.061*	*2.8*	6.4		J	*0.057*	*2.6*	12.1		J	*0.066*	*3*
Copper	4100	310	53.5	46.4		J	*0.11*	*1.4*	30.3		J	*0.098*	*1.3*	**62.1**		**J**	*0.11*	*1.5*
Iron	72000	5500	50962	17800		J	*0.78*	*5.5*	14100		J	*0.72*	*5.2*	25000		J	*0.83*	*6*
Lead	800	400	26.8	**51.1**		**J**	*0.13*	*5.5*	**37.1**		**J**	*0.12*	*5.2*	**126**		**J**	*0.14*	*6*
Magnesium	na	na	na	4910		J	*5.5*	*280*	2720		J	*5.2*	*260*	5160		J	*6*	*300*
Manganese	2000	160	2543	417	C	J	*0.055*	*0.83*	247	C	J	*0.052*	*0.77*	467	C	J	*0.06*	*0.89*
Mercury	31	2.3	0.13	0.049	J	J	*0.011*	*0.086*	0.03	J	J	*0.011*	*0.086*	0.12		J	*0.012*	*0.096*
Nickel	2000	160	62.8	12.3		J	*0.14*	*2.2*	7.7		J	*0.13*	*2.1*	16.3		J	*0.15*	*2.4*
Potassium	na	na	na	1520		J	*5.5*	*550*	1130		J	*5.2*	*520*	1530		J	*6*	*600*
Selenium	510	39	na	0.51	J	L	*0.25*	*5.5*	0.5	J	L	*0.23*	*5.2*	0.7	J	L	*0.27*	*6*
Silver	510	39	na	6.1		L	*0.078*	*0.55*	0.11	J	L	*0.072*	*0.52*	0.19	J	L	*0.083*	*0.6*
Sodium	na	na	na	264	J	B	*28*	*550*	214	J	B	*26*	*520*	341	J	L	*30*	*600*
Thallium	7.2	0.55	2.11	0.78	J	B	*0.62*	*1*	0.83	J	B	*0.6*	*1*	1.3		B	*0.66*	*1.2*
Vanadium	102	7.8	108	33.1		J	*0.055*	*2.8*	21.6		J	*0.052*	*2.6*	53		J	*0.06*	*3*
Zinc	31000	2300	202	123		J	*0.28*	*1.1*	44		J	*0.26*	*1*	145		J	*0.3*	*1.2*
Dioxins/Furans (ng/kg)																		
2,3,7,8-TCDF	na	na	na	3.6					1.62					6.94				
2,3,7,8-TCDD	19	4.3	na	1.25					0.682	J	B			3.03				
1,2,3,7,8-PECDD	na	na	na	4.6	J	J			0.932	J	J			4.8	J	J		
1,2,3,4,7,8-HXCDD	460	100	na	4.71	J	J			1.29	J	J			6.1				
1,2,3,6,7,8-HXCDD	460	100	na	8.42					2.32	J	J			9.94				
1,2,3,7,8,9-HXCDD	460	100	na	8.88					2.76	J	J			10.6				
1,2,3,4,6,7,8-HPCDD	na	na	na	167					57.2					250				
OCDD	na	na	na	4700	E	J			1440					7270	E	J		
1,2,3,7,8-PECDF	na	na	na	4.91	J	J			1.8	J	J			5.28	J	J		
2,3,4,7,8-PECDF	na	na	na	6.99					1.37	J, EMPC	J	*1.37*	*1.37*	5.6	J	J		
1,2,3,4,7,8-HXCDF	na	na	na	11.6					2.15	J	J			8.36				
1,2,3,6,7,8-HXCDF	na	na	na	8.51					1.4	J, EMPC	J	*1.4*	*1.4*	5.46	J	J		
2,3,4,6,7,8-HXCDF	na	na	na	10.1					1.76	J	J			6.04				
1,2,3,7,8,9-HXCDF	na	na	na	2.84	J	J			0.387	J, EMPC	J	*0.378*	*0.378*	1.51	J	J		
1,2,3,4,6,7,8-HPCDF	na	na	na	61.4					12.1					44.6				
1,2,3,4,7,8,9-HPCDF	na	na	na	5.15					0.845	J	J			3.15	J	J		
OCDF	na	na	na	101					23.1					84.9				
TOTAL TCDD	na	na	na	27.6					4.61	EMPC	J			34.1	EMPC	J		
TOTAL PECDD	na	na	na	56.6					12.8	EMPC	J			53	EMPC	J		
TOTAL HXCDD	460	100	na	94.4					25.5	EMPC	J			108				
TOTAL HPCDD	na	na	na	399					137					619				
TOTAL TCDF	na	na	na	63.8	EMPC	J			14.4	EMPC	J			63.3	EMPC	J		
TOTAL PECDF	na	na	na	62.4	EMPC	J			14.1	EMPC	J			53.8	EMPC	J		
TOTAL HXCDF	na	na	na	92.8	EMPC	J			18	EMPC	J			67.1				
TOTAL HPCDF	na	na	na	142					32					116	EMPC	J		

**Refer to legend immediately following this table for a list of definitions and table notes

Table 4-2
Analytes Detected in FLFA Soil - 2007 Investigation
Page 3 of 6

Analyte			Sample ID Sample Date Sample Depth	**LFSS10** **8/2/07** **0-0.5**					**LFSS11** **8/2/07** **0-0.5**					**LFSS12** **8/2/07** **0-0.5**				
	i-RBC	**r-RBC**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PCBs (mg/kg)																		
PCB-1254	1.4	0.16	na	0.067	J	J	*0.011*	*0.022*	0.402			*0.047*	*0.095*	0.117			*0.01*	*0.02*
PCB-1260	1.4	0.32	na	0.0373	J	J	*0.011*	*0.022*	0.095	U		*0.047*	*0.095*	0.02	U		*0.01*	*0.02*
Metals (mg/kg)																		
Aluminum	100000	7800	40041	14400		J	*3.1*	*13*	17300		J	*2.6*	*11*	18700		J	*3*	*12*
Antimony	41	3.1	na	0.88	J	B	*0.25*	*3.9*	0.89	J	B	*0.2*	*3.2*	0.86	J	B	*0.23*	*3.7*
Arsenic	1.9	0.43	15.8	3.7		J	*0.25*	*0.52*	6.1		J	*0.21*	*0.43*	6.8		J	*0.24*	*0.49*
Barium	20000	1600	209	69.7		J	*0.33*	*13*	89.8		J	*0.27*	*11*	112		J	*0.31*	*12*
Beryllium	200	16	1.02	**1.7**		**B**	*0.13*	*0.66*	0.7		B	*0.11*	*0.54*	**1.2**		**B**	*0.12*	*0.62*
Cadmium	51	3.9	0.69	1.3	U	UL	*1.3*	*2.6*	1.1	U	UL	*1.1*	*2.2*	1.2	U	UL	*1.2*	*2.5*
Calcium	na	na	na	2070		J	*6.5*	*330*	8340		J	*5.4*	*270*	2930		J	*6.2*	*310*
Chromium	310	23	65.3	29.9		J	*0.091*	*0.65*	24.3		J	*0.075*	*0.54*	32.1		J	*0.086*	*0.62*
Cobalt	na	na	72.3	13.7		J	*0.072*	*3.3*	6.3		J	*0.059*	*2.7*	10.6		J	*0.068*	*3.1*
Copper	4100	310	53.5	**92.3**		**J**	*0.12*	*1.6*	**86.2**		**J**	*0.1*	*1.3*	**121**		**J**	*0.12*	*1.5*
Iron	72000	5500	50962	28700		J	*0.91*	*6.5*	21900		J	*0.75*	*5.4*	25200		J	*0.86*	*6.2*
Lead	800	400	26.8	**86.2**		**J**	*0.16*	*6.5*	**372**	**C**	**J**	*0.13*	*5.4*	**241**		**J**	*0.15*	*6.2*
Magnesium	na	na	na	4540		J	*6.5*	*330*	4460		J	*5.4*	*270*	15000		J	*6.2*	*310*
Manganese	2000	160	2543	500	C	J	*0.065*	*0.98*	823		J	*0.54*	*8.1*	607		J	*0.062*	*0.92*
Mercury	31	2.3	0.13	0.12		J	*0.013*	*0.1*	**0.16**		**J**	*0.011*	*0.09*	0.1		J	*0.012*	*0.098*
Nickel	2000	160	62.8	18.7		J	*0.16*	*2.6*	25.6		J	*0.13*	*2.2*	19.5		J	*0.15*	*2.5*
Potassium	na	na	na	1440		J	*6.5*	*650*	1400		K	*5.4*	*540*	3510		K	*6.2*	*620*
Selenium	510	39	na	0.78	J	L	*0.29*	*6.5*	0.37	J	L	*0.24*	*5.4*	0.34	J	L	*0.28*	*6.2*
Silver	510	39	na	0.5	J	L	*0.091*	*0.65*	0.18	J	K	*0.075*	*0.54*	0.39	J	K	*0.086*	*0.62*
Sodium	na	na	na	357	J	L	*33*	*650*	344	J	J	*27*	*540*	397	J	J	*31*	*620*
Thallium	7.2	0.55	2.11	2		B	*0.74*	*1.2*	0.6	U		*0.6*	*1*	0.64	U		*0.64*	*1.2*
Vanadium	102	7.8	108	45		J	*0.065*	*3.3*	45.3		J	*0.054*	*2.7*	40.2		J	*0.062*	*3.1*
Zinc	31000	2300	202	**223**		**J**	*0.33*	*1.3*	132		J	*0.27*	*1.1*	172		J	*0.31*	*1.2*
Dioxins/Furans (ng/kg)																		
2,3,7,8-TCDF	na	na	na	13.4					9.35					7.34				
2,3,7,8-TCDD	19	4.3	na	16.1					3.94					1.79				
1,2,3,7,8-PECDD	na	na	na	12.1					14.3					5.6	J	J		
1,2,3,4,7,8-HXCDD	460	100	na	12.9					14.1					5.98	J	J		
1,2,3,6,7,8-HXCDD	460	100	na	21					22.8					10.3				
1,2,3,7,8,9-HXCDD	460	100	na	23.3					25.3					11.1				
1,2,3,4,6,7,8-HPCDD	na	na	na	395					458					171				
OCDD	na	na	na	7690	E	J			7440	E	J			1300		K		
1,2,3,7,8-PECDF	na	na	na	10.5					10.6					6.02	J	J		
2,3,4,7,8-PECDF	na	na	na	14.1					14.6					7.4				
1,2,3,4,7,8-HXCDF	na	na	na	20.8					20					8.77				
1,2,3,6,7,8-HXCDF	na	na	na	13.6					13.8					6.47				
2,3,4,6,7,8-HXCDF	na	na	na	15.1					17.3					8.26				
1,2,3,7,8,9-HXCDF	na	na	na	3.64	J	J			4.41	J	J			2.25	J	J		
1,2,3,4,6,7,8-HPCDF	na	na	na	89.9					112					47.6				
1,2,3,4,7,8,9-HPCDF	na	na	na	5.89	J	J			7.39					3.58	J	J		
OCDF	na	na	na	133					191					74.5				
TOTAL TCDD	na	na	na	96	EMPC	J			85	EMPC	J			40.2				
TOTAL PECDD	na	na	na	147					163					68.7				
TOTAL HXCDD	460	100	na	245					255					109	EMPC	J		
TOTAL HPCDD	na	na	na	984					1080					384				
TOTAL TCDF	na	na	na	155	EMPC	J			187	EMPC	J			87.9	EMPC	J		
TOTAL PECDF	na	na	na	123	EMPC	J			127	EMPC	J			66.1	EMPC	J		
TOTAL HXCDF	na	na	na	148	EMPC	J			172	EMPC	J			77.4				
TOTAL HPCDF	na	na	na	187					282					115	EMPC	J		

**Refer to legend immediately following this table for a list of definitions and table notes

Table 4-2
Analytes Detected in FLFA Soil - 2007 Investigation
Page 4 of 6

Analyte			Sample ID	LFSS13					LFSS14					LFSS15				
			Sample Date	8/2/07					8/2/07					8/2/07				
			Sample Depth	0-0.5					0-0.5					0-0.5				
	i-RBC	r-RBC	Background	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PCBs (mg/kg)																		
PCB-1254	1.4	0.16	na	0.111			0.011	0.021	0.0533			0.01	0.02	0.151			0.018	0.037
PCB-1260	1.4	0.32	na	0.021	U		0.011	0.021	0.02	U		0.01	0.02	0.037	U		0.018	0.037
Metals (mg/kg)																		
Aluminum	100000	7800	40041	20400		J	2.9	12	14400		J	2.7	11	17900		J	2.6	11
Antimony	41	3.1	na	1.4	J	B	0.23	3.6	0.65	J	B	0.22	3.4	0.74	J	B	0.2	3.2
Arsenic	1.9	0.43	15.8	**31.4**		**J**	0.23	0.48	4.3		J	0.22	0.45	4.9		J	0.21	0.43
Barium	20000	1600	209	84		J	0.3	12	52.9		J	0.28	11	75.5		J	0.27	11
Beryllium	200	16	1.02	**1.3**		**B**	0.12	0.6	0.64		B	0.11	0.56	0.7		B	0.11	0.54
Cadmium	51	3.9	0.69	0.14	J	L	0.06	0.24	1.1	U	UL	1.1	2.3	1.1	U	UL	1.1	2.1
Calcium	na	na	na	10600		J	6	300	1590		J	5.7	280	6850		J	5.3	270
Chromium	310	23	65.3	44		J	0.083	0.6	27.6		J	0.079	0.57	29.9		J	0.075	0.53
Cobalt	na	na	72.3	11.2		J	0.066	3	6.9		J	0.062	2.8	7.1		J	0.059	2.7
Copper	4100	310	53.5	**7560**		**J**	5.7	75	37.5		J	0.11	1.4	33.4		J	0.1	1.3
Iron	72000	5500	50962	24600		J	0.83	6	20400		J	0.79	5.7	23100		J	0.75	5.3
Lead	800	400	26.8	**161**		**J**	0.14	6	**35.9**		**J**	0.14	5.7	**186**		**J**	0.13	5.3
Magnesium	na	na	na	9290		J	6	300	1070		J	5.7	280	3500		J	5.3	270
Manganese	2000	160	2543	794		J	1.2	18	548		J	0.057	0.85	680		J	0.53	8
Mercury	31	2.3	0.13	0.087	J	J	0.012	0.099	0.1		J	0.012	0.095	**0.14**		**J**	0.011	0.086
Nickel	2000	160	62.8	34.9		J	0.15	2.4	7.5		J	0.14	2.3	10.4		J	0.13	2.1
Potassium	na	na	na	2250		J	6	600	712		J	5.7	570	957		J	5.3	530
Selenium	510	39	na	0.39	J	L	0.27	6	1.3	J	L	0.26	5.7	0.79	J	L	0.24	5.3
Silver	510	39	na	0.53	J	L	0.083	0.6	0.19	J	L	0.079	0.57	0.075	U	UL	0.075	0.53
Sodium	na	na	na	527	J	L	30	600	228	J	B	28	570	304	J	L	27	530
Thallium	7.2	0.55	2.11	0.66	U	UL	0.66	1.2	1.7		B	0.64	1.1	0.78	J	B	0.6	1
Vanadium	102	7.8	108	48.1		J	0.06	3	45.2		J	0.057	2.8	51.3		J	0.053	2.7
Zinc	31000	2300	202	**2820**		**J**	6	24	60.5		J	0.28	1.1	111		J	0.27	1.1
Dioxins/Furans (ng/kg)																		
2,3,7,8-TCDF	na	na	na	40.3					2.77					3.83				
2,3,7,8-TCDD	19	4.3	na	12.9					1.01	J, EMPC	J	0.143	0.143	1.84				
1,2,3,7,8-PECDD	na	na	na	35.9					2.76	J	J			5.6	J	J		
1,2,3,4,7,8-HXCDD	460	100	na	27					2.85	J	J			4.95	J	J		
1,2,3,6,7,8-HXCDD	460	100	na	53.8					5.01	J	J			9.97				
1,2,3,7,8,9-HXCDD	460	100	na	57.2					5.47	J	J			11.2				
1,2,3,4,6,7,8-HPCDD	na	na	na	798					123					203				
OCDD	na	na	na	6770	E	J			4270					3430				
1,2,3,7,8-PECDF	na	na	na	40					2.15	J	J			3.26	J	J		
2,3,4,7,8-PECDF	na	na	na	79.5					3.63	J	J			4.3	J	J		
1,2,3,4,7,8-HXCDF	na	na	na	82.9					4.53	J	J			5.97	J	J		
1,2,3,6,7,8-HXCDF	na	na	na	75.5					3.88	J	J			4.69	J	J		
2,3,4,6,7,8-HXCDF	na	na	na	92.9					4.44	J	J			5.07	J	J		
1,2,3,7,8,9-HXCDF	na	na	na	16.1					0.955	J	J			1.22	J	J		
1,2,3,4,6,7,8-HPCDF	na	na	na	457					25.9					38.9				
1,2,3,4,7,8,9-HPCDF	na	na	na	19.5					2.15	J	J			3.12	J	J		
OCDF	na	na	na	327					41.3					80.6				
TOTAL TCDD	na	na	na	257	Q, EMPC	J			15.3	EMPC	J			28.2	EMPC	J		
TOTAL PECDD	na	na	na	370	Q, EMPC	J			30.1	EMPC	J			53.5	EMPC	J		
TOTAL HXCDD	460	100	na	675					57.9					106				
TOTAL HPCDD	na	na	na	1660					314					463				
TOTAL TCDF	na	na	na	1220	Q, EMPC	J			41.4	EMPC	J			53.7	EMPC	J		
TOTAL PECDF	na	na	na	1040	Q, EMPC	J			29	EMPC	J			37.5	EMPC	J		
TOTAL HXCDF	na	na	na	858					37.3	EMPC	J			51.8	EMPC	J		
TOTAL HPCDF	na	na	na	667					57.8					106				

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Table 4-2
Analytes Detected in FLFA Soil - 2007 Investigation
Page 5 of 6

Analyte			Sample ID	LFSS16					LFSS17					LFSS18				
			Sample Date	8/2/07					8/2/07					8/2/07				
			Sample Depth	0-0.5					0-0.5					0-0.5				
	i-RBC	r-RBC	Background	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PCBs (mg/kg)																		
PCB-1254	1.4	0.16	na	0.18	U		*0.088*	*0.18*	0.0642	J	J	*0.0094*	*0.019*	0.11	J	J	*0.0099*	*0.02*
PCB-1260	1.4	0.32	na	1.09			*0.088*	*0.18*	0.133	J	J	*0.0094*	*0.019*	0.0677	J	J	*0.0099*	*0.02*
Metals (mg/kg)																		
Aluminum	100000	7800	40041	20000		J	*2.7*	*11*	19300		J	*2.8*	*12*	16100		J	*2.7*	*11*
Antimony	41	3.1	na	1.1	J	B	*0.21*	*3.3*	5.3		L	*0.22*	*3.5*	1.4	J	B	*0.22*	*3.4*
Arsenic	1.9	0.43	15.8	3		J	*0.22*	*0.44*	10.7		J	*0.23*	*0.47*	5.3		J	*0.22*	*0.46*
Barium	20000	1600	209	68.3		J	*0.28*	*11*	**2420**		**J**	*5.9*	*230*	**438**	**C**	**J**	*0.29*	*11*
Beryllium	200	16	1.02	**1.4**		**B**	*0.11*	*0.56*	**1.6**		**B**	*0.12*	*0.58*	**1.4**		**B**	*0.11*	*0.58*
Cadmium	51	3.9	0.69	0.056	U	UL	*0.056*	*0.22*	**5.1**		**L**	*0.059*	*0.23*	0.45		L	*0.057*	*0.23*
Calcium	na	na	na	14200		J	*5.6*	*280*	12400		J	*5.9*	*290*	11300		J	*5.7*	*290*
Chromium	310	23	65.3	30.5		J	*0.078*	*0.56*	59.1		J	*0.082*	*0.59*	33.2		J	*0.08*	*0.57*
Cobalt	na	na	72.3	8.3		J	*0.061*	*2.8*	10.2		J	*0.065*	*2.9*	26.9		J	*0.063*	*2.9*
Copper	4100	310	53.5	**97.3**		**J**	*0.11*	*1.4*	**3090**		**J**	*2.2*	*29*	**179**		**J**	*0.11*	*1.4*
Iron	72000	5500	50962	20600		J	*0.78*	*5.6*	25500		J	*0.82*	*5.9*	26200		J	*0.8*	*5.7*
Lead	800	400	26.8	**1550**		**J**	*1.3*	*56*	**1660**		**J**	*2.8*	*120*	**294**	**C**	**J**	*0.14*	*5.7*
Magnesium	na	na	na	24100		J	*5.6*	*280*	12100		J	*5.9*	*290*	8400		J	*5.7*	*290*
Manganese	2000	160	2543	355		J	*0.56*	*8.3*	907		J	*1.2*	*18*	1940		J	*0.57*	*8.6*
Mercury	31	2.3	0.13	0.048	J	J	*0.011*	*0.086*	**0.89**		**J**	*0.036*	*0.29*	**0.45**		**J**	*0.011*	*0.091*
Nickel	2000	160	62.8	19.8		J	*0.14*	*2.2*	48.3		J	*0.15*	*2.3*	20.3		J	*0.14*	*2.3*
Potassium	na	na	na	3590		J	*5.6*	*560*	2250		J	*5.9*	*590*	2030		J	*5.7*	*570*
Selenium	510	39	na	0.25	U	UL	*0.25*	*5.6*	0.68	J	L	*0.26*	*5.9*	0.49	J	L	*0.26*	*5.7*
Silver	510	39	na	0.36	J	L	*0.078*	*0.56*	65.2		L	*0.082*	*0.59*	6.2		L	*0.08*	*0.57*
Sodium	na	na	na	362	J	L	*28*	*560*	915		L	*29*	*590*	435	J	L	*29*	*570*
Thallium	7.2	0.55	2.11	0.62	U	UL	*0.62*	*1.1*	0.66	U	UL	*0.66*	*1.2*	0.64	U	UL	*0.64*	*1.2*
Vanadium	102	7.8	108	44.6		J	*0.056*	*2.8*	39		J	*0.059*	*2.9*	37.3		J	*0.057*	*2.9*
Zinc	31000	2300	202	135		J	*0.28*	*1.1*	**3150**		**J**	*5.9*	*23*	**369**	**C**	**J**	*0.29*	*1.1*
Dioxins/Furans (ng/kg)																		
2,3,7,8-TCDF	na	na	na	6.29					41.8					19.5				
2,3,7,8-TCDD	19	4.3	na	1.11	J	J			5.67					3.32				
1,2,3,7,8-PECDD	na	na	na	3.2	J	J			21.7					15.4				
1,2,3,4,7,8-HXCDD	460	100	na	2.91	J, EMPC	J	*0.57*	*0.57*	23					23.7				
1,2,3,6,7,8-HXCDD	460	100	na	6.89					46.5					37.1				
1,2,3,7,8,9-HXCDD	460	100	na	6.57					40.3					33.6				
1,2,3,4,6,7,8-HPCDD	na	na	na	144					509					507				
OCDD	na	na	na	1780					3760					4400				
1,2,3,7,8-PECDF	na	na	na	3.44	J	J			63.2					24.6				
2,3,4,7,8-PECDF	na	na	na	4.65	J	J			79.5					43.3				
1,2,3,4,7,8-HXCDF	na	na	na	24					107					61.9				
1,2,3,6,7,8-HXCDF	na	na	na	4.95	J	J			97					50.2				
2,3,4,6,7,8-HXCDF	na	na	na	5.98					116					59.5				
1,2,3,7,8,9-HXCDF	na	na	na	1.59	J	J			29.8					16.4				
1,2,3,4,6,7,8-HPCDF	na	na	na	49.2					567					300				
1,2,3,4,7,8,9-HPCDF	na	na	na	4.11	J	J			42.4					27.7				
OCDF	na	na	na	72.5					414					257				
TOTAL TCDD	na	na	na	21.5	EMPC	J			241	Q	J			135				
TOTAL PECDD	na	na	na	36.3	EMPC	J			355					218	Q, EMPC	J		
TOTAL HXCDD	460	100	na	64	EMPC	J			534					447				
TOTAL HPCDD	na	na	na	321					1290					1170				
TOTAL TCDF	na	na	na	73.3	EMPC	J			882	EMPC	J			353	Q, EMPC	J		
TOTAL PECDF	na	na	na	108	EMPC	J			715	Q, EMPC	J			314	Q, EMPC	J		
TOTAL HXCDF	na	na	na	84.3					820					459				
TOTAL HPCDF	na	na	na	110					903					525				

**Refer to legend immediately following this table for a list of definitions and table notes

Table 4-2
Analytes Detected in FLFA Soil - 2007 Investigation
Page 6 of 6

Analyte			Sample ID Sample Date Sample Depth	**LFSS19** **8/2/07** **0-0.5**					**LFSS20** **8/2/07** **0-0.5**					**LFSS21** **8/2/07** **0-0.5**				
	i-RBC	**r-RBC**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
PCBs (mg/kg)																		
PCB-1254	1.4	0.16	na	0.0343			0.01	0.02	0.331	J	J	0.051	0.1	0.206	J	J	0.053	0.11
PCB-1260	1.4	0.32	na	0.02	U		0.01	0.02	0.125	J	J	0.051	0.1	0.179	J	J	0.053	0.11
Metals (mg/kg)																		
Aluminum	100000	7800	40041	18500		J	2.9	12	35600		J	29	120	21800		J	3	13
Antimony	41	3.1	na	1.3	J	B	0.23	3.6	6.2		L	0.23	3.6	3.8		B	0.24	3.8
Arsenic	1.9	0.43	15.8	7.3		J	0.23	0.48	13.8		J	0.23	0.48	14.1		J	0.24	0.5
Barium	20000	1600	209	72.3		J	0.3	12	**824**		**J**	3	120	**776**		**J**	3.1	130
Beryllium	200	16	1.02	0.79		B	0.12	0.6	0.64		B	0.12	0.6	**1.6**		**B**	0.12	0.62
Cadmium	51	3.9	0.69	1.5	U	UL	1.5	2.4	**6.6**		**L**	0.06	0.24	**4.4**		**L**	0.063	0.25
Calcium	na	na	na	1740		J	6	300	8950		J	6	300	19200		J	6.3	310
Chromium	310	23	65.3	59.1		J	0.084	0.6	**162**		**J**	0.084	0.6	55.8		J	0.088	0.63
Cobalt	na	na	72.3	18		J	0.066	3	13.7		J	0.066	3	12.4		J	0.069	3.1
Copper	4100	310	53.5	**55.1**		**J**	0.11	1.5	**37200**		**J**	23	300	**1130**		**J**	1.2	16
Iron	72000	5500	50962	40900		J	8.4	60	40800		J	8.4	60	48900		J	8.8	63
Lead	800	400	26.8	**105**		**J**	0.14	6	**36500**		**J**	29	1200	**1230**		**J**	1.5	63
Magnesium	na	na	na	1280		J	6	300	4880		J	6	300	15600		J	6.3	310
Manganese	2000	160	2543	732		J	0.6	9	906		J	0.6	9	809		J	0.63	9.4
Mercury	31	2.3	0.13	**0.21**		**J**	0.011	0.091	**0.15**		**J**	0.011	0.091	**2.2**		**J**	0.066	0.54
Nickel	2000	160	62.8	10.2		J	0.15	2.4	**123**		**J**	0.15	2.4	49.4		J	0.16	2.5
Potassium	na	na	na	945		J	6	600	2320		J	6	600	1970		J	6.3	630
Selenium	510	39	na	1.3	J	L	0.27	6	0.27	U	UL	0.27	6	0.28	U	UL	0.28	6.3
Silver	510	39	na	2.5		L	0.084	0.6	7.5		L	0.084	0.6	24.2		L	0.088	0.63
Sodium	na	na	na	376	J	L	30	600	3230		L	30	600	850		L	31	630
Thallium	7.2	0.55	2.11	**2.9**		**B**	0.64	1.2	0.64	U	UL	0.64	1.2	0.7	U	UL	0.7	1.2
Vanadium	102	7.8	108	75.6		J	0.06	3	35.1		J	0.06	3	40.5		J	0.063	3.1
Zinc	31000	2300	202	133		J	0.3	1.2	**22100**		**J**	60	240	**2090**		**J**	3.1	13
Dioxins/Furans (ng/kg)																		
2,3,7,8-TCDF	na	na	na	12.6					245					43.5				
2,3,7,8-TCDD	19	4.3	na	2.78					166					8.08				
1,2,3,7,8-PECDD	na	na	na	7.19					481					39				
1,2,3,4,7,8-HXCDD	460	100	na	7.29					428					52.1				
1,2,3,6,7,8-HXCDD	460	100	na	13.7					821					75.4				
1,2,3,7,8,9-HXCDD	460	100	na	13.2					826					70.3				
1,2,3,4,6,7,8-HPCDD	na	na	na	215					18100					1010				
OCDD	na	na	na	7090	E	J			135000					6530	E	J		
1,2,3,7,8-PECDF	na	na	na	12.2					273					57.5				
2,3,4,7,8-PECDF	na	na	na	18.8					507					99.2				
1,2,3,4,7,8-HXCDF	na	na	na	25.1					437					137				
1,2,3,6,7,8-HXCDF	na	na	na	19.3					381					117				
2,3,4,6,7,8-HXCDF	na	na	na	24.7					484					157				
1,2,3,7,8,9-HXCDF	na	na	na	6.79					83.3					37.5				
1,2,3,4,6,7,8-HPCDF	na	na	na	108					2330					727				
1,2,3,4,7,8,9-HPCDF	na	na	na	9.47					159					60.2				
OCDF	na	na	na	86.3					4090					565				
TOTAL TCDD	na	na	na	53.9	EMPC	J			2770	Q	J			333				
TOTAL PECDD	na	na	na	92.3					4130	Q	J			545	Q, EMPC	J		
TOTAL HXCDD	460	100	na	149					8090					953				
TOTAL HPCDD	na	na	na	526					34500					2340				
TOTAL TCDF	na	na	na	160	EMPC	J			6890	Q, EMPC	J			972	EMPC	J		
TOTAL PECDF	na	na	na	145	EMPC	J			4380	Q, EMPC	J			873	Q, EMPC	J		
TOTAL HXCDF	na	na	na	175	EMPC	J			3900	Q	J			1110				
TOTAL HPCDF	na	na	na	186					6470					1220				

**Refer to legend immediately following this table for a list of definitions and table notes

Table 4-2
Legend

12	J	Shading and black font indicate an industrial RBC exceedance.
12	J	Bold outline indicates a residential RBC exceedance.
12	**J**	Bold, underlined font indicates a background 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 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 (October 2007).
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: Guidance Document (April 1999).
mg/kg = milligrams per kilogram (parts per million).
ng/kg = nanograms per kilogram (parts per trillion).
μg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.
Lab Q = Lab Data Qualifiers
B = (organics) Blank contamination. Value detected in sample and associated blank.
A (Dioxins) = B = (metals) Value <MRL and >MDL and is considered estimated.
E (metals) = Reported value is estimated because of the presence of interferences.
EMPC (Dioxins) = The ion-abundance ratio between the two characteristic PCDD/PCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).
J = (organics) Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.
X = (dioxins) Ion abundance ratio outside acceptable range. Value reported is EMPC.
Val Q = 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
N = presumptive evidence for tentatively identified compounds using a library search
U = analyte not detected
UJ = estimated concentration non-detect
UL = estimated concentration non-detect bias low

Table 4-3
Summary of Analytes Detected in FLFA Soil - 2007 Investigation

Analyte	i-RBC	r-RBC	Background	# of i-RBC Exceedances	# of r-RBC Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
PCBs (mg/kg)											
PCB-1254	1.4	0.16	na	0	5	na	17	18	0.0135	0.402	LFSS11
PCB-1260	1.4	0.32	na	0	1	na	8	18	0.0373	1.09	LFSS16
Metals (mg/kg)											
Aluminum	100000	7800	40041	0	0	0	18	18	9770	35600	LFSS20
Antimony	41	3.1	na	0	3	na	18	18	0.34	6.2	LFSS20
Arsenic	1.9	0.43	15.8	1	1	1	18	18	1.9	31.4	LFSS13
Barium	20000	1600	209	0	1	5	18	18	52.9	2420	LFSS17
Beryllium	200	16	1.02	0	0	10	18	18	0.64	1.7	LFSS10
Cadmium	51	3.9	0.69	0	3	3	5	18	0.14	6.6	LFSS20
Calcium	na	na	na	na	na	na	18	18	1520	19200	LFSS21
Chromium	310	23	65.3	0	1	1	18	18	13.1	162	LFSS20
Cobalt	na	na	72.3	na	na	0	18	18	6.3	26.9	LFSS18
Copper	4100	310	53.5	2	4	14	18	18	30.3	37200	LFSS20
Iron	72000	5500	50962	0	0	0	18	18	14100	48900	LFSS21
Lead	800	400	26.8	4	4	18	18	18	35.9	36500	LFSS20
Magnesium	na	na	na	na	na	na	18	18	1070	24100	LFSS16
Manganese	2000	160	2543	0	0	0	18	18	247	2060	LFSS06
Mercury	31	2.3	0.13	0	0	9	18	18	0.03	2.2	LFSS21
Nickel	2000	160	62.8	0	0	1	18	18	7.5	123	LFSS20
Potassium	na	na	na	na	na	na	18	18	712	3590	LFSS16
Selenium	510	39	na	0	0	na	15	18	0.34	1.3	LFSS14
Silver	510	39	na	0	1	na	17	18	0.11	65.2	LFSS17
Sodium	na	na	na	na	na	na	18	18	214	3230	LFSS20
Thallium	7.2	0.55	2.11	0	1	1	7	18	0.78	2.9	LFSS19
Vanadium	102	7.8	108	0	0	0	18	18	21.6	75.6	LFSS19
Zinc	31000	2300	202	0	3	8	18	18	44	22100	LFSS20
Dioxins/Furans (ng/kg)											
2,3,7,8-TCDF	na	na	na	na	na	na	18	18	1.62	245	LFSS20
2,3,7,8-TCDD	19	4.3	na	1	6	na	18	18	0.682	166	LFSS20
1,2,3,7,8-PECDD	na	na	na	na	na	na	18	18	0.932	481	LFSS20
1,2,3,4,7,8-HXCDD	460	100	na	0	1	na	18	18	1.29	428	LFSS20
1,2,3,6,7,8-HXCDD	460	100	na	1	1	na	18	18	2.32	821	LFSS20
1,2,3,7,8,9-HXCDD	460	100	na	1	1	na	18	18	2.76	826	LFSS20
1,2,3,4,6,7,8-HPCDD	na	na	na	na	na	na	18	18	57.2	18100	LFSS20
OCDD	na	na	na	na	na	na	18	18	1300	135000	LFSS20
1,2,3,7,8-PECDF	na	na	na	na	na	na	18	18	1.8	273	LFSS20
2,3,4,7,8-PECDF	na	na	na	na	na	na	18	18	1.37	507	LFSS20
1,2,3,4,7,8-HXCDF	na	na	na	na	na	na	18	18	2.15	437	LFSS20
1,2,3,6,7,8-HXCDF	na	na	na	na	na	na	18	18	1.4	381	LFSS20
2,3,4,6,7,8-HXCDF	na	na	na	na	na	na	18	18	1.76	484	LFSS20
1,2,3,7,8,9-HXCDF	na	na	na	na	na	na	18	18	0.387	83.3	LFSS20
1,2,3,4,6,7,8-HPCDF	na	na	na	na	na	na	18	18	12.1	2330	LFSS20
1,2,3,4,7,8,9-HPCDF	na	na	na	na	na	na	18	18	0.845	159	LFSS20
OCDF	na	na	na	na	na	na	18	18	23.1	4090	LFSS20
TOTAL TCDD	na	na	na	na	na	na	18	18	4.61	2770	LFSS20
TOTAL PECDD	na	na	na	na	na	na	18	18	12.8	4130	LFSS20
TOTAL HXCDD	460	100	na	5	13	na	18	18	25.5	8090	LFSS20
TOTAL HPCDD	na	na	na	na	na	na	18	18	137	34500	LFSS20
TOTAL TCDF	na	na	na	na	na	na	18	18	14.4	6890	LFSS20
TOTAL PECDF	na	na	na	na	na	na	18	18	14.1	4380	LFSS20
TOTAL HXCDF	na	na	na	na	na	na	18	18	18	3900	LFSS20
TOTAL HPCDF	na	na	na	na	na	na	18	18	32	6470	LFSS20

screening levels in the samples. Total HXCDD exceeded its residential screening level in seven samples and the industrial screening level in three samples.

XRF Accuracy. Eighteen XRF screening samples were collected and analyzed for lead at a fixed-based lab to confirm the accuracy of the XRF data. In order to evaluate the accuracy of the XRF field screening results, the Pearson product moment correlation coefficient (r) (sometimes referred to as the MCV or PMCC) was used to compare the data sets. The correlation coefficient is a dimensionless index that ranges from -1 to +1 and reflects the degree of linear relationship between two variables or data sets. The equation for the Pearson product moment correlation coefficient used to calculate the correlation factor was as follows:

$$r = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

where:

x = the XRF lead screening results
$\bar{x}$ = the mean of the XRF lead screening results
y = the fixed-based laboratory confirmation results
$\bar{y}$ = the mean of the fixed-based laboratory confirmation results

A correlation factor of 1 indicates that there is a perfect positive linear relationship between variables, whereas a correlation factor of -1 is indicative of a perfect negative linear relationship between variables. A correlation of 0 means there is no linear relationship between the two variables. Correlations are rarely if ever 0, 1, or -1.

As shown on **Figure 4-5**, the XRF lead field screening results and fixed-based laboratory results were compared using the Pearson correlation. This comparison showed a correlation factor of 0.901511 between the XRF lead field screening results and the fixed-based lab analytical results. This correlation factor indicates that the XRF data correlates well with the fixed based laboratory results and can be used to accurately determine the area where lead is present above screening levels.

4.1.1.2 Soil Screening Level Comparison

As shown in **Table 4-4**, detected soil results from all FLFA soil samples were compared to USEPA Region III SSL soil transfer to groundwater values, using a dilution attenuation factor of 20 (USEPA, 2007a). As indicated in the table, four SVOCs [1,4-dichlorobenzene, bis(2-chloroethyl)ether, bis(chloroisopropyl)ether, and nitrobenzene], one PCB (Aroclor-1254), and six TAL metals (antimony, arsenic, chromium, copper, silver, and zinc) were found to exceed SSLs.

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.

As discussed in *Section 4.1.4*, groundwater samples were collected from two upgradient, one on-site, and two downgradient wells during the 2007 Investigation and analyzed for TCL VOCs, SVOCs, PAHs, pest/PCBs, explosives, herbicides, TAL metals, dioxins/furans, and perchlorate.

Figure 4-5
Lead Correlation
XRF Results vs. Fixed Based Lab Results

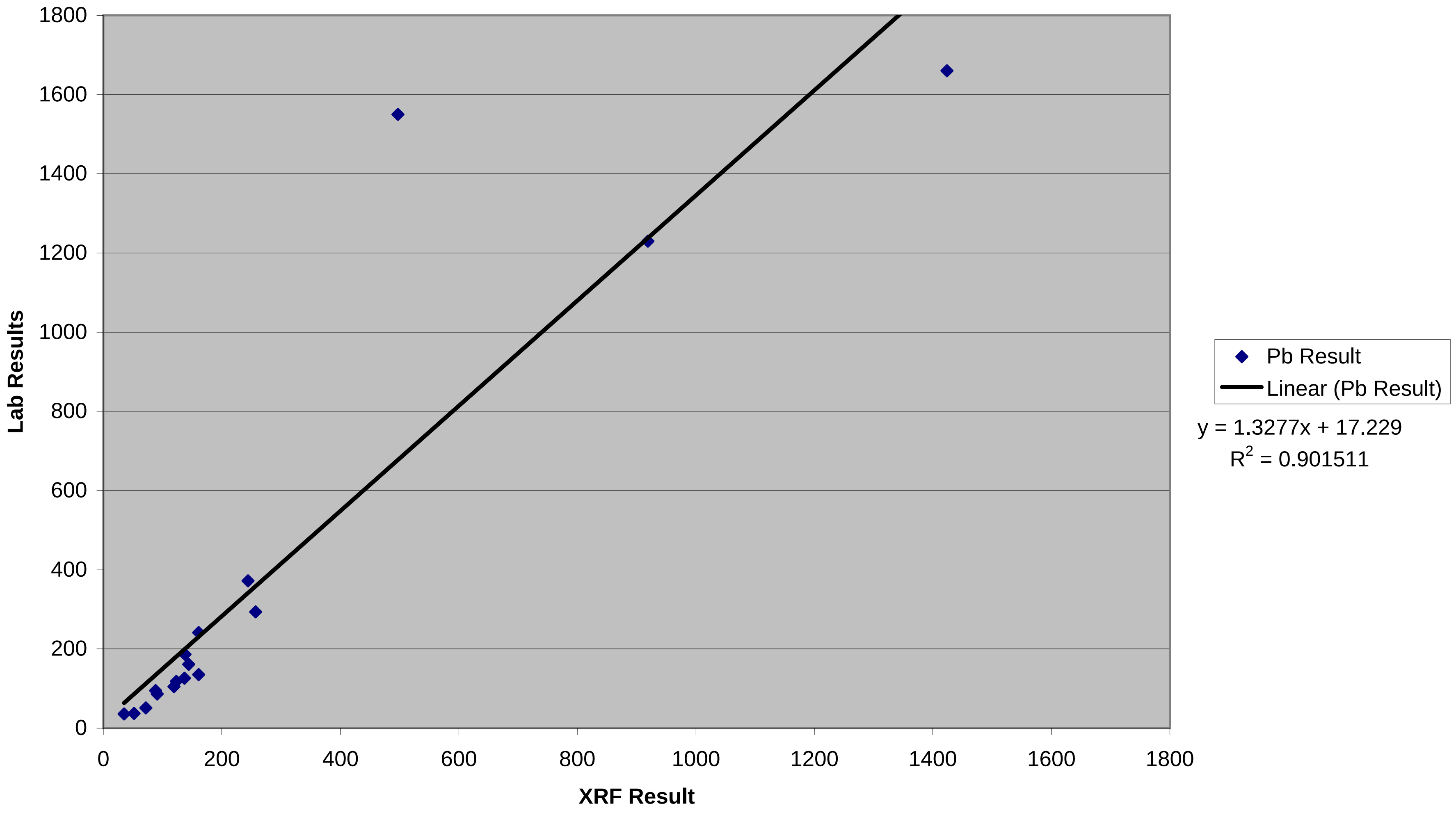


Table 4-4
Summary of SSL Exceedances in FLFA Soil
Page 1 of 2

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)													
Toluene	8200000	630000	na	27000	0	0	na	0	1	12	0.77	0.77	LFSS03
PAHs (ug/kg)													
2-Methylnaphthalene	410000	31000	na	4400	0	0	na	0	8	12	1	62	LFSB12A
Acenaphthene	6100000	470000	na	100000	0	0	na	0	6	12	1.2	2	LFSB15A
Acenaphthylene	3100000	230000	na	680000	0	0	na	0	6	12	0.76	2.6	LFSS03
Anthracene	31000000	2300000	na	470000	0	0	na	0	6	12	0.93	5.6	LFSS03
Benz(a)anthracene	3900	220	na	480	0	0	na	0	5	12	11	24	LFSS01
Benzo(a)pyrene	390	22	na	120	0	2	na	0	5	12	9.7	28	LFSS03
Benzo(b)fluoranthene	3900	220	na	1500	0	0	na	0	5	12	18	67	LFSS03
Benzo(g,h,i)perylene	3100000	230000	na	680000	0	0	na	0	5	12	4.8	25	LFSS03
Benzo(k)fluoranthene	39000	2200	na	15000	0	0	na	0	5	12	5.9	16	LFSS01
Chrysene	390000	22000	na	48000	0	0	na	0	5	12	12	37	LFSS03
Dibenz(a,h)anthracene	390	22	na	460	0	0	na	0	3	12	2.7	3.5	LFSS03
Fluoranthene	4100000	310000	na	6300000	0	0	na	0	5	12	18	41	LFSS01
Fluorene	4100000	310000	na	140000	0	0	na	0	8	12	0.86	4.4	LFSS03
Indeno(1,2,3-cd)pyrene	3900	220	na	4200	0	0	na	0	5	12	6.3	26	LFSS03
Naphthalene	2000000	160000	na	150	0	0	na	0	8	12	0.9	34	LFSS03
Phenanthrene	3100000	230000	na	680000	0	0	na	0	6	12	1.1	55	LFSS03
Pyrene	3100000	230000	na	680000	0	0	na	0	5	12	19	40	LFSS01
SVOCs (ug/kg)													
1,2,4-Trichlorobenzene	1000000	78000	na	2400	0	0	na	0	2	17	12	31	LFSB16B
1,2-Dichlorobenzene	9200000	700000	na	4600	0	0	na	0	1	17	30	30	LFSB16B
1,3-Dichlorobenzene	310000	23000	na	290	0	0	na	0	2	17	12	32	LFSB16B
1,4-Dichlorobenzene	120000	27000	na	4.2	0	0	na	2	2	17	13	34	LFSB16B
2,4,5-Trichlorophenol	10000000	780000	na	na	0	0	na	na	1	17	12	12	LFSB16B
2,4,6-Trichlorophenol	102000	7800	na	na	0	0	na	na	1	17	18	18	LFSB16B
2,4-Dichlorophenol	310000	23000	na	1200	0	0	na	0	1	17	22	22	LFSB16B
2,4-Dinitrotoluene	200000	16000	na	570	0	0	na	0	5	17	7.2	36	LFSS03
2-Chloronaphthalene	8200000	630000	na	32000	0	0	na	0	2	17	8	20	LFSB16B
2-Chlorophenol	510000	39000	na	na	0	0	na	na	2	17	8.2	25	LFSB16B
2-Methylnaphthalene	410000	31000	na	4400	0	0	na	0	4	17	12	69	LFSS03
2-Methylphenol	5100000	390000	na	na	0	0	na	na	1	17	21	21	LFSB16B
2-Nitrophenol	na	na	na	na	na	na	na	na	2	17	11	26	LFSB16B
4-Chloro-3-methylphenol	na	na	na	na	na	na	na	na	1	17	14	14	LFSB16B
4-Chlorophenyl phenyl ether	na	na	na	na	na	na	na	na	1	17	12	12	LFSB16B
4-Methylphenol	510000	39000	na	na	0	0	na	na	1	17	19	19	LFSB16B
Acenaphthene	6100000	470000	na	100000	0	0	na	0	1	17	13	13	LFSB16B
Acenaphthylene	3100000	230000	na	680000	0	0	na	0	1	17	13	13	LFSB16B
Benz(a)anthracene	3900	220	na	480	0	0	na	0	9	17	7.9	32	LFSS03
Benzo(a)pyrene	390	22	na	120	0	3	na	0	6	17	8.1	39	LFSS03
Benzo(b)fluoranthene	3900	220	na	1500	0	0	na	0	6	17	13	53	LFSS03
Benzo(g,h,i)perylene	3100000	230000	na	680000	0	0	na	0	5	17	10	50	LFSS03
Benzo(k)fluoranthene	39000	2200	na	15000	0	0	na	0	6	17	5	19	LFSS03
bis(2-Chloroethoxy)methane	na	na	na	na	na	na	na	na	1	17	13	13	LFSB16B
bis(2-Chloroethyl)ether	2600	580	na	0.044	0	0	na	1	1	17	19	19	LFSB16B
bis(2-Ethylhexyl)phthalate	200000	46000	na	2900000	0	0	na	0	14	17	13	68	LFSB15A
bis(Chloroisopropyl)ether	41000	9100	na	1.7	0	0	na	2	2	17	8.8	21	LFSB16B
Butylbenzylphthalate	20000000	1600000	na	17000000	0	0	na	0	4	17	8.8	17	LFSB17B
Chrysene	390000	22000	na	48000	0	0	na	0	7	17	8.8	40	LFSS03
Dibenzofuran	100000	7800	na	3800	0	0	na	0	2	17	13	14	LFSB16B
Diethylphthalate	82000000	6300000	na	450000	0	0	na	0	2	17	9.1	10	LFSS01
Di-n-butylphthalate	10000000	780000	na	5000000	0	0	na	0	1	17	160	160	LFSS03
Di-n-octylphthalate	na	na	na	4900000000	na	na	na	0	1	17	20	20	LFSB17A
Fluoranthene	4100000	310000	na	6300000	0	0	na	0	6	17	9.4	58	LFSS01

Table 4-4
Summary of SSL Exceedances in FLFA Soil
Page 2 of 2

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
Fluorene	4100000	310000	na	140000	0	0	na	0	1	17	9	9	LFSB16B
Hexachlorobenzene	1800	400	na	52	0	0	na	0	1	17	20	20	LFSB15A
Hexachlorobutadiene	37000	7800	na	1800	0	0	na	0	2	17	10	30	LFSB16B
Hexachloroethane	102000	7800	na	360	0	0	na	0	1	17	13	13	LFSB16B
Indeno(1,2,3-cd)pyrene	3900	220	na	4200	0	0	na	0	6	17	9.4	41	LFSS03
Isophorone	3000000	670000	na	410	0	0	na	0	2	17	7.4	10	LFSB16B
Naphthalene	2000000	160000	na	150	0	0	na	0	4	17	12	53	LFSS03
Nitrobenzene	51000	3900	na	23	0	0	na	1	1	17	35	35	LFSB16B
N-nitrosodiphenylamine	580000	130000	na	760	0	0	na	0	1	17	150	150	LFSS03
Phenanthrene	3100000	230000	na	680000	0	0	na	0	6	17	9.3	57	LFSS03
Pyrene	3100000	230000	na	680000	0	0	na	0	7	17	8.2	47	LFSS01
Pesticides (ug/kg)													
4,4'-DDD	12000	2700	na	11000	0	0	na	0	3	3	0.423	5.93	LFSB15A
4,4'-DDE	8400	1900	na	35000	0	0	na	0	3	3	0.83	49.3	LFSB15A
4,4'-DDT	8400	1900	na	1200	0	0	na	0	3	3	15.4	83.2	LFSS03
delta-BHC	na	na	na	na	na	na	na	na	1	3	0.495	0.495	LFSB12A
Endosulfan II	610000	47000	na	20000	0	0	na	0	3	3	1.23	19.9	LFSS03
Endrin aldehyde	na	na	na	na	na	na	na	na	3	3	1.87	33.4	LFSS03
Endrin ketone	na	na	na	na	na	na	na	na	1	3	4.46	4.46	LFSB15A
gamma-Chlordane	8200	1800	na	920	0	0	na	0	1	3	2.81	2.81	LFSB15A
Methoxychlor	510000	39000	na	310000	0	0	na	0	1	3	0.728	0.728	LFSB15A
PCBs (mg/kg)													
PCB-1248	1.4	0.32	na	na	1	1	na	na	1	30	1.42	1.42	LFSB14A
PCB-1254	1.4	0.16	na	1.1	1	7	na	1	22	30	0.0135	1.58	LFSS03
PCB-1260	1.4	0.32	na	na	0	1	na	na	8	30	0.0373	1.09	LFSS16
Explosives (mg/kg)													
2,4-Dinitrotoluene	200	16	na	0.57	0	0	na	0	2	12	0.062	0.12	LFSS03
Herbicides (ug/kg)		***None detected***											
Metals (mg/kg)													
Aluminum	100000	7800	40041	na	0	3	3	na	39	39	9770	47900	LFSB16C
Antimony	41	3.1	na	13	1	5	na	2	27	39	0.22	47.6	LFSB15A
Arsenic	1.9	0.43	15.8	0.026	3	3	3	3	39	39	1.39	31.4	LFSS13
Barium	20000	1600	209	6000	0	3	7	0	39	39	25.3	2630	LFSS03
Beryllium	200	16	1.02	1200	0	0	26	0	39	39	0.4	3	LFSB16C
Cadmium	51	3.9	0.69	27	0	5	5	0	12	39	0.072	19.8	LFSB15A
Calcium	na	na	na	na	na	na	na	na	39	39	488	61600	LFSS01
Chromium	310	23	65.3	42	0	3	3	3	39	39	13.1	299	LFSS03
Cobalt	na	na	72.3	na	na	na	0	na	39	39	3.7	47	LFSB15A
Copper	4100	310	53.5	11000	2	7	18	1	39	39	10.8	37200	LFSS20
Iron	72000	5500	50962	na	1	2	2	na	39	39	14100	99900	LFSB15A
Lead	800	400	26.8	na	8	8	39	na	59	59	10	36500	LFSS20
Magnesium	na	na	na	na	na	na	na	na	39	39	1070	60400	LFSB17B
Manganese	2000	160	2543	950	0	0	0	0	39	39	137	2230	LFSB15A
Mercury	31	2.3	0.13	na	0	0	14	na	35	39	0.03	2.2	LFSS21
Nickel	2000	160	62.8	na	0	1	3	na	39	39	7.5	404	LFSB15A
Potassium	na	na	na	na	na	na	na	na	39	39	712	8670	LFSB12B
Selenium	510	39	na	19	0	0	na	0	15	39	0.34	1.3	LFSS14
Silver	510	39	na	31	0	2	na	2	22	39	0.11	65.2	LFSS17
Sodium	na	na	na	na	na	na	na	na	39	39	24	3230	LFSS20
Thallium	7.2	0.55	2.11	3.6	4	4	5	0	28	39	0.099	26.9	17SB3
Vanadium	102	7.8	108	730	0	0	0	0	39	39	21.6	90.5	17SB3
Zinc	31000	2300	202	14000	0	5	11	1	39	39	26	22100	LFSS20
Dioxins/Furans (ng/kg)													
2,3,7,8-TCDD	19	4.3	na	8.6	1	8	na	5	22	32	0.368	166	LFSS20

* Data from borings 17SB2, LFSB2, LFSB5, and LFSB7 not included because the soil was removed at those locations

Groundwater results indicated that two VOCs [chloroform and tetrachloroethene (PCE)] and five metals (aluminum, antimony, chromium, iron, and manganese) were present above levels of concern.

Based on SSL and groundwater screening results, the only analyte found to exceed both SSLs and groundwater screening criteria at the FLFA was chromium. Chromium was detected above residential screening levels in three surface soil samples at the site. Chromium did not exceed background or residential screening levels in any subsurface soil samples, indicating that chromium is not migrating downward through the soil to groundwater. Although 2,3,7,8-TCDD was found to exceed SSLs in soil, it was not detected in any FLFA groundwater samples.

4.1.2 Surface Water

One surface water sample (LFSW01) was collected from the spring (SPG 3) on the New River where a dye trace study (Engineering Science, 1994) indicated discharge from the FLFA/SWMU 17A sinkhole. The sample was analyzed for TCL VOCs, SVOCs, PAHs, pest/PCBs, explosives, herbicides, TAL metals, dioxins/furans, and perchlorate. The sampling location is illustrated on **Figure 4-3**. Detected results are presented in **Table 4-5**.

As shown in **Table 4-5**, VOCs, PAHs, SVOCs, pesticides, PCBs, explosives, and herbicides were not detected in surface water sample LFSW01. TAL metal, dioxins/furan, and perchlorate results were as follows:

TAL Metals. Seven metals (barium, calcium, magnesium, manganese, potassium, sodium, and zinc), mostly consisting of essential nutrients, were detected in the sample. Concentrations of the detected metals were all below MCLs and tw-RBCs. Lead was not detected in the sample.

Dioxins/Furans. Four dioxin/furan congeners were detected in the surface water sample. None of the detected congeners have an associated screening level.

Perchlorate. The concentration of perchlorate was below the adjusted tw-RBC of 2.6 μg/L.

4.1.3 Sediment

Sediment sample LFSD01 was collocated with surface water sample LFSW01 at SPG3 on the New River. The sample was analyzed for TCL VOCs, SVOCs, PAHs, pest/PCBs, explosives, herbicides, TAL metals, and dioxins/furans. The sampling location is illustrated on **Figure 4-3**. Detected results are presented in **Table 4-6**.

As shown in **Table 4-6**, VOCs, SVOCs, explosives, and herbicides were not detected in sediment sample LFSD01. PAH, pesticide, PCB, TAL metal, and dioxin/furan results were as follows:

PAHs. Five PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene] were detected in the sample. Benzo(a)pyrene was the only PAH detected at a concentration exceeding its residential screening level in the sample.

Pesticides. One pesticide (alpha-Chlordane) was detected in the sample at a concentration below residential screening levels.

PCBs. One PCB (Aroclor-1260) was detected in the sample at a concentration below residential screening levels.

Table 4-5
Analytes Detected in FLFA Surface Water - 2007 Investigation

Analyte	Sample ID Sample Date		**LFSW01** **7/19/07**				
	MCL	**tw-RBC**	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)	None detected						
PAHs (ug/L)	None detected						
SVOCs (ug/L)	None detected						
Pesticides (ug/L)	None detected						
PCBs (ug/L)	None detected						
Explosives (ug/L)	None detected						
Herbicides (ug/L)	None detected						
Metals (ug/L)							
Barium	2000	730	103	J	J	*5*	*200*
Calcium	na	na	79600			*42*	*1000*
Magnesium	na	na	30100			*4.3*	*5000*
Manganese	50	73	3.3	J	J	*1.5*	*15*
Potassium	na	na	4320	J	B	*100*	*10000*
Sodium	na	na	24100			*500*	*10000*
Zinc	5000	1100	7.6	J	J	*1.6*	*20*
Dioxins/Furans (ng/L)							
1,2,3,4,6,7,8-HPCDD	na	na	0.00503	A, EMPC	J	*0.00593*	*0.00593*
OCDD	na	na	0.0423	A	K		
1,2,3,4,6,7,8-HPCDF	na	na	0.00205	A	J		
OCDF	na	na	0.00586	A	J		
TOTAL HPCDD	na	na	0.00949	A, EMPC	J		
TOTAL TCDF	na	na	0.00622	A, EMPC	J		
TOTAL PECDF	na	na	0.00202	A, EMPC	J	*0.00593*	*0.00593*
TOTAL HXCDF	na	na	0.00593	U		*0.00593*	*0.00593*
TOTAL HPCDF	na	na	0.00422	A, EMPC	J		
Misc. (ug/L)							
Perchlorate	na	2.6	1.28		J	*0.112*	*0.2*

**Refer to legend immediately following this table for a list of definitions and table notes

Table 4-5
Legend

12	J	Shading and black font indicate an MCL exceedance.
12	J	Bold outline indicates a tw-RBC exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

tw-RBCs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.

The pyrene tw-RBCs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene.

Secondary MCLs were used for aluminum, iron, manganese, silver, and zinc.

MCL Action Levels were used for copper and lead.

MCL = Maximum Contaminant Level (USEPA, 2006).

tw-RBC = Tap Water Risk-Based Concentration (USEPA, October 2007).

tw-RBC value in table is for the more conservative chromium VI.

tw-RBC value for chromium III is 5,500, which was not exceeded.

ng/L = nanograms per liter (parts per trillion).

µg/L = micrograms per liter (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.

A (Dioxins) = B = (metals) Value <MRL and >MDL and is considered estimated.

E (metals) = Reported value is estimated because of the presence of interferences.

EMPC (Dioxins) = The ion-abundance ratio between the two characteristic PCDD/PCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).

J = (organics) Value <MRL and >MDL and is considered estimated.

U = Analyte not-detected at the method reporting limit.

X = (dioxins) Ion abundance ratio outside acceptable range. Value reported is EMPC.

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

N = presumptive evidence for tentatively identified compounds using a library search

U = analyte not detected

UJ = estimated concentration non-detect

UL = estimated concentration non-detect bias low

Table 4-6
Analytes Detected in FLFA Sediment - 2007 Investigation

Analyte			Sample ID	**LFSD01**				
			Sample Date	**7/19/07**				
			Sample Depth	**0-0.5**				
	i-RBC	**r-RBC**	**Background**	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)	None detected							
PAHs (ug/kg)								
Benz(a)anthracene	3900	220	na	29	J	J	23	92
Benzo(a)pyrene	390	22	na	31.9	J	J	23	92
Benzo(b)fluoranthene	3900	220	na	45.6	J	J	23	92
Benzo(k)fluoranthene	39000	2200	na	31.2	J	J	23	92
Chrysene	390000	22000	na	43	J	J	23	92
SVOCs (ug/kg)	None detected							
Pesticides (ug/kg)								
alpha-Chlordane	8200	1800	na	13.7	J	J	2.8	14
PCBs (mg/kg)								
PCB-1260	1.4	0.32	na	0.135		J	0.014	0.028
Explosives (mg/kg)	None detected							
Herbicides (ug/kg)	None detected							
Metals (mg/kg)								
Aluminum	100000	7800	40041	10100			1.9	17
Antimony	41	3.1	na	1.8	J	B	0.45	5.1
Arsenic	1.9	0.43	15.8	3.4			0.33	0.68
Barium	20000	1600	209	167		J	0.42	17
Beryllium	200	16	1.02	**1.1**			0.085	0.42
Calcium	na	na	na	2480			4.8	420
Chromium	310	23	65.3	24.9			0.076	0.85
Cobalt	na	na	72.3	11.8			0.085	4.2
Copper	4100	310	53.5	22.1			0.076	2.1
Iron	72000	5500	50962	29000			1	8.5
Lead	800	400	26.8	**195**			0.17	8.5
Magnesium	na	na	na	2970			0.63	420
Manganese	2000	160	2543	1600			0.25	6.3
Mercury	31	2.3	0.13	0.076	J	B	0.012	0.14
Nickel	2000	160	62.8	11.7			0.085	3.4
Potassium	na	na	na	1180		B	8.5	850
Selenium	510	39	na	9.6		K	0.17	8.5
Sodium	na	na	na	222	J	B	70	850
Vanadium	102	7.8	108	28			0.051	4.2
Zinc	31000	2300	202	**682**			0.55	8.5
Dioxins/Furans (ng/kg)								
2,3,7,8-TCDF	na	na	na	5.58				
2,3,7,8-TCDD	19	4.3	na	2.38				
1,2,3,7,8-PECDD	na	na	na	7.55	A	J		
1,2,3,4,7,8-HXCDD	460	100	na	7.83	A	J		
1,2,3,6,7,8-HXCDD	460	100	na	19				
1,2,3,7,8,9-HXCDD	460	100	na	17.5				
1,2,3,4,6,7,8-HPCDD	na	na	na	571				
OCDD	na	na	na	5030				
1,2,3,7,8-PECDF	na	na	na	5.73	A	J		
2,3,4,7,8-PECDF	na	na	na	10.6				
1,2,3,4,7,8-HXCDF	na	na	na	19.8				
1,2,3,6,7,8-HXCDF	na	na	na	10.8				
2,3,4,6,7,8-HXCDF	na	na	na	11.7				
1,2,3,7,8,9-HXCDF	na	na	na	2.39	A	J		
1,2,3,4,6,7,8-HPCDF	na	na	na	132				
1,2,3,4,7,8,9-HPCDF	na	na	na	5.24	A	J		
OCDF	na	na	na	385				
TOTAL TCDD	na	na	na	37.9				
TOTAL PECDD	na	na	na	69.9				
TOTAL HXCDD	460	100	na	200				
TOTAL HPCDD	na	na	na	1060				
TOTAL TCDF	na	na	na	140	A, EMPC	J		
TOTAL PECDF	na	na	na	137	A, EMPC	J		
TOTAL HXCDF	na	na	na	163	A, EMPC	J		
TOTAL HPCDF	na	na	na	328				

**Refer to legend immediately following this table for a list of definitions and table notes

Table 4-6
Legend

12	J	Shading and black font indicate an industrial RBC exceedance.
12	J	Bold outline indicates a residential RBC exceedance.
12	**J**	Bold, underlined font indicates a background 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 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 (October 2007).

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: Guidance Document (April 1999).

mg/kg = milligrams per kilogram (parts per million).

ng/kg = nanograms per kilogram (parts per trillion).

µg/kg = micrograms per kilogram (parts per billion).

NA = not applicable.

NT = analyte not tested.

Lab Q = Lab Data Qualifiers

B = (organics) Blank contamination. Value detected in sample and associated blank.

A (Dioxins) = B = (metals) Value <MRL and >MDL and is considered estimated.

E (metals) = Reported value is estimated because of the presence of interferences.

EMPC (Dioxins) = The ion-abundance ratio between the two characteristic PCDD/PCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).

J = (organics) Value <MRL and >MDL and is considered estimated.

U = Analyte not-detected at the method reporting limit.

X = (dioxins) Ion abundance ratio outside acceptable range. Value reported is EMPC.

Val Q = 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

N = presumptive evidence for tentatively identified compounds using a library search

U = analyte not detected

UJ = estimated concentration non-detect

UL = estimated concentration non-detect bias low

TAL Metals. Twenty TAL metals were detected in sediment sample LFSD01. Concentrations of each metal were below residential screening levels.

Dioxins/Furans. Seventeen dioxin/furan congeners were detected in the sample. Although none of the individual congeners were detected at a concentration above the residential screening level, total HXCDD exceeded its residential screening level in the sediment sample.

4.1.4 Groundwater

Two upgradient (17MW2 and 17PZ1), one on-site (LFMW01), and two downgradient (40MW5 and 40MW6) wells were sampled to characterize the FLFA groundwater. A sample was also collected from well 17MW3. This well was later determined to be crossgradient of the FLFA and is not included in this assessment. The detected results from this well are included on **Table 4-7**. Samples 17MW2, 17PZ1, and LFMW01 were analyzed for TCL VOCs, SVOCs, PAHs, pest/PCBs, explosives, herbicides, TAL metals, dioxins/furans, and perchlorate. Samples 40MW5 and 40MW6 were analyzed for TCL VOCs, SVOCs, pesticides/PCBs, explosives, TAL metals, and perchlorate. Groundwater sample locations are shown on **Figure 4-4**. Detected results are presented in **Table 4-7** and summarized in **Table 4-8**.

As shown in **Table 4-7**, PAHs, PCBs, explosives, and herbicides were not detected in any of the wells. VOC, SVOC, pesticide, TAL metal, perchlorate, and dioxin/furan results were as follows:

VOCs. Three VOCs (chloroform, PCE, and toluene) were detected in FLFA groundwater samples. Chloroform was detected in four out of the five wells at concentrations above the tw-RBC, but below the MCL. Chloroform was not detected in the on-site well (LFMW01). PCE was detected in upgradient well 17MW2 at a concentration above the tw-RBC, but was not detected in the on-site or downgradient wells.

SVOCs. Three SVOCs (2-methylnapthalene, butylbenzylphthalate, and naphthalene) were each detected once in downgradient monitoring wells at concentrations below groundwater screening levels.

Pesticides. One pesticide (lindane) was detected in downgradient well 40MW6 at a concentration below groundwater screening levels.

TAL Metals. Eighteen TAL metals were detected in FLFA groundwater samples. Concentrations of aluminum, chromium, iron, manganese, and vanadium exceeded tw-RBCs predominantly in on-site well LFMW01. Well LFMW01 had high turbidity [>999 nephelometric turbidity unit (NTU)] and did not decrease after other water quality parameters had stabilized. The high metals concentrations are the result of suspended metals in the unfiltered sample. Chromium also exceeded its tw-RBC in upgradient wells 17MW2 and 17PZ1. Three metals (aluminum, iron, and manganese) were detected at concentrations above secondary MCLs. Lead was detected in on-site well LFMW01 at a concentration below its MCL and was not detected in the downgradient wells.

Perchlorate. Perchlorate was detected in all five FLFA wells. Concentrations of perchlorate exceeded the adjusted tw-RBC of 2.6 μg/L [but below the unadjusted tw-RBC of 26 μg/L and the Department of Defense screening value of 24 μg/L] in upgradient well 17MW2 and on-site well LFMW01.

Table 4-7
Analytes Detected in FLFA Groundwater - 2007
Page 1 of 3

Analyte		Sample ID Sample Date	LFMW01 8/21/07					17PZ01 8/21/07					17MW02 8/21/07					17MW03 8/21/07				
	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
VOCs (ug/L)																						
Chloroform	80	0.15	1	U		*0.21*	*1*	2.7			*0.21*	*1*	5.9			*0.21*	*1*	1	U		*0.21*	*1*
Tetrachloroethene	5	0.1	1	U		*0.25*	*1*	1	U		*0.25*	*1*	2.6			*0.25*	*1*	1	U		*0.25*	*1*
Toluene	1000	75	1	U		*0.27*	*1*	1	U		*0.27*	*1*	1	U		*0.27*	*1*	0.38	J	J	*0.27*	*1*
PAHs (ug/L)	None detected																					
SVOCs (ug/L)																						
2-Methylnaphthalene	na	2.4	NT					NT					NT					NT				
Butylbenzylphthalate	na	730	4.9	U		*2*	*4.9*	4.8	U		*1.9*	*4.8*	5	U		*2*	*5*	4.9	U		*1.9*	*4.9*
Diethylphthalate	na	2900	4.9	U		*2*	*4.9*	4.8	U		*1.9*	*4.8*	5	U		*2*	*5*	4.9	U		*1.9*	*4.9*
Naphthalene	na	0.65	NT					NT					NT					NT				
Pesticides (ug/L)																						
Lindane	na	0.052	0.049	U		*0.009*	*0.049*	0.048	U		*0.009*	*0.048*	0.05	U		*0.009*	*0.05*	0.049	U		*0.009*	*0.049*
PCBs (ug/L)	None detected																					
Explosives (ug/L)	None detected																					
Herbicides (ug/L)	None detected																					
Metals (ug/L)																						
Aluminum	50	3700	9320			*79*	*200*	296			*79*	*200*	222			*79*	*200*	79	U		*79*	*200*
Barium	2000	730	93	J	J	*5*	*200*	69.7	J	J	*5*	*200*	54.4	J	J	*5*	*200*	176	J	J	*5*	*200*
Beryllium	4	7.3	1.9	J	B	*1*	*4*	1.2	J	B	*1*	*4*	1.3	J	B	*1*	*4*	1	U		*1*	*4*
Calcium	na	na	120000			*100*	*1000*	76700			*100*	*1000*	76100			*100*	*1000*	110000			*100*	*1000*
Chromium	100	11	43			*0.92*	*10*	11			*0.92*	*10*	29.5			*0.92*	*10*	32.4			*0.92*	*10*
Cobalt	na	na	4.6	J	J	*1*	*50*	1	U		*1*	*50*	26.9	J	J	*1*	*50*	2.5	J	J	*1*	*50*
Copper	1300	150	6.9	J	J	*1.2*	*25*	1.2	U		*1.2*	*25*	7.9	J	J	*1.2*	*25*	1.9	J	J	*1.2*	*25*
Iron	300	2600	10100			*15*	*300*	15	U		*15*	*300*	644			*15*	*300*	15	U		*15*	*300*
Lead	15	na	3.6	J	J	*2.1*	*5*	2.1	U		*2.1*	*5*	2.1	U		*2.1*	*5*	2.1	U		*2.1*	*5*
Magnesium	na	na	56700			*100*	*5000*	29800			*100*	*5000*	28400			*100*	*5000*	39900			*100*	*5000*
Manganese	50	73	78.3			*1*	*15*	5.3	J	J	*1*	*15*	12.8	J	J	*1*	*15*	42.4			*1*	*15*
Mercury	2	1.1	0.11	U		*0.11*	*1*	0.11	U		*0.11*	*1*	0.11	U		*0.11*	*1*	0.11	U		*0.11*	*1*
Nickel	na	73	30.5	J	J	*1*	*40*	6.4	J	J	*1*	*40*	18.1	J	J	*1*	*40*	27.6	J	J	*1*	*40*
Potassium	na	na	6120	J	B	*100*	*10000*	2810	J	B	*100*	*10000*	3610	J	B	*100*	*10000*	4520	J	B	*100*	*10000*
Selenium	50	18	4	U		*4*	*10*	4	U		*4*	*10*	4	U		*4*	*10*	16	U		*16*	*20*
Silver	100	18	0.77	U		*0.77*	*10*	0.77	U		*0.77*	*10*	6.2	J	B	*0.77*	*10*	0.77	U		*0.77*	*10*
Sodium	na	na	12100			*500*	*10000*	5690	J	B	*500*	*10000*	14600			*500*	*10000*	19500			*500*	*10000*
Vanadium	na	3.7	20	J	J	*1.1*	*50*	1.1	U		*1.1*	*50*	1.5	J	J	*1.1*	*50*	1.1	U		*1.1*	*50*
Zinc	5000	1100	60.4			*5*	*20*	10	J	J	*5*	*20*	11.9	J	J	*5*	*20*	13.2	J	J	*5*	*20*
Misc. (ug/L)																						
Perchlorate	na	2.6	5.33			*0.112*	*0.2*	1.09			*0.112*	*0.2*	5.4			*0.112*	*0.2*	4.02			*0.112*	*0.2*
Dioxins/Furans (ng/L)																						
1,2,3,7,8,9-HXCDD	na	0.011	0.00268	A	J			0.00534	U		*0.00534*	*0.00534*	0.00527	U		*0.00527*	*0.00527*	0.00483	U		*0.00483*	*0.00483*
OCDD	na	na	0.0686	A	J			0.0102	A	J			0.0142	A, EMPC	J	*0.00164*	*0.00164*	0.00965	U		*0.00965*	*0.00965*
1,2,3,7,8-PECDF	na	na	0.00127	A, EMPC	J	*0.00489*	*0.00489*	0.00534	U		*0.00534*	*0.00534*	0.00527	U		*0.00527*	*0.00527*	0.00483	U		*0.00483*	*0.00483*
2,3,4,7,8-PECDF	na	na	0.00154	A	J			0.00534	U		*0.00534*	*0.00534*	0.00527	U		*0.00527*	*0.00527*	0.00483	U		*0.00483*	*0.00483*
TOTAL HXCDD	na	0.011	0.00268					0.00534	U		*0.00534*	*0.00534*	0.00527	U		*0.00527*	*0.00527*	0.00483	U		*0.00483*	*0.00483*
TOTAL PECDF	na	na	0.00282	EMPC	J			0.00534	U		*0.00534*	*0.00534*	0.00527	U		*0.00527*	*0.00527*	0.00483	U		*0.00483*	*0.00483*

**Refer to legend immediately following this table for a list of definitions and table notes

Table 4-7
Analytes Detected in FLFA Groundwater - 2007
Page 2 of 3

Analyte		Sample ID Sample Date	40MW3 8/14/07					40MW3-Diss 8/14/07					40MW5 8/15/07				
	MCL	**tw-RBC**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																	
Chloroform	80	0.15	19			*0.061*	*1*	NT					23			*0.061*	*1*
Tetrachloroethene	5	0.1	0.15	U		*0.15*	*1*	NT					0.15	U		*0.15*	*1*
Toluene	1000	75	0.072	U		*0.072*	*1*	NT					0.09	J	B	*0.072*	*1*
PAHs (ug/L)	None detected																
SVOCs (ug/L)																	
2-Methylnaphthalene	na	2.4	0.015	U		*0.015*	*5*	NT					0.094	J		*0.015*	*5*
Butylbenzylphthalate	na	730	0.057	J	B	*0.029*	*5*	NT					0.029	U		*0.029*	*5*
Diethylphthalate	na	2900	0.038	J	B	*0.034*	*5*	NT					0.034	U		*0.034*	*5*
Naphthalene	na	0.65	0.023	U		*0.023*	*5*	NT					0.094	J		*0.023*	*5*
Pesticides (ug/L)																	
Lindane	na	0.052	0.0018	U		*0.0018*	*0.05*	NT					0.0018	U		*0.0018*	*0.05*
PCBs (ug/L)	None detected																
Explosives (ug/L)	None detected																
Herbicides (ug/L)	None detected																
Metals (ug/L)																	
Aluminum	50	3700	44	U		*44*	*150*	44	U		*44*	*150*	44	U		*44*	*150*
Barium	2000	730	29			*0.52*	*2*	29			*0.52*	*2*	45			*0.52*	*2*
Beryllium	4	7.3	0.31	U		*0.31*	*2*	0.31	U		*0.31*	*2*	0.31	U		*0.31*	*2*
Calcium	na	na	52000			*40*	*500*	53000			*40*	*500*	69000			*40*	*500*
Chromium	100	11	1.7	J	B	*0.31*	*2*	1.2	J	B	*0.31*	*2*	1.9	J	B	*0.31*	*2*
Cobalt	na	na	0.16	J		*0.096*	*1*	0.3	J		*0.096*	*1*	0.13	J		*0.096*	*1*
Copper	1300	150	1.3			*0.33*	*1*	0.86	J		*0.33*	*1*	0.79	J		*0.33*	*1*
Iron	300	2600	21		B	*5.7*	*20*	17	J		*5.7*	*20*	14	J	B	*5.7*	*20*
Lead	15	na	0.51	J	B	*0.33*	*1*	0.33	U		*0.33*	*1*	0.33	U		*0.33*	*1*
Magnesium	na	na	18000			*38*	*500*	18000			*38*	*500*	22000			*38*	*500*
Manganese	50	73	0.48	J	B	*0.43*	*3*	0.43	U		*0.43*	*3*	0.43	U		*0.43*	*3*
Mercury	2	1.1	0.04	J		*0.039*	*0.2*	0.039	U		*0.039*	*0.2*	0.039	U		*0.039*	*0.2*
Nickel	na	73	1.8	J		*0.28*	*2*	1.3	J		*0.28*	*2*	1	J		*0.28*	*2*
Potassium	na	na	1200			*54*	*200*	1200			*54*	*200*	1000			*54*	*200*
Selenium	50	18	0.92	U		*0.92*	*3*	1.3	J	B	*0.92*	*3*	1.4	J	B	*0.92*	*3*
Silver	100	18	0.12	U		*0.12*	*0.4*	0.12	U		*0.12*	*0.4*	0.12	U		*0.12*	*0.4*
Sodium	na	na	7600			*84*	*500*	7800			*84*	*500*	7000			*84*	*500*
Vanadium	na	3.7	0.83	U		*0.83*	*3*	0.83	U		*0.83*	*3*	0.83	U		*0.83*	*3*
Zinc	5000	1100	15		B	*0.84*	*10*	4.5	JB	B	*0.84*	*10*	11		B	*0.84*	*10*
Misc. (ug/L)																	
Perchlorate	na	2.6	0.52			*0.08*	*0.2*	NT					0.64			*0.08*	*0.2*
Dioxins/Furans (ng/L)																	
1,2,3,7,8,9-HXCDD	na	0.011	NT					NT					NT				
OCDD	na	na	NT					NT					NT				
1,2,3,7,8-PECDF	na	na	NT					NT					NT				
2,3,4,7,8-PECDF	na	na	NT					NT					NT				
TOTAL HXCDD	na	0.011	NT					NT					NT				
TOTAL PECDF	na	na	NT					NT					NT				

**Refer to legend immediately following this table for a list of definitions and table notes

Table 4-7
Analytes Detected in FLFA Groundwater - 2007
Page 3 of 3

Analyte		Sample ID Sample Date	40MW5-Diss 8/15/07					40MW6 8/14/07					40MW6-Diss 8/14/07				
	MCL	tw-RBC	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																	
Chloroform	80	0.15	NT					24			*0.061*	*1*	NT				
Tetrachloroethene	5	0.1	NT					0.15	U		*0.15*	*1*	NT				
Toluene	1000	75	NT					0.072	U		*0.072*	*1*	NT				
PAHs (ug/L)	None detected																
SVOCs (ug/L)																	
2-Methylnaphthalene	na	2.4	NT					0.015	U		*0.015*	*5*	NT				
Butylbenzylphthalate	na	730	NT					0.038	J	B	*0.029*	*5*	NT				
Diethylphthalate	na	2900	NT					0.034	U		*0.034*	*5*	NT				
Naphthalene	na	0.65	NT					0.023	U		*0.023*	*5*	NT				
Pesticides (ug/L)																	
Lindane	na	0.052	NT					0.0098	J	J	*0.0018*	*0.05*	NT				
PCBs (ug/L)	None detected																
Explosives (ug/L)	None detected																
Herbicides (ug/L)	None detected																
Metals (ug/L)																	
Aluminum	50	3700	44	U		*44*	*150*	44	U		*44*	*150*	44	U		*44*	*150*
Barium	2000	730	46			*0.52*	*2*	39			*0.52*	*2*	39			*0.52*	*2*
Beryllium	4	7.3	0.31	U		*0.31*	*2*	0.31	U		*0.31*	*2*	0.31	U		*0.31*	*2*
Calcium	na	na	69000			*200*	*2500*	71000			*40*	*500*	68000			*40*	*500*
Chromium	100	11	1.4	J	B	*0.31*	*2*	5		B	*0.31*	*2*	1.3	J	B	*0.31*	*2*
Cobalt	na	na	0.31	J		*0.096*	*1*	0.3	J		*0.096*	*1*	0.3	J		*0.096*	*1*
Copper	1300	150	0.98	J		*0.33*	*1*	1			*0.33*	*1*	0.91	J		*0.33*	*1*
Iron	300	2600	10	J		*5.7*	*20*	28		B	*5.7*	*20*	15	J		*5.7*	*20*
Lead	15	na	0.33	U		*0.33*	*1*	0.33	U		*0.33*	*1*	0.33	U		*0.33*	*1*
Magnesium	na	na	22000			*38*	*500*	22000			*38*	*500*	21000			*38*	*500*
Manganese	50	73	0.43	U		*0.43*	*3*	0.43	U		*0.43*	*3*	0.43	U		*0.43*	*3*
Mercury	2	1.1	0.039	U		*0.039*	*0.2*	0.039	U		*0.039*	*0.2*	0.039	U		*0.039*	*0.2*
Nickel	na	73	0.49	J		*0.28*	*2*	2.1			*0.28*	*2*	1.8	J		*0.28*	*2*
Potassium	na	na	1000			*54*	*200*	1200			*54*	*200*	1100			*54*	*200*
Selenium	50	18	0.92	U		*0.92*	*3*	0.92	U		*0.92*	*3*	1.1	J	B	*0.92*	*3*
Silver	100	18	0.12	U		*0.12*	*0.4*	0.12	U		*0.12*	*0.4*	0.12	U		*0.12*	*0.4*
Sodium	na	na	7000			*84*	*500*	7300			*84*	*500*	7000			*84*	*500*
Vanadium	na	3.7	0.83	U		*0.83*	*3*	0.83	U		*0.83*	*3*	0.83	U		*0.83*	*3*
Zinc	5000	1100	3.3	JB	B	*0.84*	*10*	15		B	*0.84*	*10*	4.7	JB	B	*0.84*	*10*
Misc. (ug/L)																	
Perchlorate	na	2.6	NT					0.52			*0.08*	*0.2*	NT				
Dioxins/Furans (ng/L)																	
1,2,3,7,8,9-HXCDD	na	0.011	NT					NT					NT				
OCDD	na	na	NT					NT					NT				
1,2,3,7,8-PECDF	na	na	NT					NT					NT				
2,3,4,7,8-PECDF	na	na	NT					NT					NT				
TOTAL HXCDD	na	0.011	NT					NT					NT				
TOTAL PECDF	na	na	NT					NT					NT				

**Refer to legend immediately following this table for a list of definitions and table notes

Table 4-7
Legend

12	J	Shading and black font indicate an MCL exceedance.
12	J	Bold outline indicates a tw-RBC exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

tw-RBCs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.

The pyrene tw-RBCs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene.

Secondary MCLs were used for aluminum, iron, manganese, silver, and zinc.

MCL Action Levels were used for copper and lead.

MCL = Maximum Contaminant Level (USEPA, 2006).

tw-RBC = Tap Water Risk-Based Concentration (USEPA, October 2007).

tw-RBC value in table is for the more conservative chromium VI.

tw-RBC value for chromium III is 5,500, which was not exceeded.

ng/L = nanograms per liter (parts per trillion).

µg/L = micrograms per liter (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.

A (Dioxins) = B = (metals) Value <MRL and >MDL and is considered estimated.

E (metals) = Reported value is estimated because of the presence of interferences.

EMPC (Dioxins) = The ion-abundance ratio between the two characteristic PCDD/PCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).

J = (organics) Value <MRL and >MDL and is considered estimated.

U = Analyte not-detected at the method reporting limit.

X = (dioxins) Ion abundance ratio outside acceptable range. Value reported is EMPC.

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

N = presumptive evidence for tentatively identified compounds using a library search

U = analyte not detected

UJ = estimated concentration non-detect

UL = estimated concentration non-detect bias low

Table 4-8
Summary of Analytes Detected in FLFA Groundwater - 2007

Analyte	MCL	tw-RBC	# of MCL Exceedances	# of tw-RBC Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/L)									
Chloroform	80	0.15	0	5	5	7	2.7	24	40MW6
Tetrachloroethene	5	0.1	0	1	1	7	2.6	2.6	17MW02
Toluene	1000	75	0	0	2	7	0.09	0.38	17MW03
PAHs (ug/L)		***None detected***							
SVOCs (ug/L)									
2-Methylnaphthalene	na	2.4	na	0	1	3	0.094	0.094	40MW5
Butylbenzylphthalate	na	730	na	0	2	7	0.038	0.057	40MW3
Diethylphthalate	na	2900	na	0	1	7	0.038	0.038	40MW3
Naphthalene	na	0.65	na	0	1	3	0.094	0.094	40MW5
Pesticides (ug/L)									
Lindane	na	0.052	na	0	1	7	0.0098	0.0098	40MW6
PCBs (ug/L)		***None detected***							
Explosives (ug/L)		***None detected***							
Herbicides (ug/L)		***None detected***							
Metals (ug/L)									
Aluminum	50	3700	3	1	3	10	222	9320	LFMW01
Barium	2000	730	0	0	10	10	29	176	17MW03
Beryllium	4	7.3	0	0	3	10	1.2	1.9	LFMW01
Calcium	na	na	na	na	10	10	52000	120000	LFMW01
Chromium	100	11	0	4	10	10	1.2	43	LFMW01
Cobalt	na	na	na	na	9	10	0.13	26.9	17MW02
Copper	1300	150	0	0	9	10	0.79	7.9	17MW02
Iron	300	2600	2	1	8	10	10	10100	LFMW01
Lead	15	na	0	na	2	10	0.51	3.6	LFMW01
Magnesium	na	na	na	na	10	10	18000	56700	LFMW01
Manganese	50	73	1	1	5	10	0.48	78.3	LFMW01
Mercury	2	1.1	0	0	1	10	0.04	0.04	40MW3
Nickel	na	73	na	0	10	10	0.49	30.5	LFMW01
Potassium	na	na	na	na	10	10	1000	6120	LFMW01
Selenium	50	18	0	0	3	10	1.1	1.4	40MW5
Silver	100	18	0	0	1	10	6.2	6.2	17MW02
Sodium	na	na	na	na	10	10	5690	19500	17MW03
Vanadium	na	3.7	na	1	2	10	1.5	20	LFMW01
Zinc	5000	1100	0	0	10	10	3.3	60.4	LFMW01
Misc. (ug/L)									
Perchlorate	na	2.6	na	3	7	7	0.52	5.4	17MW02
Dioxins/Furans (ng/L)									
1,2,3,7,8,9-HXCDD	na	0.011	na	0	1	4	0.00268	0.00268	LFMW01
OCDD	na	na	na	na	3	4	0.0102	0.0686	LFMW01
1,2,3,7,8-PECDF	na	na	na	na	1	4	0.00127	0.00127	LFMW01
2,3,4,7,8-PECDF	na	na	na	na	1	4	0.00154	0.00154	LFMW01
TOTAL HXCDD	na	0.011	na	0	1	4	0.00268	0.00268	LFMW01
TOTAL PECDF	na	na	na	na	1	4	0.00282	0.00282	LFMW01

***Dioxins/Furans*.** Four dioxin/furan congeners were detected in the samples. None of the individual congeners were detected at a concentration above groundwater screening levels. Total HXCDD concentrations were also below groundwater screening levels in all five wells.

4.2 Nature and Extent Summary and Conclusions

4.2.1 Soil

The soil at the FLFA was investigated during the 1992 VI, the 1998 RFI, the 2002 RFI, and again in 2007. The combined data set from these investigations indicates that metals (primarily lead, with lesser amounts of arsenic and copper), dioxins/furans, and PCBs, mostly in surface soil, are the constituents of concern at the FLFA. 1998 RFI activities took out the furnace structures and grossly contaminated soil within and around the structures.

Additional, smaller areas outside the footprint of the lead furnace remained at the site after the 1998 activities. These areas were identified in the 2002 Investigation, and the extent of these areas was bound during the 2007 Investigation. Arsenic, copper, dioxins/furans, and PCBs were found collocated with the lead in 2002 Investigation samples. Because these compounds originated from the same source and have similar fate and transport properties, XRF field screening was used to define the extent of lead with fixed-base laboratory confirmation samples analyzed for metals, PCBs, and dioxins/furans to confirm the association of the organic constituents and secondary metals with the lead. The confirmation samples were also analyzed for lead to assess the accuracy of the XRF sample results (*Section 3.1.1*).

4.2.2 Surface Water/Sediment

Surface water and sediment samples were collected during the 1996 RFI and the 2007 Investigation from the spring (SPG 3) on the New River where a dye trace study (Engineering Science, 1994) indicated a hydraulic connection with the FLFA/SWMU 17A sinkhole. Based on the age of the data [samples collected on 1/13/95 (13 years)] collected for the 1996 RFI, the more recent data from 2007 was used to evaluate the current state of the surface water and sediment at the spring. The two samples were collected before and after the lead furnace and grossly contaminated soil were taken out in 1998. The engineered burn pad at SWMU 17A was also installed in the years between the two sampling events. These samples provide an opportunity to assess the impact of these remediation activities on the transport of constituents through groundwater from the sinkhole to the discharge spring.

Prior to remediation activities at the FLFA in 1998 and SWMU 17A in 2003, lead was detected in the spring water at a concentration of 25.2 µg/L, exceeding the MCL of 15 µg/L. Lead was not detected in the post-remediation spring water sample collected in 2007. Similarly, the lead concentration in the spring sediment in 1995 was 550 mg/kg, greater than the residential screening level of 400 mg/kg. In 2007, the lead concentration was 195 mg/kg. Arsenic concentrations in sediment follow a similar pattern, with a 1995 concentration of 17.4 mg/kg, exceeding the background value of 15.8 mg/kg. In 2007, the concentration was reduced to 3.4 mg/kg, well below the background concentration. Comparisons between PCB and dioxin/furan concentrations are not possible because the 1995 sample was not analyzed for these constituent groups. Aroclor-1260 was detected in the 2007 sediment sample at a concentration below the residential screening level. Dioxins/furans were detected in the 2007 sample as well; with Total HXCDD exceeding it is residential screening criterion. Although the 1995 sample was not analyzed for PCBs or dioxins/furans, it is reasonable to assume that concentrations of these constituents have also been reduced through test pitting activities at the FLFA and the installation of the burn cap at SWMU 17A. These engineered controls have had a positive impact on the spring quality and have reduced constituents' ability to migrate through the groundwater system to the spring, either through reduction in soil concentrations resulting from 1998 activities or through the engineered collection of runoff from the burn pad.

4.2.3 Groundwater

Groundwater samples were collected from two upgradient wells, one on-site well, and two downgradient wells during the 2007 Investigation. Although samples were collected from the two upgradient wells during the 1996 RFI, more recent data from the 2007 Investigation will be used to assess potential groundwater contamination at the FLFA.

Two VOCs (chloroform and PCE), five metals (aluminum, chromium, iron, manganese, and vanadium), and perchlorate were detected in FLFA wells at concentrations exceeding groundwater screening levels. PCE was detected in a single upgradient well (17MW-2) at a concentration below its MCL. Chloroform was detected in five of the seven wells sampled. The maximum concentration was 24 µg/L, well below the MCL of 80 µg/L. These detections of chloroform are attributable to leaks in potable water supply lines throughout the Installation. Chloroform has also been detected at similar concentrations at other sites downgradient from water lines (Area O, for example). Neither of the VOCs are originating from the FLFA, as evidenced by the fact that: 1) they were not detected in site soil; and, 2) they were not detected in the on-site well. Perchlorate is currently being detected in every sample taken on RFAAP property at very low levels. However, there has been no probable perchlorate source identified on RFAAP property and no plume detected. Therefore, it has been hypothesized that the new lab detection method is the reason for the consistent perchlorate detections throughout the property or the source is from a location outside of RFAAP property.

Metals in groundwater were detected at their highest concentrations in on-site well LFMW01. This sample was a total (unfiltered) groundwater sample that was preserved with nitric acid immediately after collection. The sample had high turbidity (>999 NTU) that did not clear up during purging after the other water quality parameters had stabilized. The result of adding preservative (nitric acid) to the turbid sample is mobilization of suspended metals into solution through the reduction in pH, which explains the high metals in that well.

Perchlorate is a component of propellants used to control their burn rate and is generally more mobile than the explosives components of the propellants. The FLFA is not the source of perchlorate in groundwater based on the following lines of evidence:

1) There is no history of use of propellants at the FLFA.
2) Explosives were not detected in FLFA soil.
3) Perchlorate was found in wells upgradient of the FLFA.

5.0 CONTAMINANT FATE AND TRANSPORT

This section presents a discussion of the fate and transport mechanisms for constituents of potential concern at the FLFA. 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**. A discussion of the physical and chemical properties affecting soil conditions at the FLFA is presented as *Section 5.1*.

Organic (PCBs and dioxins/furans) and inorganic contaminants (aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, nickel, silver, thallium, and zinc) were detected at concentrations greater than their respective residential screening level in soil samples collected at the FLFA. A generalized fate and transport discussion for those constituents identified as risk drivers in the human health risk assessment (HHRA) are presented in *Section 5.2*.

5.1 Soil Properties at the FLFA

The chemical and physical properties of the soil influence the fate and transport of constituents through the environment. Samples were collected from the FLFA during the 2002 RFI and analyzed for grain size distribution, pH, and TOC to assess these chemical and physical characteristics of the soil. A summary of each follows.

Grain Size Distribution. The grain size distribution measures the amount of clay, silt, sand, and gravel in a sample based on the diameter of the material. Soil particles less than 0.002 millimeters are classified as clay and have a very large specific surface area, allowing them a significant capacity to adsorb water and other substances. Clay composition greatly influences soil fertility and the physical conditions of the soil. Clay directly affects the permeability and the plasticity of soil by generally lowering the soil’s permeability and increasing the plasticity. Because pores between clay particles are very small and convoluted, movement of both water and air is very slow. Fate and transport of chemical compounds are hindered when passing through a soil with a high composition of clay due to clay’s ability to adsorb cat-ions and to retain soil moisture. The grain size distribution is also used to assess the permeability of soil. Well-sorted sands and gravels have a smaller distribution of grain size and a higher permeability. Poorly sorted, clayey sands and gravels have a large range in grain size and lower permeability because the smaller clay and silt particles fill in the void spaces between the sand and gravel.

One surface and one subsurface soil sample were collected and analyzed for grain size distribution at the FLFA during the 2002 RFI (samples LFSB12A and LFSB12C, respectively). The surface soil sample was classified as sandy lean clay (9% gravel, 26% sand, and 65% silt and clay) and the subsurface soil sample was classified as lean clay with sand (9% gravel, 13% sand, and 78% silt and clay). With this soil make-up and distribution, the surface soil is mostly silt and clay, considered poorly-sorted, and therefore has a low permeability. The subsurface soil is also mostly silt and clay, but on the other hand, is better sorted and therefore has a slightly higher permeability. Therefore, in a fairly low permeability soil environment, contaminants have a more difficult time migrating deeper into the soil or making their way into the groundwater.

Soil pH. Soil pH is a measure of acidity or alkalinity and is an important chemical property because it is an indication of soil reaction potential. Soil reaction influences the fate of many pollutants, affecting their breakdown and potential movement. For example, 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. 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. The transport of some contaminants is also affected by pH. This is less significant for neutral and slightly polarized organic compounds, which are somewhat affected by pH, but is significant for chemicals that tend to ionize (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, retarding transport rates. pH also affects the rate of biodegradation that may occur at a site. 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).

Soil at RFAAP generally ranges in pH from slightly less than 4.0 to slightly more than 9.61. A review of pH results during the Facility-Wide Background Study Report (IT, 2001) across soil types at the MMA did not yield outstanding trends. Higher soil pH results were generally associated with limestone and shale parent material (IT, 2001).

One surface and one subsurface soil sample were collected and analyzed for pH at the FLFA during the 2002 RFI (samples LFSB12A and LFSB12C, respectively). The pH was 7.57 in the surface soil sample and 7.56 in the subsurface soil sample. This indicates that the pH of the soil is in the range that would favor precipitation and adsorption of most metals (including arsenic, copper, and lead), rather than dissolution into the water phase.

Total Organic Carbon. Organic matter content is expressed as a percentage, by weight, of the soil material that is a composition of plant and animal residues in the soil at various stages of decomposition. Available water capacity and infiltration rate are affected by organic matter content. Sorption and desorption are two major mechanisms affecting the fate of contaminants in the subsurface. 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. 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. For nonionic organic chemicals and aquifer materials, sorption is largely controlled by the clay and organic carbon content of the soil. Therefore, the amount of TOC present in the soil matrix has a large affect on the fate of both organic and inorganic compounds. The degree to which TOC affects the fate of a chemical varies dependent on the properties of the chemical itself. Soil TOC concentrations at RFAAP range from 0.075% to 30.4%, with a media value of 0.5%.

One surface and one subsurface soil sample were collected and analyzed for TOC during the 2002 RFI (samples LFSB12A and LFSB12C, respectively). The TOC concentration was 1.45% in the surface soil sample and 0.374% mg/kg in the subsurface soil sample.

5.2 Fate and Transport of Analytes Detected Above Screening Levels

5.2.1 Inorganic Compounds

Thirteen metals (aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, nickel, silver, thallium, and zinc) were detected in soil above residential screening levels and background concentrations at the FLFA. Specific characteristics of those metals (arsenic, lead, and copper) identified as risk drivers in the HHRA (*Section 6.0*) are discussed in more detail in the following sections.

5.2.1.1 Arsenic

Arsenic (As) is a natural component of the earth's crust and can be released to the environment from natural sources (e.g., erosion of sulfide mineral deposits) as well as from human activities. Levels of arsenic are found in natural environmental media, ranging from 1 to 400 mg/kg in soil.

The most common forms of arsenic found in nature (As^{+5} and As^{+3}) are found in aqueous solution as arsenate (AsO_4^{-3}) and arsenite (AsO_2^{-1}), respectively. However, the metallic (0 state) and –3 state may also occur. Both arsenate and arsenite are toxic; however, arsenite is the more toxic form, and arsenate is the most common form. Arsenate is relatively immobile in the environment due to its formation of insoluble complexes with iron, aluminum, and calcium. The presence of iron is most effective in controlling the mobility of arsenate. Iron is present at high concentrations in FLFA soil and groundwater. In contrast, arsenite compounds are 4 to 10 times more soluble than arsenate compounds. The adsorption of arsenite is also strongly pH dependent. One study found increased adsorption of arsenite by two clays over the pH range of 3 to 9, while another study found the maximum adsorption of arsenite by iron oxide occurred at pH 7 (USEPA, 1992). FLFA soil has a pH of approximately 7.5, indicating that adsorption of arsenic by the clayey soil would be high.

5.2.1.2 Copper

Copper (Cu) is distributed in the natural environment in many forms. When present in water as a salt it is highly soluble. There are also many anthropogenic sources of copper. The most common anthropogenic source of copper in the environment is the weathering of copper pipes in the subsurface. Low levels of copper are essential in living things for maintaining good health. High levels can cause harmful effects.

Once introduced into the soil and water environments, pH, drainage, redox conditions, and the amount of organic matter in the soil will largely influence copper transport. More alkaline conditions will result in the precipitation of copper; whereas, more acidic conditions (primarily a pH of 3 or less) will promote the solubility and leachability of copper. Soil at the FLFA is neutral to slightly basic (approximately 7.5) and would favor precipitation of copper.

5.2.1.3 Lead

Lead (Pb) is a naturally-occurring bluish-gray metal found in small amounts in the earth's crust. Lead can be found in all parts of our environment. Much of it comes from human activities including burning fossil fuels, mining, and manufacturing. Lead has many different uses. It is used in the production of batteries, ammunition, metal products (solder and pipes), and devices to shield X-rays. Because of health concerns, lead from paints and ceramic products, caulking, and pipe solder has been dramatically reduced in recent years.

The most common form of lead found in nature is Pb (II), although lead also exists to a lesser extent as Pb (IV) and in the organic form with up to four Pb-carbon bonds. 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. 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 soil. Adsorption of lead increases with increasing pH with most lead precipitating out at a pH greater than 6 (USEPA, 1990).

5.2.2 Organic Compounds

Three groups of organic compounds, including PAHs, dioxins/furans, and PCBs, were detected in soil above residential screening levels at the FLFA. Specific characteristics of those organics (dioxins/furans and PCBs) identified as risk drivers in the HHRA (*Section 6.0*) are discussed in more detail in the following sections.

5.2.2.1 Dioxins/Furans

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.

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 degrees Celsius (°C). Dioxins/furans also have low vapor pressures [e.g., $1.0\text{x}10^{-6}$ 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., $3.30\text{x}10^{+6}$ 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% by photodegradation over a 16-month period, but the dioxin concentrations below this depth did not change.

In summary, dioxins and furans are 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.

5.2.2.2 Polychlorinated Biphenyls

PCBs, which are also known by the trade name "Aroclor," were produced by the partial chlorination of biphenyl in the presence of a catalyst. The production of PCBs in large quantities began in 1929. Prior to 1974, PCBs were used both for nominally closed applications (e.g., capacitor and transformers, and heat transfer and hydraulic fluids) and in open-end applications (e.g., flame retardants, inks, adhesives, microencapsulation of dyes for carbonless duplicating paper, paints, pesticide extenders, plasticizers, polyolefin catalyst carriers, slide-mounting mediums for microscopes, surface coatings, wire insulators, and metal coatings) (Durfee, 1976; IARC, 1978; Orris et al., 1986; Safe, 1984; Welsh, 1995). The manufacture of PCBs in the United States ceased in 1977 because of evidence that PCBs were toxic and accumulated in the environment.

PCBs are distinguished by a four-digit code in which the first two digits (e.g., 12) indicate the production process and the second two digits indicate the weight percent of chlorine (e.g., 48). Thus, Aroclor-1254 is a PCB with an average chlorine content of 54%. The water solubility for Aroclor-1254 is 4.1 x 10^{-2} mg/L. Therefore, this Aroclor is not soluble in water. The vapor pressure of Aroclor-1254 is 4.40 x 10^{-5} mm Hg. As a result of the low vapor pressure, this PCB will not volatilize to the atmosphere. This point is further supported by the Henry's Law Constant, which for this compound is 2.0 x 10^{-4} atm-m^3/mole. The log K_{oc} and log K_{ow} values for Aroclor-1254 is 6.33 and 6.94, respectively. The log K_{oc} values indicate that the PCBs will tend to stay bound to the organic fraction of the soil instead of leaching into groundwater or surface water runoff. The log K_{ow} values support this argument indicating that PCBs have a stronger affinity for nonpolar soil particles than a polar water phase.

PCBs are highly immobile. PCBs are very persistent in the environment and are extremely resistant to oxidation and hydrolysis. The properties that made PCBs applicable for industrial use are the same properties that cause it to be persistent in the environment: chemical stability; thermal stability; resistance to hydrolysis by water, alkalis, and acids; and low flammability. Based on the K_{oc} and K_{ow} values, Aroclor-1248 and Aroclor-1254 will tend to remain in soil once released into the environment.

5.3 Summary and Conclusions

Elevated constituents that were identified as risk drivers in FLFA soil include metals (arsenic, copper, and lead), PCBs, and dioxins/furans.

Because the fate and transport of constituents is dependent on environmental conditions, the physical properties of the FLFA soil (grain size distribution, pH, and TOC content) were tested during the 2002 investigation. Grain size analysis shows that both surface and subsurface soil is mostly silt and clay, with lesser amounts of gravel and sand. Clays and silt are low permeability materials that tend to act as barriers to movement of groundwater and contaminants. Clays are also highly adsorptive which will also tend to restrict the movement of contaminants. pH was similar in the surface and subsurface and ranged from 7.56 (surface) to 7.57 (subsurface). This pH indicates that the soil is neutral to slightly basic, which favors the precipitation of metals in solution. Soil TOC at the FLFA was 1.45% in the surface soil and 0.374% in the subsurface soil. Soil TOC, in addition to clay content, plays a large role in the sorption of constituents. In summary, all three of these physical soil properties at the FLFA would tend to favor partition into the solid phase rather than the aqueous phase, and would therefore limit the mobility of constituents in the environment.

Physical characteristics of the elevated constituents also play a role in their fate and transport. PCBs and dioxins/furans are organic constituents that are both highly immobile, with strong sorption tendencies in the environment and are stable in the soil. They will persist in the soil with limited breakdown, but are unlikely to migrate through environmental processes. Fate and transport of FLFA metals (arsenic, copper and lead) is highly dependent on the soil pH. Acidic conditions favor migration, while neutral and basic conditions (similar to the FLFA) favor precipitation.

The physical properties of the soil at the FLFA, as well as the chemical properties of the contaminants themselves, play a role in the fate and transport of these constituents. At the FLFA, properties of the soil and the constituents would both tend to favor partition of constituents to the soil (through precipitation and adsorption), rather than to the groundwater. Constituents bound in soil are more immobile and do not tend to be transported in the environment.

6.0 HUMAN HEALTH RISK ASSESSMENT

This HHRA evaluates the probability and magnitude of potential adverse effects on human health associated with exposure to site-related chemicals in soil and groundwater. Refer to *Section 2.0* for additional information regarding the site background. The HHRAs were conducted for the sites consistent with guidance included in USEPA's *Interim Final Risk Assessment Guidance for Superfund* (RAGS) and other current USEPA/USEPA Region III resources and guidance documents as noted on the RAGS Part D tables provided in **Appendix E-1**.

This HHRA is organized consists of the following six sections:

- ***Section 6.1*: Data Summary and Selection of Chemicals of Potential Concern (COPCs):** Relevant site data are gathered, examined, and discussed. Basic constituent statistics and screening levels are summarized. COPCs are identified by comparison to screening criteria as discussed in *Section 6.1.2*.
- ***Section 6.2*: Exposure Assessment:** Potentially exposed populations (e.g., receptors) and exposure routes are identified, and exposure point concentrations (EPCs) are calculated for COPCs. Standard exposure factors and health-protective assumptions are used to assess the magnitude, frequency, and duration of exposure for each exposure route and intakes are calculated.
- ***Section 6.3*: Toxicity Assessment:** Toxicity criteria for COPCs are gathered and presented.
- ***Section 6.4*: Risk Characterization:** Quantitative risks and hazards are estimated and summarized by combining toxicity criteria with intakes for each exposure route.
- ***Section 6.5*: Uncertainties Analysis:** Uncertainties, "including uncertainties in the physical setting definition for the site, in the models used, in the exposure parameters, and in the toxicity assessment" (USEPA, 1989b) are discussed.
- ***Section 6.6*: Summary and Conclusions:** The results of the HHRA are summarized.

As previously stated, the tabulated risk assessment results are presented in accordance with USEPA guidance described in RAGS: Volume I - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments) (USEPA, 2001a). RAGS D requires the risk assessment results to be presented in a series of standardized tables, which are presented in **Appendix E-1**.

6.1 Data Summary and Selection of COPCs

6.1.1 Data Summary

Table 6-1 identifies the soil and groundwater samples used in the HHRA for the FLFA. Refer to *Section 4.0* for data screening tables for detected analytes for each media. Additional information regarding the data used in the HHRAs is summarized below:

- Though several dioxins are known to be toxic, toxicity criteria are limited to 2,3,7,8-TCDD. Therefore, the HHRA uses the method outlined in Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans (CDDs and CDFs) (USEPA, 1989a and WHO, 2006) and

Table 6-1
FLFA Sample Groupings

SURFACE SOIL[a]

LFSS01
LFSS02
LFSS03
LFSS04
LFSS05
LFSS06
LFSS07
LFSS08
LFSS09
LFSS10
LFSS11
LFSS12
LFSS13
LFSS14
LFSS15
LFSS16
LFSS17
LFSS18
LFSS19
LFSS20
LFSS21
TMSS01
TMSS20
LFSB1A
LFSB3A
LFSB8A
LFSB9A
LFSB10A
LFSB11A
LFSB12A
LFSB15A
LFSB16A
LFSB16B
LFSB17A
LFSB17B

TOTAL SOIL[b]

17SB1A
17SB1B
17SB3A
17SB3B
LFSS01
LFSS02
LFSS03
LFSS04
LFSS05
LFSS06
LFSS07
LFSS08
LFSS09
LFSS10
LFSS11
LFSS12
LFSS13
LFSS14
LFSS15
LFSS16
LFSS17
LFSS18
LFSS19
LFSS20
LFSS21
TMSS01
TMSS20
LFSB1A
LFSB3A
LFSB4A
LFSB6A
LFSB8A
LFSB9A
LFSB10A
LFSB10B
LFSB11A
LFSB12A
LFSB12B
LFSB12C
LFSB13A
LFSB14A
LFSB14B
LFSB15A
LFSB15B
LFSB15C
LFSB16A
LFSB16B
LFSB16C
LFSB17A
LFSB17B
LFTP1
LFTP2
LFTP3
LFTP4
LFTP5
LFTP6
LFTP7
LFTP8

GROUNDWATER[c]

17MW02
17PZ01
LFMW01
40MW5
40MW6
40MW5-DUP

(a) Surface soil samples consist of samples collected at depths of 0-2 ft. If soil sample depth straddled this 0-2 ft range, then it was also considered a surface soil sample. Samples LFSB16B and LFSB17B were collected at a 1-3 ft depth interval and are, therefore, part of the surface soil grouping.

(b) Total soil sample group includes all surface and subsurface soil samples, with the exception of samples from borings 17SB2, LFSB2, LFSB5, and LFSB7, where the soil was removed at these locations.

(c) Groundwater samples 40MW5, 40MW6, and 40MW5-DUP were collected off site.

USEPA Region III Dioxin/Furan Data Validation Guidance (USEPA, 1999b) to assess risks due to exposure to dioxins and/or furans. In accordance with USEPA Region III guidance, each detected congener is converted to 2,3,7,8-TCDD equivalent utilizing a toxicity equivalence factor (TEF), which corresponds to its toxicity relative to 2,3,7,8-TCDD. The concentration of the congener is multiplied by its corresponding TEF. Assuming toxic effects are additive, the adjusted concentrations for all congeners detected in the sample are then summed to derive one total 2,3,7,8-TCDD equivalent concentration. This concentration is then compared with toxicity criteria for 2,3,7,8-TCDD to calculate risks. Consistent with the guidance, congeners that were not detected in the sample are not included in the calculation of the toxicity equivalent. TEFs are presented and total 2,3,7,8-TCDD equivalents are calculated for surface soil, total soil, and groundwater in **Appendix E-2**.

- If a constituent was measured by two methods, results from the more sensitive analytical method were used. For example, PAHs were analyzed as part of the SVOC method, as well as by a PAH-specific method. Results from the specific method were used.
- J-flagged data (estimated concentration) are considered detections and are used without modification.
- 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, 1995a, 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 the FLFA was greater than 50%, 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%, the B-qualified data for the analyte were eliminated.
- Rejected results (R-flagged) are not used.
- Data from duplicate sample pairs are averaged and treated as one result. If an analyte is detected in one of the sample pair, one half the detection limit of the non-detect is averaged with the detected result and the result is considered detected.

Additional information regarding specific soil and groundwater samples used in the HHRA is provided in *Sections 6.1.1.1 and 6.1.1.2.*

6.1.1.1 Surface Soil and Total Soil

Soil samples collected during sampling events completed in 1991, 1998, 2002, and 2007 were used for the COPC screenings. Soil samples from the 1991 and 1998 sampling events that were located in the excavated area (17SB2, LFSB2, LFSB5, and LFSB7) were not included in the risk assessment since that soil is no longer present and is not representative of current site conditions. As presented in **Table 6-1**, the soil samples for the FLFA have been divided into surface soil (0-2 ft bgs) and total (0-10 ft bgs). Two samples (LFSB16B and LFSB17B) were collected between 1 and 3 ft; therefore, these samples were considered to be surface soil samples. The total soil data grouping was assembled by combining the surface and subsurface soil data sets to address mixing of potential soil contamination during construction or land development activities. A total of 35 surface soil samples and 58 subsurface soil samples were used for the HHRA.

6.1.1.2 Groundwater

Groundwater samples collected during sampling events completed in 2007 were used for the COPC screenings. A total of six samples (including one duplicate) were collected. Two groundwater monitoring wells (17MW2 and 17PZ1) were located upgradient and one well (LFMW01) was located on site at the FLFA. Two additional wells (40MW5 and 40MW6) were located downgradient of the site. These locations are listed in **Table 6-1**.

6.1.2 Identification of COPCs

COPCs were identified for the sites by comparing the maximum detected concentration (MDC) to the following screening levels for each media: USEPA Region III r-RBCs (surface soil and total soil) and USEPA tw-RBCs (groundwater) as presented in the October 2007 USEPA Region III RBC and Alternate RBC Tables (USEPA, 2007a). In accordance with USEPA Region III guidance, RBCs for non-carcinogenic chemicals were adjusted downward to a hazard quotient (HQ) of 0.1 to ensure that chemicals with additive effects were not prematurely eliminated during screening. In addition, a lead action level of 400 mg/kg for residential receptors was used in the COPC identification since toxicity criteria were not available for lead (USEPA, 1994a).

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). 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.

Analytes detected at a maximum concentration greater than the corresponding adjusted RBC or screening values identified above for nutrients and lead were selected as COPCs. Analytes for which no screening criteria exist were also selected as COPCs. COPC screening tables for each area are presented in **Appendix E.1**, **Tables E.1-2** (COPC Determination Detects-Surface Soil), **E.1-4** (COPC Determination Detects-Total Soil), and **E.1-6** (COPC Determination Detects-Groundwater). The COPCs selected for each medium are summarized in **Table 6-2**.

Similarly, the reporting limits for those constituents that were not detected were compared with RBCs for each medium. Chemicals that were not detected in at least one medium have not been included in the HHRA. The reporting limits for the non-detected constituents were screened against the RBCs to ensure that the range of reporting limits was generally low enough to detect constituents that would exceed RBCs. The maximum reporting limits for these constituents were compared with RBCs. The results of these comparisons are shown in **Appendix E.1**, **Tables E.1-3** (Non-Detect Screening- Surface Soil), **E.1-5** (Non-Detect Screening-Total Soil), and **E.1-7** (Non-Detect Screening-Groundwater). Detected constituents identified as COPCs were carried through the quantitative risk assessment. The reporting limits for constituents that were

Table 6-2
Summary of Chemicals of Potential Concern at the FLFA

Chemical (a)	Surface Soil	Total Soil	Groundwater
Organics			
Aroclor-1254	X	X	
Aroclor-1260	X	X	
Benzo(a)pyrene	X	X	
bis(2-chloroethoxy)methane	X	X	
Chloroform			X
4-Chlorophenyl phenyl ether	X	X	
Di-n-octyl phthalate	X	X	
2-Nitrophenol	X	X	
p-Chloro-m-cresol	X	X	
Perchlorate			X
TCDD-Toxicity Equivalent	X	X	X
Tetrachloroethene			X
Inorganics			
Aluminum	X	X	X
Antimony	X	X	
Arsenic	X	X	
Barium	X	X	
Cadmium	X	X	
Chromium	X	X	X
Cobalt	X	X	X
Copper	X	X	
Iron	X	X	X
Lead	X	X	
Manganese	X	X	X
Nickel	X	X	
Silver	X	X	
Thallium		X	
Vanadium	X	X	X
Zinc	X	X	

(a) Chemicals detected in all media at the FLFA.
Shaded cells indicate that the chemical lacks toxicity criteria and cannot be quantitatively evaluated.
X = Selected as a COPC in this media.

not detected in surface soil, total soil, or groundwater are evaluated with respect to their screening criteria and discussed in the uncertainty section (*Section 6.5.2*).

6.2 Exposure Assessment

The objective of the exposure assessment is to estimate "the type and magnitude of exposures to chemicals of potential concern" (USEPA, 1989b). When combined with chemical-specific toxicity information (summarized in the toxicity assessment), these exposures produce estimations of potential risks.

6.2.1 Conceptual Site Model/Receptor Characterization

Refined CSMs for the FLFA are presented on **Figure 1-2** and **Figure 1-3** for current and future exposure scenarios, respectively. The FLFA encompasses an approximately 0.78 acre area located in the MMA at the bottom of a steeply sloping hillside in the southeast portion of SWMU 17A, the Stage and Burn Area. Building foundations and surrounding soil have been taken out (0.05 acre area) and replaced by clean fill.

The FLFA is not currently in use. Land use around the FLFA is industrial, with an open burn area and a shipping/receiving facility nearby. Vehicle traffic to the FLFA is restricted, though the site itself is not fenced. The nearest residences are a few miles away. It is expected that the FLFA and surrounding vicinity will remain industrial into the foreseeable future.

Even though the site is not currently used, it was conservatively assumed that maintenance workers are the most likely receptors at the site. Due to Installation security, it is unlikely that trespassers could gain access to the FLFA; however, risks associated with the maintenance worker are considered protective of the limited exposure experienced by the trespasser.

If future development occurs, maintenance workers, industrial/commercial workers, and excavation workers could be exposed to surface and subsurface soil as a result of disturbing soil during construction/excavation activities. Therefore, maintenance worker, industrial worker, and excavation worker exposures at the FLFA were evaluated for total soil in the HHRA.

RFAAP is likely to remain a military installation; therefore, a residential scenario is considered unlikely. However, the residential use scenario was evaluated as part of the HHRA in order for the Army to make a determination if it was possible to obtain clean closure under RCRA.

6.2.2 Identification of Exposure Pathways

The potential receptors identified for the FLFA include maintenance workers, industrial workers, excavation workers, child residents, adult residents, and lifetime residents. An excavation worker is an individual who would be engaged in excavation work as well as other site construction activities. **Appendix E-1, Table E.1-1** summarizes the selection of exposure pathways for each receptor listing the rationale for the inclusion or exclusion of each pathway. CSMs for the FLFA are presented on **Figures 1-2 and 1-3**.

6.2.3 Calculation of EPCs

To calculate intakes, a 95% upper confidence limit of the mean concentration (95% UCL) for each COPC is used as a conservative estimate of the average concentration in a given environmental medium to which a receptor would be exposed. The 95% UCL estimate is referred to as the EPC. The 95% UCL is used rather than the mean concentration, to account for uncertainty when estimating EPCs from sample data (USEPA, 1989b). Methods used to calculate 95% UCLs are based on guidance provided in the following documents *Calculating*

UCLs for EPCs at Hazardous Waste Sites (USEPA, 2002a) and *ProUCL Version 4.0 Technical Guide* (USEPA, 2007b).

In general, the method used to calculate a 95% UCL depends on 1) the prevalence of non-detects, and 2) the data distribution (e.g., normal, gamma, or lognormal). Non-detects introduce uncertainty in the data set because the true concentration may be between zero to just below the detection limit. Therefore, distributional assumptions are difficult to ascertain for COPCs with a high rate of non-detects. USEPA's (2007b) ProUCL 4.00.02 statistical program was used to evaluate estimate 95% UCL values for nearly all the soil COPC data sets. For data sets with non-detects, ProUCL uses the Kaplan-Meier estimation method to derive a recommended 95% UCL (USEPA, 2007b). Where ProUCL recommends the results of more than one statistical approach, the most conservative (highest) 95% UCL value was used in the HHRA. Where fewer than 5% of samples had detected values, ProUCL does not recommend a 95% UCL value. In these cases, 95% UCL values were derived using a bootstrap-t statistical program, described by Efron (1982) and discussed in USEPA (1997a). Non-detect values are represented in this bootstrap-t program as random numbers between zero and the detection limit that are generated by the iterative process written into the program. EPCs for soil COPCs are presented in **Appendix E-1, Tables E.1-8 and E.1-9**. EPCs were not calculated for groundwater; therefore, the MDC for COPCs identified for groundwater was used in the risk assessment. The EPC values for groundwater are shown in **Appendix E-1, Table E.1-10**. The output from ProUCL 4.0 is provided in **Appendix E-3**.

The migration of volatile COPCs from groundwater to air was modeled for several scenarios. The EPCs for these scenarios are presented in **Tables E.1-11 through E.1-14**. The exposure models are described in *Section 6.2.4*.

6.2.4 Quantification of Exposure: Calculation of Daily Intakes

For each receptor and pathway, chronic daily intake (CDI, expressed as milligrams of COPC per kilogram body weight per day) for each COPC is estimated by combining the EPC with exposure parameters such as ingestion rate, frequency of contact, duration, and frequency of exposure. In addition, intake parameters are selected so the combination of intake variables results in an estimate of the reasonable maximum exposure for that pathway (USEPA, 1989a, 1997b). Intake formulas, exposure parameters, and chemical-specific parameters for each of the receptors for the FLFA are provided in **Appendix E.1**, **Tables E.1-15 through E.1-24**.

The particulate emission factors (PEFs) and volatilization factors (VFs) used to calculate inhalation daily intakes associated with soil were calculated in accordance with the Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002b), as provided in **Appendix E.1, Tables E.1-25 through E.1-30**.

For exposures to groundwater via dermal contact, the amount of chemical in water absorbed through the skin must be estimated in order to calculate the dose used in the intake formula. The dose absorbed per unit area per event (DA) is a function of chemical concentration in water, the permeability coefficient for that chemical from water through the skin, and exposure time. Following USEPA (2004b) guidance, receptor-specific DA values were calculated using USEPA's worksheet and chemical-specific parameters described in **Appendix E.1, Table E.1-31**.

To evaluate inhalation of VOCs from groundwater, EPCs were calculated for VOCs in air using the models depicted in the following sections and provided in **Appendix E.1, Tables E.1-32**

through E.1-35. For this scenario, the volatilization model outlined in ASTM Risk-Based Corrective Action (RBCA) Guidance (ASTM, 1995) for volatilization from groundwater to ambient air was used. In this case, chemical intake is a result of inhalation of outdoor vapors that originate from dissolved hydrocarbons in groundwater located somewhere below ground surface. The equations used to calculate the volatilization factor to ambient air for VOCs in FLFA groundwater are presented in **Appendix E.1**, **Table E.2-32**.

The Johnson and Ettinger model (USEPA, 2004a) is used to estimate indoor air concentrations of volatiles migrating from groundwater through the groundwater and into a structure. The worksheet for this model was used to estimate air concentrations of VOCs in office buildings and residences for this HHRA (USEPA, 2004a). The worksheets are found in **Appendix E.4** and the results are given in **Appendix E.1, Table E.1-33**.

In the event that excavation work is performed on site, the worker may be exposed to volatile emissions from groundwater below the bottom of the trench. While USEPA does not have a standardized model for estimating concentrations of airborne VOCs in a trench or a pit, the Virginia Department of Environmental Quality (VDEQ) provides such a model on their Voluntary Remediation Program (VRP) web site (VDEQ, 2007). The equation and parameters are given in **Appendix E.1, Table E.1-34**.

EPCs of VOCs in air due to volatilization from groundwater were estimated for a showering scenario, applicable to the adult resident, using the Foster-Chrostowski (1987, 2003) shower room model. The model is described in **Appendix E.1, Table E.1-35**.

6.3 Toxicity Assessment

The methodology used for classifying health effects from exposure to chemicals is recommended by USEPA (2007c). 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, 2007c).
- 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 (USEPA, 2003b). Because access to PPRTV is limited, these values were obtained directly from USEPA Region III's RBC table (USEPA, 2007a).
- 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, 1997c).

Toxicity criteria used to quantify non-carcinogenic hazards (risk reference doses - RfDs) and carcinogenic risks (e.g., slope factors - CSFs) are presented in **Appendix E-1**, **Tables E.1-36 through E.1-39**.

Quantitative oral toxicity criteria were not available for lead. Lead was selected as a COPC in total soil at the FLFA. The Adult Lead Model (ALM), developed by USEPA's Technical Review Work Group for Lead (USEPA, 2003c), 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, 2003c). 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 total soil at the FLFA. Because the lead model is a probabilistic model, several of the USEPA default parameters are based on central tendency (i.e., average) values (USEPA, 2003c). Therefore, the arithmetic mean for total soil served as input values for the soil concentrations.

Spreadsheets for the ALM (USEPA, 2005a) were used to calculate blood lead concentrations for surface and total soil for the maintenance worker and industrial worker, and total soil for the excavation worker. The input parameters are presented in **Appendix E-1, Tables E.1-40a, E.1-41a, and E.1-42a**, respectively. The spreadsheets are provided as **Appendix E-1, Tables E.1-40b, E.1-41b, and E.1-42b** 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 micrograms per deciliter (µg/dL) (below which adverse manifestations are not expected). Populations of workers with 5% or less of the population exceeding a blood lead level of 10 µg/dL are regarded as sufficiently protected.

The potential risks associated with residential exposures to lead are addressed using the Integrated Exposure Uptake Biokinetic (IEUBK) Lead Model for Windows®, Version 1.0, Build 264 (USEPA, 1994a, 2002c, 2007d). 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.1-43**. Populations of children with 5% or less exceeding blood-lead levels of 10 µg/dL are regarded as sufficiently protected (USEPA, 2002c). The corresponding input parameters and the probability density plots from the model are included with the table.

The toxic effects associated with chromium are dependent upon its valence state (USEPA, 1998a). 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 use 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. Hexavalent chromium analyses were not performed for the environmental media samples at the FLFA.

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. The pH values for two samples taken at the FLFA are 7.56 and 7.57. The relationship between corresponding chromium concentrations versus pH, is shown in **Appendix E-5, Plot 1**. The pH values were indicative of relatively neutral soil conditions. Because there were only two data points, no trend could be observed. This relationship suggests that the elevated chromium measurement may not be Cr(III). 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 Oak Ridge National Laboratory (ORNL) (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.

The relationship between increasing chromium concentrations in soil and increasing TOC are presented in **Appendix E-5, Plot 2**. The elevated Cr may be due to the elevated TOC. Reduction of Cr(VI) to Cr(III) would be likely or possible.

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.

6.4 Risk Characterization

Quantitative risks and hazards due to exposure to COPCs are estimated and summarized by combining toxicity criteria (presented in the Toxicity Assessment) with CDIs (calculated in the Exposure Assessment). Methods used to calculate risks and hazards are taken from USEPA (1989b).

For exposures to potential carcinogens, the individual upper-bound excess lifetime cancer risk was calculated by multiplying the estimated CDI by the CSF. In order to assess the individual excess lifetime cancer risks associated with simultaneous exposure to COPCs, the risks derived from the individual chemicals are summed within each exposure pathway. For the residential scenario, carcinogenic risk was evaluated for the lifetime resident.

Non-carcinogenic adverse health effects are calculated by dividing the CDI of each COPC by its RfD, forming an HQ. HQs greater than one indicate the potential for adverse health effects. To estimate non-carcinogenic adverse health effects due to simultaneous exposure to several COPCs, HQs for individual COPCs are summed within each exposure pathway to form an HI. As with HQs, HIs that are greater than 1 indicate potential adverse health effects. In such cases, COPCs are divided into categories based on the target organ affected (e.g., liver, kidney) and target organ-specific HIs are recalculated. Non-carcinogenic hazards were evaluated for both child and adult residents independently.

Excess lifetime cancer risks derived in this report are compared to USEPA's target risk range for Superfund sites of 1E-06 to 1E-04 (USEPA, 1989b). In addition, USEPA's Office of Solid Waste and Emergency Response (OSWER) has issued a directive (USEPA, 1991b) clarifying the role of HHRA in the Superfund process. The directive states that, if the cumulative carcinogenic risk to a receptor (based on reasonable maximum exposure for both current and future land use) is less than 1E-04 and the non-carcinogenic HI is equal to or less than 1, action generally is not warranted unless adverse environmental effects are likely.

Calculation of risks and hazards due to exposure to COPCs are presented in **Appendix E-1**, **Tables E.1-44 through E.1-59**. The spreadsheets for the risk and hazard calculations are provided in **Appendix E-l**, **Tables E.1-60 through E.1-67** and summarized in **Table 6-3**. A refinement of the HIs based on target organs is conducted by calculating HIs on a target organ-specific basis. In addition, **Appendix E-1, Tables E.1-68 through E.1-75** summarize risks and hazards for risk/HI drivers (i.e., those COPCs contributing to a total risk greater than 1.E-06 or a total target organ hazard greater than 1).

6.4.1 Lead Exposure Models

The MDC for lead in total soil for the FLFA was above the lead screening level of 400 mg/kg, and therefore, the potential hazard associated with lead was evaluated using the EPA ALM (USEPA, 2005a) for adult industrial/maintenance and excavation workers and the IEUBK model for the child resident scenario (USEPA, 2007d). Similarly, the lead MDC for FLFA surface soil exceeded 400 mg/kg. Therefore, the ALM was also run for maintenance/industrial workers based on exposure to surface soil only.

The ALM is used to evaluate risks of lead exposure to the fetus of pregnant female industrial workers, excavation workers, and other workers that are identified as relevant receptors at a site. This calculation was based on the site-specific mean concentration of lead detected in total soil (763 mg/kg) and surface soil (1,212 mg/kg). The assumptions and output of the

Table 6-3
Summary of Risks and Hazards
FLFA
Page 1 of 2

Timeframe/Receptor	Risk	HI	Risk Drivers	Target Organ Segregation HI>1[a]
Current maintenance worker	**5E-06**	2E-01	Surface Soil Dioxin/furans Arsenic	N/A
Future maintenance worker	**5E-06**	2E-01	Surface Soil Dioxin/furans Arsenic Total Soil Dioxin/furans Arsenic	N/A
Future industrial worker	**3E-05**	**1E+00**	Surface soil Dioxin/furans Arsenic Total Soil Dioxin/furans Arsenic Groundwater Tetrachloroethylene	N/A[c]
Future excavation worker[b]	**1E-06**	**2E+00**	None[d]	N/A[c]
Future adult resident[b]	N/A	**3E+00**	N/A	N/A[c]
Future child resident[b]	**9E-05**	**1E+01**	Total Soil Aroclor 1254 Dioxins/furans Arsenic Groundwater PCE Dioxin/furans	**CNS** (2.0) - Soil [Aluminum - Ing (0.3)); Manganese - Ing (0.5) and Derm (0.3)]; Groundwater [Aluminum - Ing (0.6); Manganese - Ing (0.3)] **Blood** (4.7) - Soil [Antimony - Ing (0.2); Iron - Ing (0.7); Thallium - Ing (2.6); and Zinc - Ing (0.2)]; Groundwater [Iron - Ing (0.9)] **Kidney** (3.3) - Soil [Vanadium - Ing (0.7) and Derm (0.7)]; Groundwater [Vanadium - Ing (1.3) and Derm (0.3)] **GI Irritation** (4.0) - Soil [Copper - Ing (2.4); Iron - Ing (0.7)]; Groundwater - Iron - Ing (0.9)] **Liver** (4.4)- Soil [Iron - Ing (0.7); Thallium - Ing (2.6)]; Groundwater [Iron - Ing (0.9)] **Hair** (2.7) - Soil [Thallium - Ing (2.6)]

Table 6-3
Summary of Risks and Hazards
FLFA
Page 2 of 2

Timeframe/Receptor	Risk	HI	Risk Drivers	Target Organ Segregation HI>1[a]
Future lifetime resident	**2E-04**	N/A	Total Soil Aroclor 1254 Dioxins/furans Arsenic Groundwater Dioxin/furans PCE Chloroform	N/A
Future adult resident (off-site)	N/A	**2E+00**	N/A	N/A[c]
Future child resident (off-site)	**3E-05**	**4E+00**	Groundwater PCE Dioxin/furans	Kidney (1.6) - Groundwater [Vanadium - Ing (1.3) and Derm (0.3)]
Future lifetime resident (off-site)	**8E-05**	N/A	Groundwater PCE Dioxin/furans Chloroform	N/A

NA = Not applicable.
HI = Hazard Index.
HQ = Hazard Quotient.

Bold = Exceeds USEPA Risk or Hazard Range.

PCE = tetrachloroethene
Ing = Ingestion; Inh - Inhalation; Derm = Dermal.
CNS = Central nervous system.
GI = Gastrointestinal.

a) Cumulative HIs and individual HQs are rounded to the nearest tenth. HIs > 1 and HQs > 0.1 are listed.
b) For this receptor, site concentrations of lead in total soil were above the health protective criterion for lead.
c) None of the HIs or HQs for individual COPCs or target organs exceeded 1.
d) None of the Risks for individual COPCs exceeded 1.0E-06.

[NOTE: Antimony, arsenic, iron, thallium, and vanadium are within background concentrations in total soil.]

modeling is presented in **Appendix E-1, Tables E.1-40a, E.1-40b, E.1-41a, E.1-41b, E.1-42a, and E.1-42b**. The results are summarized in this section.

Site-specific lead exposures were evaluated for residential exposures using the IEUBK model. This calculation was based on the site-specific mean concentration of lead detected in total soil (763 mg/kg). Because the future water supply for the FLFA is not known, the mean concentration for groundwater was conservatively assumed to be the action level for lead (15 µg/L) in drinking water. The assumptions and results of the model are presented in **Appendix E-1, Table E.1-43**. The corresponding input parameters and distribution probability plot are also provided with **Appendix E-1, Table E.1-43**. The IEUBK model predicts the probability of children expected to have blood levels of 10 grams per deciliter (g/dL) or greater. The lead risks are considered unacceptable if the child-blood lead level for more than 5% of children is estimated to equal or exceed the Center for Disease Control and Prevention concern threshold of 10 g/dL.

Default parameters were utilized for the ALM model with the following ingestion rates and exposure frequencies: maintenance worker and industrial workers - ingestion rate (50 mg/day) and exposure frequency (219 days), and excavation worker - ingestion rate (100 mg/day) and exposure frequency (219 days).

Default parameters were used for the IEUBK model. The arithmetic mean for lead in total soil (763 mg/kg) was used in the IEUBK model (resident) and the ALM (future industrial/ maintenance and excavation workers) to represent potential future conditions; the mean lead concentration of surface soil (1,212 mg/kg) was used in the ALM (industrial/maintenance workers) to represent current conditions. The results of the lead assessments are provided below:

- Current Maintenance/Industrial Worker (surface soil): 4.1% probability that fetal blood levels would exceed 10 g/dL (≤5%; therefore passes).
- Future Maintenance/Industrial Worker (total soil): 2.0% probability that fetal blood levels would exceed 10 g/dL (≤5%; therefore passes).
- Future Excavation Worker (total soil): 6.0% probability that fetal blood levels would exceed 10 g/dL (>5%; therefore fails).
- Future Child Resident (total soil): 36.4% probability that child blood levels would exceed 10 g/dL (>5%; therefore fails).

The FLFA passes the lead exposure assessment for the maintenance worker and the industrial worker, both with respect to surface soil only and total soil, but fails for the excavation worker and residents for total soil.

6.4.2 Background

Statistical evaluations were conducted to compare metals concentrations in soil at the FLFA to background concentrations presented in the RFAAP Facility-Wide Background Study Report (IT, 2001). These evaluations followed the procedures outlined in the USEPA *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (USEPA, 2002d) and were conducted using USEPA's ProUCL 4.0 statistical program. Background analyses included distribution testing of site data sets and background data sets, evaluation of data using descriptive summary statistics, and comparisons of site data to background. Distribution testing showed that either site data sets or background data sets in each case were not normal, and therefore, consistent with Section 4.1 of the above-referenced USEPA guidance, comparisons of site to background were conducted using non-parametric testing rather than attempting to transform the data sets logarithmically. Wilcoxon Mann Whitney tests were conducted for each metal with background data sets to evaluate whether site concentrations were consistently higher or lower than the background data set. The notes on the methodology, as well as the results of the background evaluation, are summarized in **Tables 6-4 and 6-5** for surface and total soil, respectively.

Based on the background evaluations presented in **Appendix E-6**, COPCs identified for the FLFA that exceed background include the following:

- Surface Soil – aluminum, arsenic, barium, chromium, copper, iron, lead, nickel, vanadium, and zinc.
- Total Soil – aluminum, barium, chromium, copper, lead, manganese, nickel, and zinc.

6.5 Uncertainties

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 COPCs.

Consideration of the uncertainty attached to various aspects of the risk assessment allows better interpretation of the risk assessment results and understanding of 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.

6.5.1 Environmental Sampling and Analysis

If the samples do not adequately represent media at the FLFA, hazard/risk estimates could be overestimated or underestimated. The sampling and analysis plan was designed to investigate anticipated areas of contamination and delineate area(s) of concern. Therefore, there is less chance that the hazard/risk estimates are biased low. Also, if the analytical methods used do not apply to some chemicals that are present at each area, risk could be underestimated. Because the analytical methods at the site were selected to address all chemicals that are known or suspected to be present on the basis of the history of each area, the potential for not identifying a COPC is reduced.

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 method reporting limit but still included in data analysis and with those chemicals qualified “J” indicating that the concentrations are estimated.

Another uncertainty associated with sampling and analysis concerns the inclusion of chemicals that are potentially present in the environment due to anthropogenic sources. For example,

Table 6-4
Background Comparison for Surface Soil at the FLFA

Soil COPC	**Wilcoxon Mann Whitney Test [a, b] Site > Background?**	**Considered to be Background?**
Aluminum	**Yes**	No
Antimony	No [c]	Yes [c]
Arsenic	**Yes**	No
Barium	**Yes**	No
Beryllium	No	Yes
Cadmium	No	Yes
Calcium	**Yes**	No
Chromium	**Yes**	No
Cobalt	No	Yes
Copper	**Yes**	No
Iron	**Yes**	No
Lead	**Yes**	No
Magnesium	**Yes**	No
Manganese	No	Yes
Mercury	**Yes**	No
Nickel	**Yes**	No
Potassium	**Yes**	No
Selenium	No	Yes
Silver	No	Yes
Sodium	**Yes**	No
Thallium	No	Yes
Vanadium	**Yes**	No
Zinc	**Yes**	No

[a] Wilcoxon Mann Whitney Test, unless otherwise noted. See **Appendix E.6** for backup statistics.
[b] If both Site and Background data sets had normal distribution, the t-test was used (not for the FLFA).
[c] Note: Antimony was 100% non-detect in the background data set, so this finding is uncertain.

Table 6-5
Background Comparison for Total Soil at the FLFA

Soil COPC	**Wilcoxon Mann Whitney Test [a, b] Site > Background?**	**Considered to be Background?**
Aluminum	**Yes**	No
Antimony	No [c]	Yes [c]
Arsenic	No	Yes
Barium	**Yes**	No
Cadmium	No	Yes
Chromium	**Yes**	No
Cobalt	No	Yes
Copper	**Yes**	No
Iron	No	Yes
Lead	**Yes**	No
Manganese	**Yes**	No
Nickel	**Yes**	No
Silver	No [c]	Yes [c]
Thallium	No	Yes
Vanadium	No	Yes
Zinc	**Yes**	No

[a] Wilcoxon Mann Whitney Test, unless otherwise noted. See **Appendix E.6** for backup statistics.
[b] If both Site and Background data sets had normal distribution, the t-test was used (not for the FLFA).
[c] Note: Antimony was 100% non-detect in the background data set, and silver was 98.7% non-detect in the background data set, so these findings are uncertain.

dioxins are considered ubiquitous in soil from anthropogenic sources, such as combustion and incineration of municipal waste, coal, wood, and fuel. If such chemicals are not site-related, or if contributions from the ambient conditions are significant, then the risks associated with the site may be overestimated. This uncertainty may have a low-to-moderate effect on overestimating risks.

6.5.2 Selection of Chemicals for Evaluation

A comparison of maximum detected chemical concentrations to USEPA Region III RBCs was conducted for both surface and subsurface soil. Chemicals whose maximum concentrations were below their respective RBCs were not carried through the assessment. It is unlikely that this risk-based screening excluded chemicals that should be included, 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 cumulative risk estimates would not be expected to be significantly greater. As presented on the non-detect method detection limit (MDL) screening tables in **Appendix E-1, Tables E.1-3, E.1-5, and E.1-7**, the maximum MDL exceeded the adjusted RBCs for several chemicals in soil and groundwater; therefore, the site-related risks and hazards could be underestimated for the risk assessments due to inadequate detection limits.

Background concentrations of metals in soil at RFAAP have been characterized and are used in statistical comparisons to site soil to evaluate whether concentrations of metals detected at the FLFA are consistently higher or lower than background. However, the background data obtained may not fully characterize naturally-occurring metals levels in off-site fill used at the site. Uncertainties associated with the use of these data may lead to a low-to-moderate overestimation or underestimation of surface and total soil risks due to metals.

Screening criteria are derived from recommended daily allowances for essential human dietary minerals, trace elements, and electrolytes that are toxic at very high doses (i.e., calcium, magnesium, potassium, and sodium). Omitting these essential human nutrients from further evaluation is expected to have a low effect on risk and hazard estimates.

The reporting limits for chemicals that were not detected in surface soil, total soil, and groundwater at FLFA were compared with RBCs in **Appendix E-1, Tables E.1-3, E.1-5,** and **E.1-7**, respectively. As shown in **Table E.1-3,** reporting limits in surface soil exceeded RBCs for 3 of 103 constituents (3 percent). These constituents include MCPA, MCPP, and n-nitroso-di-n-propylamine. These constituents have neither been used at the FLFA nor detected at other sites at RFAAP. For 16 of 103 constituents (16 percent) in surface soil, there were no RBCs for comparison. These constituents include 2-hexanone, 2-nitroaniline, 3-nitroaniline, 3-nitrotoluene, 4,6-dinitro-o-cresol, 4-bromophenyl phenylether, 4-methyl-2-pentanone, 4-nitroaniline, 4-nitrophenol, chloromethane, cis-1,3-dichloro-1-propene, delta-BHC, dichloroprop, dimethylphthalate, pentaerythritol tetranitrate (PETN), and trans-1,3-dichloropropene. These chemicals are not known to be associated with past disposal at the FLFA.

As shown in **Table E.1-5**, reporting limits in total soil exceeded RBCs for 3 of 102 constituents (3 percent). These constituents include MCPA, MCPP, and n-nitroso-di-n-propylamine. These chemicals are not likely to have been associated with past disposal at the FLFA. For 16 of 102 constituents (16 percent) in total soil, there were no RBCs for comparison. These constituents were similar to those identified for surface soil and are not known to be associated with past disposal at the FLFA.

As shown in **Table E.1-7**, reporting limits in groundwater exceeded RBCs for 58 of 189 constituents (31 percent). For 35 of 189 constituents (18 percent) in groundwater, there were no RBCs for comparison. Some of these constituents are potentially site-related. It is assumed, however, groundwater exposures at the FLFA involve limited exposure frequency and exposure duration for maintenance and industrial workers. In addition, while a residential scenario has been included for completeness, it is unlikely that FLFA groundwater will be used for residential purposes in the future.

6.5.3 Exposure Assessment

The primary areas of uncertainty affecting exposure parameter estimation involve the assumptions regarding exposure pathways, the estimation of EPCs, and the exposure parameters used to estimate chemical doses.

An underlying assumption in the HHRA is that individuals at the site would engage in activities that result in exposures via each selected pathway. For example, it was assumed that maintenance workers engage in regular activities (once a week) under current and future land use conditions resulting in exposure to COPCs. This assumption is conservative, in that it is more likely that the activity patterns occur only occasionally.

The non-cancer hazard estimates for the inhalation of inorganic COPCs by the excavation worker receptor are based on the excavation worker PEF calculation. The excavation worker evaluation was based on site-specific and default assumptions for the calculation, which include that active excavation activities will occur for 125 days over a 6-month period (5-day workweeks) with 8-hour workdays. During this construction period, it was assumed that two 10-ton construction vehicles and two 2-ton cars would be present daily. As mentioned, this site is only 0.78 acre and is on a steep hillside which would restrict the number of vehicles which could be present. Also, the small size of the site would seemingly dictate that the duration of any heavy construction on site would likely be 6 months or less. There is generally a higher level of uncertainty associated with the use of modeled concentrations (i.e., PEF) than in the use of measured concentrations if valid measurement data are available for the exposure medium and exposure location. However, in view of these plans, the inhalation cancer risk/non-cancer hazard estimates are unlikely to be overestimated in the HHRA.

In establishing EPCs, the concentrations of chemicals in the media evaluated are assumed to remain constant over time. Depending on the properties of the chemical and the media in which it was detected, this assumption could overestimate risks, depending on the degree of chemical transport to other media or the rate and extent a chemical degrades over time.

The ProUCL software package estimates 95% UCLs based on the values and distributional characteristics of each data set. Where more than one ProUCL output was recommended, the higher value was used. Although uncertainty may exist as to whether a given recommended statistical approach truly provides full coverage of the mean at 95% confidence, the use of the recommended 95% UCL would generally result in an overestimate of the true population mean and the associated risks.

For data sets where greater than 95% of samples were reported as non-detects, random numbers between zero and the MDL were substituted by the bootstrap-t software program.

Approaches which substitute values for non-detected chemical concentrations are associated with uncertainty. The direction of the bias introduced by the generation of random numbers is uncertain for a given data set; however, the use of bootstrap-t method to derive a 95% UCL should result in a value that tends to overestimate the true population mean.

If the 95% UCL exceeds the maximum detected value or if five or fewer samples are available, the maximum is conservatively used as a default EPC. This is the case with groundwater, where five samples were included in the data set. Using a value that is based on one sampling location (i.e., the maximum) has associated uncertainty and likely adds a high (conservative) bias to the estimate of exposure and associated risks.

The exposure parameters used to describe the extent, frequency, and duration of exposure introduce uncertainties. Actual risks for individuals within an exposed population may differ from those predicted, depending upon their actual intake rates (e.g., soil ingestion rates), nutritional status, or body weight. 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. For example, 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), indicate 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 are assumed to be 100% bioavailable, meaning that virtually 100% of the concentration of each COPC present in ingested soil is absorbed through the gastrointestinal (GI) tract. This assumption is unlikely due to the affinity of contaminants for soil 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 dermal exposure parameters. For example, there is uncertainty associated with the exposed skin surface areas used, since the choice of exposed body parts could slightly overestimate or underestimate risks. Uncertainties that are more significant are associated with the selection and use of dermal absorption factors. For this HHRA, the dermal absorption factors and calculations were based on USEPA Region III guidance, USEPA's *RAGS: Part E, Supplemental Guidance for Dermal Risk Assessment* (USEPA, 2004b). Very limited information is available on dermal absorption of chemicals from contacted soil under environmental conditions. In fact, there are no actual human epidemiological data to support the hypothesis that absorption of soil-bound compounds under typical soil exposure conditions is a complete route of exposure for these compounds. For example, the Public Health Statements from the Agency for Toxic Substance Disease Registry (ATSDR, 1992a,b; 2000; 2006) indicate that aluminum, antimony, manganese, and vanadium are not known to result in human health effects by dermal absorption because very little can enter the body through the skin under normal circumstances (i.e., without exposure to very high concentrations for long periods or exposure to skin that is damaged). Therefore, using the dermal absorption factors to evaluate dermal absorption exposures to soil may result in an overestimation of risks.

For exposures to COPCs in groundwater via dermal absorption, the USEPA's dermal guidance (USEPA, 2004b) cautions that the procedures for estimating dermal dose from water contact are very new. The dermal permeability estimates are probably the most uncertain of the parameters in the dermal dose equation. The equation used to calculate the term, DA_{event}, is based on a regression model that predicts the water permeability coefficient for organics. Statistical analysis of the regression equation provides the range of octanol/water partition coefficients (K_{ow}) and molecular weights where this regression model could be used to predict permeability coefficients (Effective Prediction Domain or EPD). For chemicals outside the EPD, such as dioxins, a model for predicting the fraction absorbed dose (FA) is proposed for chemicals with a high K_{ow}, taking into account the balance between the increased lag time of these chemicals in the stratum corneum and the desquamation of skin during the absorption process. The consequence is a net decrease in total systemic absorption. Therefore, by applying an FA of 0.5 to the calculation of DA_{event}, the risk is 50% lower than it would have been calculated without accounting for the EPD. In addition, the guidance (USEPA, 2004b) notes that particulate-bound chemicals in aqueous medium (e.g., suspended soil particles) would be considered much less bioavailable for dermal absorption due to inefficient adsorption of suspended particles onto the skin surface and a slower rate of absorption into the skin. Because dioxins adsorb to soil, the detection of dioxins in FLFA groundwater samples is possibly attributable to the presence of particulates. Therefore, risks due to dermal absorption could potentially be overestimated.

Several models were used to evaluate exposure scenarios that involve the volatilization of COPCs from groundwater to air. These models include: the ASTM Model for volatilization from groundwater to ambient air, the Johnson & Ettinger Model for migration of VOCs from groundwater into indoor air, the VDEQ Trench Model for volatilization of VOCs from groundwater into a construction/utility trench, and the Foster-Chrostowski Shower Model for volatilization of VOCs from groundwater into shower air. The uncertainties associated with these models are discussed in the following sections.

The volatilization model outlined in ASTM Risk-Based Corrective Action (RBCA) Guidance (ASTM, 1995) was used to estimate the concentration of VOCs in ambient or outdoor air that originate from dissolved hydrocarbons in groundwater located some distance below ground surface (**Table E.1-32**). This model calculates a representative concentration in air based on the following assumptions:

- A constant dissolved concentration in groundwater.
- Linear equilibrium partitioning between the dissolved chemicals and groundwater and chemical vapors in the groundwater table.
- Steady-state vapor- and liquid-phase diffusion through the capillary fringe and vadose zones to ground surface.
- No loss of chemical as it diffuses towards the ground surface (i.e., no biodegradation).
- Steady well-mixed atmospheric dispersion for the emanating vapors within the breathing zone as modeled by a “box model” for air dispersion.

A number of uncertainties associated with this model would likely result in an overestimation of risk and hazard in this HHRA. First, the maximum concentrations of chloroform and PCE in groundwater were assumed to be the constant dissolved concentrations. Use of the maximum values may over-estimate risk and hazard. Second, it is assumed that there is no loss of chemical due to biodegradation over time. This assumption is especially conservative with respect to exposure for the industrial worker scenario, which is based on an exposure duration (ED) of 25 years. Third, it is assumed that vapor concentrations remain constant over the duration of exposures and that all inhaled chemicals are absorbed.

The ASTM model also considers wind speed, mixing height, depth to groundwater, and diffusion coefficients in air and water. Uncertainty based on mechanisms such as partitioning, diffusion, and dispersion would be dependent on chemical-specific and site-specific conditions and could result in either over- or underestimation of chemical concentrations at the FLFA. The depth to groundwater assumed for the model was based on the depth to groundwater (69.9 ft or 2,131 cm) measured at the FLFA, which is relatively deep. In addition, the water table at the FLFA is overlain by approximately 50 ft of rock. Therefore, concentrations of VOCs migrating from groundwater to the ground surface over time would likely be negligible.

The Johnson and Ettinger model (1991; USEPA, 2004a) was used to estimate indoor air concentrations of volatiles migrating from groundwater through the soil and into potential future on-site and off-site residences and buildings (**Table E.1-33**). As acknowledged in the *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings* (USEPA, 2004a), the Johnson and Ettinger (J&E) model "…was developed for use as a screening level model and consequently is based on a number of simplifying assumptions regarding contaminant distribution and occurrence, subsurface characteristics, transport mechanisms, and building construction." Limitations and assumptions associated with the Johnson and Ettinger model are described in the *User's Guide* (USEPA, 2004a). These include:

Contaminant Distribution and Occurrence

- No contaminant free-liquid/precipitate phase present.
- Contaminant is homogeneously distributed within the zone of contamination.
- No contaminant sources or sinks in the building.
- Equilibrium partitioning at contaminant source.
- Chemical or biological transformations are not significant (i.e., the model will predict more intrusion).

For the FLFA HHRA, the maximum concentrations of chloroform and PCE in groundwater were conservatively used as the inputs for the groundwater concentrations in the model. Although homogeneous distribution is assumed, the maximum concentration is not likely to be representative of chloroform and PCE concentrations across the site. Also, neither sorption nor biodegradation is accounted for in the transport of vapor from the source to the base of the building. Based on these factors, the risk and hazard associated with inhalation of chloroform and PCE in indoor air are likely to be overestimated.

Subsurface Characteristics

- Soil is homogeneous within any horizontal plane.
- All soil properties in any horizontal plane are homogeneous.
- The top of the capillary fringe must be below the bottom of the building floor in contact with the soil.
- The EPA version of the Johnson and Ettinger Model assumes the capillary fringe is uncontaminated.

Because the water level is below the rock layer in the study area, it is assumed that the capillary fringe is relatively small. Due to the presence of the rock layer, the soil and the soil properties in any horizontal plane are not homogeneous. The *User's Guide* (USEPA, 2004a) acknowledges that "…In theory the limitations are readily conceptualized, but in practice the presence of these limiting conditions may be difficult to verify even when extensive characterization data are available". Although there are a number of limitations associated with the Johnson and Ettinger Model, it is likely that similar limitations are encountered at other RCRA and Superfund sites. The results of the risk assessments at RFAAP as well as others would be more uncertain if a less accepted or documented model was used.

Transport Mechanisms

- Transport is one-dimensional.
- There are two separate flow zones: diffusive and convective.
- Vapor-phase diffusion is the dominant mechanism for transporting contaminant vapors from contaminant sources located away from the foundation to the soil region near the foundation.
- There is a straight-line gradient in the diffusive flow zone.
- Diffusion through soil moisture is insignificant.
- Convective transport is likely to be most significant in the region very close to the basement or the foundation, and vapor velocities decrease rapidly with increasing distance from a structure.
- Vapor flow is described by Darcy's Law (i.e., porous media flow assumption).
- Steady state convection is assumed (i.e., the flow is not affected by barometric pressure or infiltration). Convective flow near the foundation is uniform (i.e., flow rate does not vary by location).
- Convective velocity through cracks or porous medium is uniform.
- Significant convective transport only occurs in the vapor phase.
- All contaminant vapors originating from directly below the basement will enter the basement, unless the floor and walls are perfect barriers. Contaminant vapors enter structures primarily through cracks and openings in the walls and foundation.

Because most of the inputs to the model are not collected during a typical site characterization, conservative inputs were estimated or inferred from available data and other non-site-specific sources of information. In addition, because there are currently no structures at or near the FLFA, the default values for a typical residential building were used to represent the building characteristics in the model. It was also assumed that the building would be constructed with a basement and would be located in an area where depth to groundwater is 69.9 ft. It is assumed that vapor velocities decrease rapidly with increasing distance from a structure. These assumptions contribute to a conservative estimate of hypothetical VOC concentrations in building air at the FLFA.

As stated in *Section 6.2.3*, EPA has not developed a standardized model for estimating concentrations of airborne VOCs released from groundwater during construction or excavation activities. Therefore, VDEQ's VRP trench model was used in this HHRA (**Appendix E.1**,

Table E.1-34). Due to several conservative assumptions used in VDEQ's trench model, risks and hazards due to potential exposures to groundwater during the hypothetical excavation of a construction/utility trench are likely to be overestimated. The uncertainties associated with this model include:

- The maximum concentration of VOCs (chloroform and PCE) in the FLFA groundwater were used to estimate exposures to COPCs in ambient air in a construction/utility trench. The use of the maximum value is likely to overestimate risk and hazard. In addition, the model does not account for the dilution, dissipation, or degradation of VOCs over time.
- The depth of the trench was set at VDEQ's default value at 8 ft. The depth to groundwater at the FLFA is 69.9 ft. Migration of VOCs from this depth is unlikely.
- To be consistent with the other excavation/construction exposures in this HHRA, an exposure frequency (EF) of 250 days/year and exposure duration (ED) of 1 year were assumed for a worker in the trench. The default value for exposure time (ET) in the trench model was 4 hours per each day of excavation/construction work. As a practical matter, it is unlikely that the same individual(s) would work in a trench at the FLFA for 4 hours each day for 1 year.

The Foster-Chrostowski (1987, 2003) shower room model was used to estimate the EPC of chloroform and PCE in air due to volatilization from groundwater during showering and applied to an adult resident (**Table E.1-35**). Although VOCs may volatilize into indoor air from most typical household uses of groundwater, showering likely represents the upper–bound for exposure. The warm water temperature of a shower facilitates volatilization and the receptor is confined in a relatively small space with the released VOCs. The showering scenario and the characteristics of a typical shower room have been studied sufficiently to permit the estimation of shower room air concentrations of VOCs.

There are several factors that contribute to the potential uncertainty of the results of the shower model (Foster & Chrostowski, 2003). These factors include chemical-specific input parameters (e.g., Henry's Law constants), calculation of mass-transfer coefficients, and indoor air compartment flow rates. The calculation of mass transfer coefficients is an important component of modeling volatilization and requires information on chemical-specific properties as well as the interfacial area across which volatilization can occur. Mass transfer can be affected by different water characteristics, such as water flow rate, shower nozzle type, droplet size, distribution, and water temperature. There are also uncertainties associated with the choice of the flow. For example, a plug flow model represents the mass transfer from a flowing water supply, such as a shower. Other model uncertainties include the exclusion of some sources of VOC volatilization into indoor air other than the water droplet in the shower. The Foster-Chrostowski model does not address volatilization from water after it has impacted nearby surfaces or as it drains from the floor of the shower. As a result, risk or hazard could be underestimated.

Finally, although the shower model focuses on indoor air concentrations associated with showering, it does not address other indoor air from uses of water such as bathing, air humidifiers, dish washing machines, clothes washing machines, toilets, and sinks. Therefore, with respect to VOCs in indoor air from all potential household uses, risk and hazard are likely to be underestimated.

6.5.4 Toxicological Data

The HHRA relies 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, 1986), 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 in the derivation of CSFs by using the 95% upper bound of the dose-response curve, which is extrapolated from relatively high experimental doses to the lower dose ranges typical in environmental exposure scenarios. For noncarcinogens, an RfD is typically derived based on an experimental or estimated no-observed-adverse-effect level (NOAEL) to which one or more uncertainty factor has been introduced; the uncertainty factors for the FLFA COPCs are up to three orders of magnitude. The assumptions used here provide a rough but plausible estimate of the upper limit of toxicity; in other words, it is not likely that the actual toxicity would be much more than the estimated toxicity, but it could very well be considerably lower, even approaching zero. Thus, the use of CSFs and RfDs add a conservative bias to the estimate of cancer and noncancer risks. More refined modeling in the area of dose response calculation (e.g., using maximum likelihood dose response values rather than the 95% upper bound) would be expected to substantially lower the final risk.

For dermal absorption exposure pathways, the absence of dermal toxicity criteria necessitates the use of oral toxicity data. To calculate risk estimates for the dermal absorption pathway, absorbed dermal absorption doses are combined with oral toxicity values (also discussed above 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 those chemicals lacking sufficient information, a default oral absorption factor of 1.0 was used. The exposure estimates for the dermal absorption pathways may be overestimated or underestimated, depending on how the values used in the HHRA reflect the difference between the oral and dermal routes, which may introduce an associated high bias or low bias to the risk results associated with this pathway.

Inhalation toxicity criteria are unavailable for many of the COPCs. This HHRA does not use oral-based toxicity criteria to estimate risks from inhalation exposure because of the following uncertainties associated with such a substitution:

- Many contaminants show portal-of-entry toxicity - that is, adverse health effects occur primarily at the tissue site at which the chemical is introduced into the body (e.g., GI tract, lung, or skin).
- Physiological and anatomical differences between the GI tract and respiratory systems invalidate a cross-route quantitative risk extrapolation. The small intestine of humans

contains a very large surface area that readily absorbs most compounds by passive diffusion (Klaasen, 1986). The oral absorption of a few compounds, such as iron, is an energy-dependent (active-transport) process, wherein; the absorption rate is proportional to the body's current need for iron.

- The rate and extent of pulmonary absorption are much more complex and depend on such factors as particle size distribution of the airborne toxicant and blood-gas solubility of the toxicant (Klaasen, 1986). Particles with median aerodynamic diameters of approximately 1 micrometer or less are absorbed by the alveolar region of the human lung. Larger particles deposit in the tracheobronchial or nasopharyngeal regions where they are cleared by mucociliary mechanisms and subsequently swallowed or physically removed and exhaled. Therefore, pulmonary absorption is more highly dependent on the physiochemical properties of the material than oral absorption.
- Because highly soluble gases (e.g., chloroform) are more rapidly absorbed into the blood than poorly soluble gases (e.g., ethylene), they take much longer to reach equilibrium. Thus, the inhalation absorption rate of a gas is more dependent on blood solubility than the oral absorption rate of the same substance administered as a liquid.
- Human inhalation risk estimates based on oral toxicity data in subhuman species are distorted by both route-to-route extrapolation and interspecies extrapolation. For example, the rodent GI tract, which includes a structurally unique fore stomach, is anatomically and functionally distinct from the human lung, which contains a very large alveolar surface area for extensive absorption. The rate and extent of absorption across these distinct physiological systems are not alike.

In addition, for inhalation exposure to substances present as dusts, vapors, gases, or airborne particulate matter, dose extrapolation is far more complex, and therefore associated with uncertainty. The major confounding factors that prohibit a direct dose extrapolation of an inhaled toxicant are the following:

- Over 40 functionally different cell types in the lung – the distribution, consequent metabolic reactions, and air exchange rates vary widely across species.
- Differential concentration and activity of the detoxifying protein glutathione.
- Interspecies and intraspecies differences in the ability to repair pulmonary cell damage, and to clear toxic contaminants and immune complexes from the respiratory tract. For example, species vary in the ability to activate macrophages – nonspecific immune cells that can both protect the inner lining of the respiratory system and, at high concentrations, damage healthy tissues.
- Anatomical variations in the respiratory pathway, which affect both absorption rates and time to reach steady-state blood levels.
- Sensitivity to solubility and concentration variables; because of metabolic saturation (i.e., the exhaustion of normal metabolic activity caused by exposure to high concentrations), highly soluble contaminants deviate from first-order kinetics – which makes it difficult to predict the rates and extent of biotransformation and detoxification reactions. Furthermore, intermittent inhalation exposure to highly blood-soluble chemicals results in bioaccumulation in fat tissue because of the insufficient time between exposure sessions

for complete clearance of the contaminant. Such slow release from the fat compartment to other body tissues can result in toxicological and metabolic effects that are difficult to assess and vary across species.

For chemicals without IRIS toxicity criteria, provisional toxicity criteria were used where available (**Appendix E-1, Tables E.1-36 through E.1-39**). Provisional toxicity criteria (i.e., PPRTVs) present a source of uncertainty, since USEPA has evaluated the compound, but consensus has not been established on the toxicity criteria. PPRTVs were used for aluminum, iron, PCE, thallium, and vanadium. Provisional inhalation toxicity values were used for aluminum, chloroform, cadmium, and PCE. The oral RfD for copper, the inhalation RfD for barium, and the 2,3,7,8-TCDD TE were obtained from HEAST. The HEAST document, however, has not been updated since 1997. In addition, the oral RfD for 2-nitrophenol was obtained from the VDEQ (2007) database. For this assessment, use of provisional toxicity criteria was preferable to not evaluating the chemical in order to limit data gaps. However, because these 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.

For some chemicals, toxicity criteria were unavailable (**Appendix E-1, Tables E.1-36 through E.1-39**). 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.

It is noted that the Supplemental SSL Guidance (USEPA, 2002b) recommends that toxicity values for subchronic exposures be used to calculate the HQs for the excavation worker pathway. Although subchronic values for some chemicals are included in USEPA's database of Provisional Peer-Reviewed Toxicity Values, this website cannot be accessed without authorization. Because the VDEQ compiles subchronic toxicity values, however, the website for the VDEQ Voluntary Remediation Program was consulted for subchronic values (VDEQ, 2007). While toxicity values based on subchronic exposures were available for some COPCs at the FLFA, the only COPC for which the subchronic value differed from the chronic value was barium (1.4×10^{-3} mg/kg-day and 1.4×10^{-4} mg/kg-day, respectively, for inhalation). However, these values were listed in HEAST and have not been updated since 1997. The overall lack of subchronic toxicity values for the COPCs at these sites contributes to the uncertainty of the cancer risk estimates and the HIs. Typically, subchronic toxicity values are 10-fold greater than chronic toxicity values. Because chronic toxicity values were used for all COPCs, the calculated risks and hazards are likely to be overestimated for the excavation worker.

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 total soil at the FLFA. Adult exposures to lead were evaluated using the ALM. Residential exposures to lead were evaluated using the IEUBK model. Because the non-carcinogenic effects from lead are evaluated separately as they are not regarded as additive with the effects of other non-carcinogens, these effects are not represented in the cumulative HI.

Because the ALM 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 ALM is 219 days/year, while the exposure frequency for the maintenance worker is 50 days/year. According to the guidance for the ALM (USEPA, 2003c), 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 ALM. The incidental ingestion rate for the excavation worker was 330 mg/day, whereas the suggested default value for exposure to an excavation worker via incidental ingestion is 100 mg/day (USEPA, 2007e). However, the ALM model includes input data which considers the heterogeneity of the population and variances in the baseline blood lead levels. Because the ALM model already addresses considerable uncertainty, the upper-bound estimates on intake rates typically used in risk assessment are not recommended by USEPA (2002e).

Because chromium was analyzed and reported as total chromium, there is uncertainty regarding the species of chromium that exists at the FLFA. The toxicity values for chromium III were used in this HHRA because chromium III is the predominant form of chromium in nature. Based on past processes at the FLFA, chromium VI would not be expected to be present at the site. In addition, chromium VI is more unstable in nature.

6.5.5 Risk Characterization

Minor uncertainty is associated with rounding of the risk and hazard estimates. Thus, the actual risk or hazard may be slightly greater or less than the presented values. A related issue is that rounding causes minor differences between summed risk and hazard values, depending on how the summing is performed. For example, the RAGS Table 7 spreadsheets in **Appendix E-1** present risks and hazards that are summed for exposure route, exposure point, exposure medium, and medium total. Only for the first (exposure route) are the individual chemical-specific risks and hazards summed to derive the total. For the subsequent summations (exposure point, exposure medium, and medium total), each is the summation of the preceding sums. For this reason, there can also be minor rounding-related differences between the 'same' values presented in RAGS Table 9 and 10 spreadsheets in **Appendix E-1**.

According to USEPA (1989b) risk assessment guidance, summing of cancer risks is only 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 and an alternate equation should be used (see *Section 6.4*).

6.6 HHRA Summary and Conclusions

This HHRA was performed to evaluate the potential human health effects associated with previous activities at the FLFA. Receptors evaluated for both areas included current/future maintenance worker, future industrial worker, future excavation worker, future adult resident, future child resident, and lifetime resident. Off-site adult and child residents were also evaluated for potential exposures to groundwater in the event that groundwater migrates off site in the future.

As presented in *Section 6.4*, the total cancer risk for current maintenance worker exposures to surface soil (5E-06) was within the target risk range, primarily due to dioxins/furans and arsenic. The total HI was less than 1. Site concentrations of lead were below the health protective criterion for lead.

For the future maintenance worker, the total cancer risk associated with total soil (5E-06) was within the target risk range, primarily due to dioxins/furans and arsenic. Arsenic has been determined to be within background concentrations for total soil. The total HI was below 1. In addition, lead concentrations in total soil were below the criterion for blood lead levels. The total cancer risk associated with groundwater (9E-12) was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

For future industrial worker exposures to surface soil, the total cancer risk associated with surface soil (2E-05) was within the target risk range, primarily due to dioxins/furans and arsenic. The total HI was less than 1. The total cancer risk associated with exposures to total soil (2E-05) was within the target risk range, primarily due to dioxins/furans and arsenic. Arsenic has been determined to be within background concentrations for total soil. The total HI (HI = 1E+00) was equal to 1. Site concentrations of lead in surface and total soil were below the health protective criterion for lead. The total cancer risk associated with groundwater (5E-06) was within the target risk range of 1E-06 to 1E-04, primarily due to PCE. The total HI was less than 1.

For the future excavation worker, the total cancer risk associated with total soil (1E-06) was equal to the target risk range. The risks for individual COPCs were below 1E-06. The total HI (HI = 2E+00) was above 1. None of the HIs for individual COPCs were above 1. Site concentrations of lead in total soil were above the health protective criterion for lead. The total cancer risk associated with groundwater (3E-09) was below the target risk range of 1E-06 to 1E-04. The total HI (HI = 2E+00) was above 1. When recalculated by target organ, none of the HIs for the individual target organs were exceeded.

For the future lifetime resident, the total cancer risks associated with total soil (9E-05) were within the target risk range, primarily due to Aroclor-1254, dioxin/furans, and arsenic. Arsenic has been determined to be within background concentrations in total soil. For future adult residents, the total HI for total soil (HI = 1E+00) was above 1. None of the HIs for individual COPCs exceeded 1. For the lifetime scenario, site concentrations of lead in total soil were above the health protective criterion for lead. The total cancer risk associated with groundwater (8E-05) was within the target risk range of 1E-06 to 1E-04, due to dioxins/furans, chloroform, and PCE. For future adult resident exposures, the total HI (HI = 2E+00) was above 1. None of the HIs for individual COPCs were above 1. When recalculated by target organ, none of the HIs for individual target organs exceeded 1.

For the future child resident, the total cancer risks associated with total soil (6E-05) were within the target risk range, primarily due to Aroclor-1254, dioxin/furans, and arsenic. Arsenic has been determined to be within background concentrations in total soil. The total HI (HI = 1E+01) was above 1, primarily due to copper, thallium, and vanadium. Thallium and vanadium have been determined to be within background concentrations in total soil. For the residential scenario, site concentrations were above the health protective criterion for lead. The total cancer risk associated with groundwater (3E-05) was within the target risk range of 1E-06 to 1E-04, due to PCE. The total HI (HI = 4E+00) was above 1, primarily due to vanadium. When recalculated by target organ, the following target organs exceeded 1: CNS (2.0), blood (4.7), kidney (3.3), liver (4.4), GI tract (4.0), and hair (2.7).

Off-site residents were evaluated to address potential future migration of COPCs in groundwater. For future lifetime resident exposures to COPCs in off-site groundwater, the total cancer risk associated with groundwater (8E-05) was within the target risk range of 1E-06 to 1E-04 due to dioxins/furans, chloroform, and PCE. For future adult resident exposures, the total HI (HI = 2E+00) was above 1. None of the HIs for individual COPCs or target organs exceeded 1.

For future child resident exposures to COPCs in off-site groundwater, the risk characterization results showed cancer risk associated with groundwater (3E-05) was within the target risk range of 1E-06 to 1E-04, due to dioxins/furans and PCE. The total HI (HI = 4E+00) was above 1, primarily due to vanadium. When re-calculated by target organ, the HI (1.6) for kidney exceeded 1.

7.0 ECOLOGICAL RISK ASSESSMENT

A screening level ecological risk assessment (SLERA) was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at the FLFA. The results of the SLERA contribute to the overall characterization of the site, and the scientific/management decision point 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.
- The information collected and presented indicates that a more thorough assessment is warranted.

The SLERA was performed following the *RFAAP Final MWP* (URS, 2003), the *RFAAP Site Screening Process* (USEPA, 2001b), 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 (ERAGS): Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997d). 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. Characterizing the ecological communities in the vicinity of the FLFA, assessing the particular hazardous substances being released, identifying pathways for receptor exposure, and estimating the magnitude and likelihood of potential risk to identified receptors meets this objective. 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 the FLFA.

Concentrations of chemicals were measured in surface soil, which was the only relevant environmental media at the FLFA. Surface water was not present directly on site and groundwater does not discharge to the surface in the immediate vicinity of the FLFA, so there is no potential exposure for ecological receptors to surface water, sediment, or groundwater at this site. Using available concentration data, a SLERA was performed by following Steps 1 and 2 of USEPA (1997d). 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

The FLFA site characterization section includes a general discussion of the FLFA, vegetative communities, a species inventory, and a discussion on threatened and endangered species.

During World War II, a lead furnace was in operation in the southeastern portion of SWMU 17A (Stage and Burn Area), which is located in the south-central portion of the MMA. Typically, lead recovered during routine operations at RFAAP would be melted in the furnace and cast into ingots for salvage. The former furnace was located at the foot of a steeply sloping hillside in a depression formed by a sinkhole. Based on the occurrence of lead slag, lead was probably off-loaded on the rim of the depression with the lead smelter at the bottom of the slope. The FLFA study area is defined as an area encompassing 0.78 acres surrounding the former lead furnace location. The FLFA was built into the sloping side of the sinkhole. The elevation of the top of the slope above the FLFA is approximately 1,892 ft msl, while the bottom of the slope is approximately 1,874 ft msl. The location of the removed used oil tank (SWMU 76) is upslope to the east of the FLFA at an elevation of 1,895 ft msl. There are paved and gravel roads in the vicinity.

Subsurface soil investigations have shown that the bedrock surface is variable and consists of broken and weathered limestone. Unconsolidated soil above bedrock consists of surficial fill material. Based on topography, surface water in the area of the FLFA would flow from the surrounding hillsides and collect in the areas of lower elevations of SWMU 17A. This water runoff would probably percolate into the surface and enter the water table. According to RFAAP utility maps, there are no manholes, catch basins or storm drains in the vicinity of the FLFA.

It is not known precisely how long the lead furnace was in operation, but available maps of RFAAP, dated 1968 to 1988, show the location of the lead furnace. The location has apparently been used for various activities and is listed in the RFAAP 1989 RCRA Permit as a used oil and transfer location area (SWMU 76). The FLFA was not identified in the RCRA Facility Assessment (USEPA, 1987) and was not included in the RCRA Permit, but was added to the VI by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) in response to conditions uncovered when used oil tank at SWMU 76 were removed in 1991. Solid lead slag was observed in the soil around and below the tank, with soil samples containing elevated lead concentrations.

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.
- Water.

Endangered plants or animals were not observed at the FLFA 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. Migratory waterfowl are found throughout the spring and winter near the New River because the Installation is on the Atlantic Flyway. 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.
- 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.

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).

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**.

Based on previous site visits and investigations, the available photographic record was compiled (**Appendix F-1**). A Shaw ecologist performed site reconnaissance activities in June 2002. 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 many of the RFAAP SWMUs and areas of concern. 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 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.

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

7.1.2 Surface Water

There is no surface water or aquatic habitat directly on site.

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 the FLFA. 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 during the reconnaissance and documented in photographs in **Appendix F-1**. **Appendix F-1, Photos F-1 through F-4** show the area surrounding the FLFA is primarily maintained grass with a small pavement-covered area. The grass area is contained within successional forest habitat, as shown in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey. However, based on **Appendix F-1, Photo F-5**, the nearest forested areas are approximately 200 ft to the southeast. The grass area is mowed on an infrequent basis to eliminate woody plants. No signs of vegetative stress were observed during the site reconnaissance.

This habitat type can be expected to support different wildlife species assemblages. Many species would be expected to spend some amount of time within the area for foraging and resting activities, depending on the season.

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 the FLFA.

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 (calcareous fen) exists within the RFAAP grassland community type, it is not found at or near the FLFA.

7.2 Identification of COPECs and Concentration Statistics

A list of samples used in the SLERA is presented in **Table 7-4**. COPECs are selected in **Tables 7-5 and 7-6**, and the COPEC selection process is described in more detail in the following subsections. A discussion of nondetected 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 FLFA SLERA

LFSB1A	LFSS07
LFSB3A	LFSS08
LFSB8A	LFSS09
LFSB9A	LFSS10
LFSB10A	LFSS11
LFSB11A	LFSS12
LFSB12A	LFSS13
LFSB15A	LFSS14
LFSB16A	LFSS15
LFSB16B	LFSS16
LFSB17A	LFSS17
LFSB17B	LFSS18
LFSS01	LFSS19
LFSS02	LFSS20
LFSS03	LFSS21
LFSS04	TMSS01 (duplicate)
LFSS05	TMSS20 (duplicate)
LFSS06	

Table 7-5
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at the FLFA
Page 1 of 3

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	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
	N/A	2,3,7,8-TCDD-TE	2.09E-07	4.34E-05	mg/kg	LFSS20	25/25	N/A	Yes	DET
Surface Soil	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	5.91E-06	2.31E-03	mg/kg	LFSS20	25/25	N/A	No	TEQ
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	2.28E-05	1.88E-02	mg/kg	LFSS20	25/25	N/A	No	TEQ
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	5.63E-07 J	1.59E-04	mg/kg	LFSS20	25/25	N/A	No	TEQ
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	1.20E-06 J	7.57E-04	mg/kg	LFSB15A	25/25	N/A	No	TEQ
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1.29E-06 J	4.41E-04	mg/kg	LFSS20	24/25	2.11E-07 - 2.11E-07	No	TEQ
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	1.06E-06 J	3.68E-04	mg/kg	LFSS20	24/25	1.41E-07 - 1.41E-07	No	TEQ
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	8.01E-07	8.49E-04	mg/kg	LFSS20	25/25	N/A	No	TEQ
	72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	3.87E-07 J	7.82E-05	mg/kg	LFSS20	20/25	7.70E-08 - 2.94E-07	No	TEQ
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.16E-06 J	8.53E-04	mg/kg	LFSS20	25/25	N/A	No	TEQ
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	3.20E-07 J	2.64E-04	mg/kg	LFSS20	24/25	1.81E-07 - 1.81E-07	No	TEQ
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	6.22E-07 J	5.00E-04	mg/kg	LFSS20	24/25	2.55E-07 - 2.55E-07	No	TEQ
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	4.37E-07 J	2.58E-04	mg/kg	LFSS20	24/25	2.29E-07 - 2.29E-07	No	TEQ
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	1.28E-06 J	4.67E-04	mg/kg	LFSS20	24/25	1.65E-07 - 1.65E-07	No	TEQ
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	7.88E-07 J	4.80E-04	mg/kg	LFSS20	24/25	1.89E-07 - 1.89E-07	No	TEQ
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.44E-07	1.67E-04	mg/kg	LFSS20	21/24	4.10E-08 - 1.66E-07	No	TEQ
	3268-87-9	Octachlorodibenzodioxin	7.55E-04 J	1.45E-01	mg/kg	LFSS20	25/25	N/A	No	TEQ
	39001-02-0	Octachlorodibenzofuran	1.62E-05	4.15E-03	mg/kg	LFSS20	25/25	N/A	No	TEQ
	120-82-1	1,2,4-Trichlorobenzene	1.20E-02 J	5.45E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	DET
	95-50-1	1,2-Dichlorobenzene	3.00E-02 J	5.10E-02 J	mg/kg	LFSS01	2/9	1.70E-01 - 2.00E-01	Yes	DET
	541-73-1	1,3-Dichlorobenzene	1.20E-02 J	5.10E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	DET
	106-46-7	1,4-Dichlorobenzene	1.30E-02 J	5.25E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	DET
	95-95-4	2,4,5-Trichlorophenol	1.20E-02 J	1.20E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	Yes	DET
	88-06-2	2,4,6-Trichlorophenol	1.80E-02 J	1.80E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	Yes	DET
	120-83-2	2,4-Dichlorophenol	2.20E-02 J	4.69E-02 J	mg/kg	LFSS01	2/9	1.70E-01 - 2.00E-01	Yes	DET
	121-14-2	2,4-Dinitrotoluene	8.10E-02 J	1.20E-01 J	mg/kg	LFSS03	2/9	1.80E-01 - 4.00E-01	Yes	DET
	91-58-7	2-Chloronaphthalene	8.00E-03 J	4.80E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	DET
	95-57-8	2-Chlorophenol	8.20E-03 J	4.90E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	DET
	91-57-6	2-Methylnaphthalene	4.20E-03	6.20E-02	mg/kg	LFSB12A	7/9	2.00E-01 - 2.00E-01	Yes	DET
	88-75-5	2-Nitrophenol	1.10E-02 J	5.50E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	DET
	72-54-8	4,4'-DDD	4.23E-04 J	5.93E-03	mg/kg	LFSB15A	3/3	N/A	Yes	DET

Table 7-5
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at the FLFA
Page 2 of 3

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
Surface Soil	72-55-9	4,4'-DDE	2.32E-03	4.93E-02	mg/kg	LFSB15A	2/2	N/A	Yes	DET
	50-29-3	4,4'-DDT	1.54E-02	8.32E-02	mg/kg	LFSS03	3/3	N/A	Yes	DET
	7005-72-3	4-Chlorophenyl phenylether	1.20E-02 J	1.20E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	Yes	DET
	83-32-9	Acenaphthene	1.30E-02 J	1.30E-02 J	mg/kg	LFSB16B	1/5	1.70E-03 - 2.00E-01	Yes	DET
	208-96-8	Acenaphthylene	8.55E-04 J	1.30E-02 J	mg/kg	LFSB16B	5/9	1.80E-03 - 2.00E-01	Yes	DET
	120-12-7	Anthracene	1.90E-03	5.60E-03	mg/kg	LFSS03	5/9	1.80E-01 - 2.10E-01	Yes	DET
	11097-69-1	Aroclor 1254	1.35E-02 J	4.02E-01	mg/kg	LFSS11	17/18	1.80E-01 - 1.80E-01	Yes	DET
	11096-82-5	Aroclor 1260	3.73E-02 J	1.09E+00	mg/kg	LFSS16	8/18	1.80E-02 - 9.50E-02	Yes	DET
	56-55-3	Benzo(a)anthracene	7.90E-03 J	2.80E-02	mg/kg	LFSS01	8/9	2.10E-01 - 2.10E-01	Yes	DET
	50-32-8	Benzo(a)pyrene	9.70E-03	2.80E-02	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	DET
	205-99-2	Benzo(b)fluoranthene	1.80E-02	6.70E-02	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	DET
	191-24-2	Benzo(g,h,i)perylene	4.80E-03 L	2.50E-02 L	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	DET
	207-08-9	Benzo(k)fluoranthene	5.90E-03	1.85E-02	mg/kg	LFSS01	6/9	2.00E-01 - 2.10E-01	Yes	DET
	111-91-1	bis(2-Chloroethoxy)methane	1.30E-02 J	4.90E-02 J	mg/kg	LFSS01	2/9	1.70E-01 - 2.00E-01	Yes	DET
	111-44-4	bis(2-Chloroethyl)ether	1.90E-02 J	1.90E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	Yes	DET
	108-60-1	bis(2-Chloroisopropyl)ether	8.80E-03 J	4.95E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	DET
	218-01-9	Chrysene	1.20E-02	3.70E-02	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	DET
	53-70-3	Dibenz(a,h)anthracene	2.60E-03 J	3.50E-03 J	mg/kg	LFSS03	3/9	1.70E-03 - 2.10E-01	Yes	DET
	132-64-9	Dibenzofuran	1.30E-02 J	4.62E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	DET
	117-84-0	Di-n-octyl phthalate	2.00E-02 J	2.00E-02 J	mg/kg	LFSB17A	1/9	1.70E-01 - 2.10E-01	Yes	DET
	33213-65-9	Endosulfan II	1.23E-03	1.99E-02	mg/kg	LFSS03	3/3	N/A	Yes	DET
	7421-93-4	Endrin aldehyde	1.87E-03	3.34E-02	mg/kg	LFSS03	3/3	N/A	Yes	DET
	53494-70-5	Endrin ketone	4.46E-03	4.46E-03	mg/kg	LFSB15A	1/3	6.80E-04 - 6.79E-03	Yes	DET
	206-44-0	Fluoranthene	1.80E-02	5.35E-02 J	mg/kg	LFSS01	6/9	2.00E-01 - 2.10E-01	Yes	DET
	86-73-7	Fluorene	1.20E-03 J	9.00E-03 J	mg/kg	LFSB16B	6/9	1.80E-01 - 2.00E-01	Yes	DET
	5103-74-2	gamma-Chlordane	2.81E-03	2.81E-03	mg/kg	LFSB15A	1/3	6.79E-04 - 6.80E-04	Yes	DET
	118-74-1	Hexachlorobenzene	2.00E-02 J	2.00E-02 J	mg/kg	LFSB15A	1/9	1.70E-01 - 2.10E-01	Yes	DET
	87-68-3	Hexachlorobutadiene	1.00E-02 J	5.20E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	DET
	67-72-1	Hexachloroethane	1.30E-02 J	1.30E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	Yes	DET
	193-39-5	Indeno(1,2,3-cd)pyrene	6.30E-03	2.60E-02	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	DET
	78-59-1	Isophorone	7.40E-03 J	4.64E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	DET
	72-43-5	Methoxychlor	7.28E-04 J	7.28E-04 J	mg/kg	LFSB15A	1/3	6.79E-04 - 6.80E-04	Yes	DET
	91-20-3	Naphthalene	7.40E-03	3.40E-02	mg/kg	LFSS03	5/7	2.00E-01 - 2.00E-01	Yes	DET
	98-95-3	Nitrobenzene	3.50E-02 J	3.50E-02 J	mg/kg	LFSB16B	1/9	1.80E-01 - 4.00E-01	Yes	DET
	86-30-6	n-Nitrosodiphenylamine	1.50E-01 J	1.50E-01 J	mg/kg	LFSS03	1/9	1.70E-01 - 2.10E-01	Yes	DET
	59-50-7	p-Chloro-m-cresol	1.40E-02 J	1.40E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	Yes	DET
	85-01-8	Phenanthrene	1.40E-02 J	5.50E-02	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	DET

Table 7-5
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at the FLFA
Page 3 of 3

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
	129-00-0	Pyrene	1.90E-02	5.05E-02 J	mg/kg	LFSS01	6/9	2.00E-01 - 2.10E-01	Yes	DET
Surface Soil	7429-90-5	Aluminum	9.77E+03 J	4.78E+04	mg/kg	LFSB15A	27/27	N/A	Yes	DET
	7440-36-0	Antimony	4.30E-01 J	4.76E+01 J	mg/kg	LFSB15A	7/26	3.40E-01 - 3.80E+00	Yes	DET
	7440-38-2	Arsenic	1.79E+00 J	6.89E+01 J	mg/kg	LFSS20	27/27	N/A	Yes	DET
	7440-39-3	Barium	2.53E+01	2.63E+03	mg/kg	LFSS03	27/27	N/A	Yes	DET
	7440-41-7	Beryllium	4.00E-01 J	1.72E+00	mg/kg	LFSB16B	9/27	6.40E-01 - 1.70E+00	Yes	DET
	7440-43-9	Cadmium	7.20E-02 J	1.98E+01	mg/kg	LFSB15A	11/27	5.60E-02 - 1.50E+00	Yes	DET
	7440-70-2	Calcium	1.28E+03 J	5.57E+04 J	mg/kg	LFSB17B	27/27	N/A	Yes	DET
	7440-47-3	Chromium	1.31E+01 J	2.99E+02 J	mg/kg	LFSS03	27/27	N/A	Yes	DET
	7440-48-4	Cobalt	3.70E+00 J	4.70E+01 J	mg/kg	LFSB15A	27/27	N/A	Yes	DET
	7440-50-8	Copper	1.08E+01 J	2.38E+04 J	mg/kg	LFSS20	27/27	N/A	Yes	DET
	7439-89-6	Iron	1.41E+04 J	9.99E+04 J	mg/kg	LFSB15A	27/27	N/A	Yes	DET
	7439-92-1	Lead	1.83E+01	2.59E+04 J	mg/kg	LFSS20	33/33	N/A	Yes	DET
	7439-95-4	Magnesium	1.07E+03 J	6.04E+04	mg/kg	LFSB17B	27/27	N/A	Yes	DET
	7439-96-5	Manganese	1.37E+02 J	2.23E+03 J	mg/kg	LFSB15A	27/27	N/A	Yes	DET
	7439-97-6	Mercury	3.00E-02 J	2.20E+00 J	mg/kg	LFSS21	26/27	6.05E-02 - 6.05E-02	Yes	DET
	7440-02-0	Nickel	7.50E+00 J	4.04E+02 J	mg/kg	LFSB15A	27/27	N/A	Yes	DET
	7440-09-7	Potassium	7.12E+02 J	7.87E+03	mg/kg	LFSB17B	27/27	N/A	Yes	DET
	7782-49-2	Selenium	3.40E-01 L	1.30E+00 L	mg/kg	LFSS19	16/27	2.50E-01 - 1.27E+00	Yes	DET
	7440-22-4	Silver	1.10E-01 L	6.52E+01 L	mg/kg	LFSS17	19/27	7.50E-02 - 1.27E+00	Yes	DET
	7440-23-5	Sodium	3.95E+01	3.17E+03	mg/kg	LFSS20	23/23	N/A	Yes	DET
	7440-28-0	Thallium	9.90E-02 J	3.16E-01	mg/kg	LFSS01	9/20	6.00E-01 - 1.62E+00	Yes	DET
	7440-62-2	Vanadium	2.16E+01 J	7.56E+01 J	mg/kg	LFSS19	27/27	N/A	Yes	DET
	7440-66-6	Zinc	2.60E+01 J	1.52E+04 J	mg/kg	LFSS20	27/27	N/A	Yes	DET

COPEC Selection Rationale Codes

Selection Reason: Detected constituent (DET)

Deletion Reason: Dioxins and furans will be analyzed by the toxicity equivalent provided by the TCDD-TE (TEQ)

Notes/Definitions:

N/A = Not Applicable or Not Available

COPEC = Chemical of Potential Ecological Concern

J = Estimated Value

L = Estimated Value

mg/kg = milligrams per kilogram

Table 7-6
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at the FLFA
Page 1 of 3

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	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
Surface Soil	N/A	2,3,7,8-TCDD-TE	2.09E-07	4.34E-05	mg/kg	LFSS20	25/25	N/A	Yes	IBC
	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	5.91E-06	2.31E-03	mg/kg	LFSS20	25/25	N/A	No	TEQ
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	2.28E-05	1.88E-02	mg/kg	LFSS20	25/25	N/A	No	TEQ
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	5.63E-07 J	1.59E-04	mg/kg	LFSS20	25/25	N/A	No	TEQ
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	1.20E-06 J	7.57E-04	mg/kg	LFSB15A	25/25	N/A	No	TEQ
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1.29E-06 J	4.41E-04	mg/kg	LFSS20	24/25	2.11E-07 - 2.11E-07	No	TEQ
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	1.06E-06 J	3.68E-04	mg/kg	LFSS20	24/25	1.41E-07 - 1.41E-07	No	TEQ
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	8.01E-07	8.49E-04	mg/kg	LFSS20	25/25	N/A	No	TEQ
	72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	3.87E-07 J	7.82E-05	mg/kg	LFSS20	20/25	7.70E-08 - 2.94E-07	No	TEQ
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.16E-06 J	8.53E-04	mg/kg	LFSS20	25/25	N/A	No	TEQ
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	3.20E-07 J	2.64E-04	mg/kg	LFSS20	24/25	1.81E-07 - 1.81E-07	No	TEQ
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	6.22E-07 J	5.00E-04	mg/kg	LFSS20	24/25	2.55E-07 - 2.55E-07	No	TEQ
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	4.37E-07 J	2.58E-04	mg/kg	LFSS20	24/25	2.29E-07 - 2.29E-07	No	TEQ
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	1.28E-06 J	4.67E-04	mg/kg	LFSS20	24/25	1.65E-07 - 1.65E-07	No	TEQ
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	7.88E-07 J	4.80E-04	mg/kg	LFSS20	24/25	1.89E-07 - 1.89E-07	No	TEQ
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.44E-07	1.67E-04	mg/kg	LFSS20	21/24	4.10E-08 - 1.66E-07	No	TEQ
	3268-87-9	Octachlorodibenzodioxin	7.55E-04 J	1.45E-01	mg/kg	LFSS20	25/25	N/A	No	TEQ
	39001-02-0	Octachlorodibenzofuran	1.62E-05	4.15E-03	mg/kg	LFSS20	25/25	N/A	No	TEQ
	120-82-1	1,2,4-Trichlorobenzene	1.20E-02 J	5.45E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	IBC
	95-50-1	1,2-Dichlorobenzene	3.00E-02 J	5.10E-02 J	mg/kg	LFSS01	2/9	1.70E-01 - 2.00E-01	Yes	IBC
	541-73-1	1,3-Dichlorobenzene	1.20E-02 J	5.10E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	IBC
	106-46-7	1,4-Dichlorobenzene	1.30E-02 J	5.25E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	IBC
	95-95-4	2,4,5-Trichlorophenol	1.20E-02 J	1.20E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	No	NIBC
	88-06-2	2,4,6-Trichlorophenol	1.80E-02 J	1.80E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	No	NIBC
	120-83-2	2,4-Dichlorophenol	2.20E-02 J	4.69E-02 J	mg/kg	LFSS01	2/9	1.70E-01 - 2.00E-01	No	NIBC
	121-14-2	2,4-Dinitrotoluene	8.10E-02 J	1.20E-01 J	mg/kg	LFSS03	2/9	1.80E-01 - 4.00E-01	No	NIBC
	91-58-7	2-Chloronaphthalene	8.00E-03 J	4.80E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	No	NIBC
	95-57-8	2-Chlorophenol	8.20E-03 J	4.90E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	No	NIBC
	91-57-6	2-Methylnaphthalene	4.20E-03	6.20E-02	mg/kg	LFSB12A	7/9	2.00E-01 - 2.00E-01	No	NIBC
	88-75-5	2-Nitrophenol	1.10E-02 J	5.50E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	No	NIBC
	72-54-8	4,4'-DDD	4.23E-04 J	5.93E-03	mg/kg	LFSB15A	3/3	N/A	Yes	IBC

Table 7-6
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at the FLFA
Page 2 of 3

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
Surface Soil	72-55-9	4,4'-DDE	2.32E-03	4.93E-02	mg/kg	LFSB15A	2/2	N/A	Yes	IBC
	50-29-3	4,4'-DDT	1.54E-02	8.32E-02	mg/kg	LFSS03	3/3	N/A	Yes	IBC
	7005-72-3	4-Chlorophenyl phenylether	1.20E-02 J	1.20E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	Yes	IBC
	83-32-9	Acenaphthene	1.30E-02 J	1.30E-02 J	mg/kg	LFSB16B	1/5	1.70E-03 - 2.00E-01	Yes	IBC
	208-96-8	Acenaphthylene	8.55E-04 J	1.30E-02 J	mg/kg	LFSB16B	5/9	1.80E-03 - 2.00E-01	Yes	IBC
	120-12-7	Anthracene	1.90E-03	5.60E-03	mg/kg	LFSS03	5/9	1.80E-01 - 2.10E-01	Yes	IBC
	11097-69-1	Aroclor 1254	1.35E-02 J	4.02E-01	mg/kg	LFSS11	17/18	1.80E-01 - 1.80E-01	Yes	IBC
	11096-82-5	Aroclor 1260	3.73E-02 J	1.09E+00	mg/kg	LFSS16	8/18	1.80E-02 - 9.50E-02	Yes	IBC
	56-55-3	Benzo(a)anthracene	7.90E-03 J	2.80E-02	mg/kg	LFSS01	8/9	2.10E-01 - 2.10E-01	Yes	IBC
	50-32-8	Benzo(a)pyrene	9.70E-03	2.80E-02	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	IBC
	205-99-2	Benzo(b)fluoranthene	1.80E-02	6.70E-02	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	IBC
	191-24-2	Benzo(g,h,i)perylene	4.80E-03 L	2.50E-02 L	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	IBC
	207-08-9	Benzo(k)fluoranthene	5.90E-03	1.85E-02	mg/kg	LFSS01	6/9	2.00E-01 - 2.10E-01	Yes	IBC
	111-91-1	bis(2-Chloroethoxy)methane	1.30E-02 J	4.90E-02 J	mg/kg	LFSS01	2/9	1.70E-01 - 2.00E-01	No	NIBC
	111-44-4	bis(2-Chloroethyl)ether	1.90E-02 J	1.90E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	No	NIBC
	108-60-1	bis(2-Chloroisopropyl)ether	8.80E-03 J	4.95E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	No	NIBC
	218-01-9	Chrysene	1.20E-02	3.70E-02	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	IBC
	53-70-3	Dibenz(a,h)anthracene	2.60E-03 J	3.50E-03 J	mg/kg	LFSS03	3/9	1.70E-03 - 2.10E-01	Yes	IBC
	132-64-9	Dibenzofuran	1.30E-02 J	4.62E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	No	NIBC
	117-84-0	Di-n-octyl phthalate	2.00E-02 J	2.00E-02 J	mg/kg	LFSB17A	1/9	1.70E-01 - 2.10E-01	No	NIBC
	33213-65-9	Endosulfan II	1.23E-03	1.99E-02	mg/kg	LFSS03	3/3	N/A	Yes	IBC
	7421-93-4	Endrin aldehyde	1.87E-03	3.34E-02	mg/kg	LFSS03	3/3	N/A	Yes	IBC
	53494-70-5	Endrin ketone	4.46E-03	4.46E-03	mg/kg	LFSB15A	1/3	6.80E-04 - 6.79E-03	Yes	IBC
	206-44-0	Fluoranthene	1.80E-02	5.35E-02 J	mg/kg	LFSS01	6/9	2.00E-01 - 2.10E-01	Yes	IBC
	86-73-7	Fluorene	1.20E-03 J	9.00E-03 J	mg/kg	LFSB16B	6/9	1.80E-01 - 2.00E-01	Yes	IBC
	5103-74-2	gamma-Chlordane	2.81E-03	2.81E-03	mg/kg	LFSB15A	1/3	6.79E-04 - 6.80E-04	Yes	IBC
	118-74-1	Hexachlorobenzene	2.00E-02 J	2.00E-02 J	mg/kg	LFSB15A	1/9	1.70E-01 - 2.10E-01	Yes	IBC
	87-68-3	Hexachlorobutadiene	1.00E-02 J	5.20E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	Yes	IBC
	67-72-1	Hexachloroethane	1.30E-02 J	1.30E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	Yes	IBC
	193-39-5	Indeno(1,2,3-cd)pyrene	6.30E-03	2.60E-02	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	IBC
	78-59-1	Isophorone	7.40E-03 J	4.64E-02 J	mg/kg	LFSS01	3/9	1.70E-01 - 2.00E-01	No	NIBC
	72-43-5	Methoxychlor	7.28E-04 J	7.28E-04 J	mg/kg	LFSB15A	1/3	6.79E-04 - 6.80E-04	Yes	IBC
	91-20-3	Naphthalene	7.40E-03	3.40E-02	mg/kg	LFSS03	5/7	2.00E-01 - 2.00E-01	No	NIBC
	98-95-3	Nitrobenzene	3.50E-02 J	3.50E-02 J	mg/kg	LFSB16B	1/9	1.80E-01 - 4.00E-01	No	NIBC
	86-30-6	n-Nitrosodiphenylamine	1.50E-01 J	1.50E-01 J	mg/kg	LFSS03	1/9	1.70E-01 - 2.10E-01	No	NIBC
	59-50-7	p-Chloro-m-cresol	1.40E-02 J	1.40E-02 J	mg/kg	LFSB16B	1/9	1.70E-01 - 2.00E-01	No	NIBC
	85-01-8	Phenanthrene	1.40E-02 J	5.50E-02	mg/kg	LFSS03	6/9	2.00E-01 - 2.10E-01	Yes	IBC

Table 7-6
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at the FLFA
Page 3 of 3

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
	129-00-0	Pyrene	1.90E-02	5.05E-02 J	mg/kg	LFSS01	6/9	2.00E-01 - 2.10E-01	Yes	IBC
Surface Soil	7429-90-5	Aluminum	9.77E+03 J	4.78E+04	mg/kg	LFSB15A	27/27	N/A	No	NIBC
	7440-36-0	Antimony	4.30E-01 J	4.76E+01 J	mg/kg	LFSB15A	7/26	3.40E-01 - 3.80E+00	No	NIBC
	7440-38-2	Arsenic	1.79E+00 J	6.89E+01 J	mg/kg	LFSS20	27/27	N/A	Yes	IBC
	7440-39-3	Barium	2.53E+01	2.63E+03	mg/kg	LFSS03	27/27	N/A	No	NIBC
	7440-41-7	Beryllium	4.00E-01 J	1.72E+00	mg/kg	LFSB16B	9/27	6.40E-01 - 1.70E+00	No	NIBC
	7440-43-9	Cadmium	7.20E-02 J	1.98E+01	mg/kg	LFSB15A	11/27	5.60E-02 - 1.50E+00	Yes	IBC
	7440-70-2	Calcium	1.28E+03 J	5.57E+04 J	mg/kg	LFSB17B	27/27	N/A	No	NIBC
	7440-47-3	Chromium	1.31E+01 J	2.99E+02 J	mg/kg	LFSS03	27/27	N/A	Yes	IBC
	7440-48-4	Cobalt	3.70E+00 J	4.70E+01 J	mg/kg	LFSB15A	27/27	N/A	No	NIBC
	7440-50-8	Copper	1.08E+01 J	2.38E+04 J	mg/kg	LFSS20	27/27	N/A	Yes	IBC
	7439-89-6	Iron	1.41E+04 J	9.99E+04 J	mg/kg	LFSB15A	27/27	N/A	No	NIBC
	7439-92-1	Lead	1.83E+01	2.59E+04 J	mg/kg	LFSS20	33/33	N/A	Yes	IBC
	7439-95-4	Magnesium	1.07E+03 J	6.04E+04	mg/kg	LFSB17B	27/27	N/A	No	NIBC
	7439-96-5	Manganese	1.37E+02 J	2.23E+03 J	mg/kg	LFSB15A	27/27	N/A	No	NIBC
	7439-97-6	Mercury	3.00E-02 J	2.20E+00 J	mg/kg	LFSS21	26/27	6.05E-02 - 6.05E-02	Yes	IBC
	7440-02-0	Nickel	7.50E+00 J	4.04E+02 J	mg/kg	LFSB15A	27/27	N/A	Yes	IBC
	7440-09-7	Potassium	7.12E+02 J	7.87E+03	mg/kg	LFSB17B	27/27	N/A	No	NIBC
	7782-49-2	Selenium	3.40E-01 L	1.30E+00 L	mg/kg	LFSS19	16/27	2.50E-01 - 1.27E+00	Yes	IBC
	7440-22-4	Silver	1.10E-01 L	6.52E+01 L	mg/kg	LFSS17	19/27	7.50E-02 - 1.27E+00	Yes	IBC
	7440-23-5	Sodium	3.95E+01	3.17E+03	mg/kg	LFSS20	23/23	N/A	No	NIBC
	7440-28-0	Thallium	9.90E-02 J	3.16E-01	mg/kg	LFSS01	9/20	6.00E-01 - 1.62E+00	No	NIBC
	7440-62-2	Vanadium	2.16E+01 J	7.56E+01 J	mg/kg	LFSS19	27/27	N/A	No	NIBC
	7440-66-6	Zinc	2.60E+01 J	1.52E+04 J	mg/kg	LFSS20	27/27	N/A	Yes	IBC

COPEC Selection Rationale Codes

Selection Reason: Important Bioaccumulative Compounds (IBC) [as defined in Table 4-2, of USEPA 823-R-00-001, February 2000]

Deletion Reason: Not Important Bioaccumulative Compound (NIBC)
Dioxins and furans will be analyzed by the toxicity equivalent provided by the TCDD-TE (TEQ)

Notes/Definitions
N/A = Not Applicable or Not Available
COPEC = Chemical of Potential Ecological Concern
J = Estimated Value
L = Estimated Value
mg/kg = milligrams per kilogram

7.2.1 Data Organization

Soil measurements are the only data available for the FLFA that relevant to ecological exposures. To assess potential ecological impacts, soil from 0-1 ft bgs have been considered, although actual FLFA soil samples were all collected from 0 to 2 ft, except for VOCs that were collected from 0.5 to 1.0 ft. The 0- to 1-foot-depth interval was selected as recommended as a typical default by Suter et al. (2000). Although some burrowing wildlife (e.g., the red fox) may actually burrow to depths greater than 1 foot, 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- to 1-foot-depth range.

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, Tables F-1 and F-2**. Available background data exist for soil, as summarized in the Site Screening Process (USEPA, 2001b), 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 QC 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 (1989b). Besides taking into account the ecological depth of interest, the methodology for data summary was identical for the SLERA and the HHRA.

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 7-7**). The calculation of EPCs follows the same procedure used for the HHRA (*Section 6.2.3*).

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 (Essential Nutrients)

As a conservative step, the essential nutrients calcium, magnesium, potassium, and sodium were assessed in the SLERA.

7.2.5 Selection of COPECs

COPECs were selected as shown in **Tables 7-5 and 7-6**. In general, COPECs were selected as a concern for the direct contact exposure pathway if the constituent was detected in an environmental medium (**Table 7-5**). For food chain exposure pathways, detected COPECs were selected unless they were not important bioaccumulative constituents (USEPA, 2000d) (**Table 7-6**).

Dioxin-like compounds were treated according to procedures provided by USEPA and the World Health Organization (WHO) (USEPA, 1989a, 1994b; WHO, 1998, 2006). 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

Table 7-7
Medium-Specific Exposure Point Concentration Summary for the FLFA
Page 1 of 3

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No) [1]	95% UCL (Distribution) [2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale [4]
Surface Soil	2,3,7,8-TCDD-TE	mg/kg	1.28E-06	No	1.98E-05 (NP)	4.34E-05	1.98E-05	mg/kg	99% Cheby, Mean, SD	Test (3)
	1,2,4-Trichlorobenzene	mg/kg	3.25E-02	Yes	5.54E-02 (N)	5.45E-02	5.45E-02	mg/kg	Max	Test (2)
	1,2-Dichlorobenzene	mg/kg	4.05E-02	Yes	6.00E-02 (NP)	5.10E-02	5.10E-02	mg/kg	Max	Test (2)
	1,3-Dichlorobenzene	mg/kg	3.17E-02	Yes	5.26E-02 (N)	5.10E-02	5.10E-02	mg/kg	Max	Test (2)
	1,4-Dichlorobenzene	mg/kg	3.32E-02	Yes	5.44E-02 (N)	5.25E-02	5.25E-02	mg/kg	Max	Test (2)
	2,4,5-Trichlorophenol [5]	mg/kg	7.26E-02	Yes	8.95E-02 (N)	1.20E-02	1.20E-02	mg/kg	Max	Test (2)
	2,4,6-Trichlorophenol [5]	mg/kg	8.64E-02	Yes	1.16E-01 (NP)	1.80E-02	1.80E-02	mg/kg	Max	Test (2)
	2,4-Dichlorophenol	mg/kg	3.44E-02	Yes	5.75E-02 (NP)	4.69E-02	4.69E-02	mg/kg	Max	Test (2)
	2,4-Dinitrotoluene	mg/kg	1.01E-01	Yes	1.37E-01 (NP)	1.20E-01	1.20E-01	mg/kg	Max	Test (2)
	2-Chloronaphthalene	mg/kg	2.53E-02	Yes	4.80E-02 (N)	4.80E-02	4.80E-02	mg/kg	95% KM-% Btstrp	Test (4)
	2-Chlorophenol	mg/kg	2.74E-02	Yes	4.94E-02 (N)	4.90E-02	4.90E-02	mg/kg	Max	Test (2)
	2-Methylnaphthalene	mg/kg	2.36E-02	No	3.91E-02 (N)	6.20E-02	3.91E-02	mg/kg	95% KM-t	Test (4)
	2-Nitrophenol	mg/kg	3.07E-02	Yes	5.47E-02 (N)	5.50E-02	5.47E-02	mg/kg	95% KM-t	Test (1)
	4,4-DDD	mg/kg	2.41E-03	N/A	N/A	5.93E-03	5.93E-03	mg/kg	Max	Test (7)
	4,4-DDE	mg/kg	2.58E-02	N/A	N/A	4.93E-02	4.93E-02	mg/kg	Max	Test (7)
	4,4-DDT	mg/kg	4.81E-02	N/A	N/A	8.32E-02	8.32E-02	mg/kg	Max	Test (7)
	4-Chlorophenyl Phenyl Ether [5]	mg/kg	8.30E-02	Yes	1.16E-01 (NP)	1.20E-02	1.20E-02	mg/kg	Max	Test (2)
	Acenaphthene	mg/kg	6.08E-02	N/A	N/A	1.30E-02	1.30E-02	mg/kg	Max	Test (7)
	Acenaphthylene	mg/kg	3.75E-03	Yes	7.28E-03 (G)	1.30E-02	7.28E-03	mg/kg	95% KM-BCA	Test (1)
	Anthracene	mg/kg	3.49E-03	Yes	4.76E-03 (N)	5.60E-03	4.76E-03	mg/kg	95% KM-t	Test (1)
	Aroclor 1254	mg/kg	2.01E-01	No	4.88E-01 (G)	1.58E+00	4.88E-01	mg/kg	95% KM-Cheby	Test (6)
	Aroclor 1260	mg/kg	2.19E-01	Yes	2.19E-01 (L)	1.09E+00	2.19E-01	mg/kg	95% KM-BCA	Test (1)
	Benzo(a)anthracene	mg/kg	1.55E-02	No	2.02E-02 (N)	2.80E-02	2.02E-02	mg/kg	95% KM-t	Test (4)
	Benzo(a)pyrene	mg/kg	1.87E-02	Yes	2.47E-02 (N)	2.80E-02	2.47E-02	mg/kg	95% KM-t	Test (1)
	Benzo(b)fluoranthene	mg/kg	3.39E-02	Yes	4.82E-02 (N)	6.70E-02	4.82E-02	mg/kg	95% KM-t	Test (1)
	Benzo(g,h,i)perylene	mg/kg	1.26E-02	Yes	1.85E-02 (N)	2.50E-02	1.85E-02	mg/kg	95% KM-t	Test (1)
	Benzo(k)fluoranthene	mg/kg	1.05E-02	Yes	1.43E-02 (N)	1.85E-02	1.43E-02	mg/kg	95% KM-t	Test (1)

Table 7-7
Medium-Specific Exposure Point Concentration Summary for the FLFA
Page 2 of 3

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No) [1]	95% UCL (Distribution) [2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale [4]
Surface Soil	bis(2-Chloroethoxy)methane	mg/kg	3.10E-02	Yes	6.45E-02 (NP)	4.90E-02	4.90E-02	mg/kg	Max	Test (2)
	Bis(2-chloroethyl)ether [5]	mg/kg	8.38E-02	Yes	1.17E-01 (NP)	1.90E-02	1.90E-02	mg/kg	Max	Test (2)
	Bis(2-chloroisopropyl)ether	mg/kg	2.64E-02	Yes	4.95E-02 (N)	4.95E-02	4.95E-02	mg/kg	95% KM-% Btstrp	Test (1)
	Chrysene	mg/kg	2.18E-02	Yes	2.93E-02 (N)	3.70E-02	2.93E-02	mg/kg	95% KM-t	Test (1)
	Dibenz(a,h)Anthracene	mg/kg	2.93E-03	Yes	3.50E-03 (N)	3.50E-03	3.50E-03	mg/kg	95% KM-% Btstrp	Test (1)
	Dibenzofuran	mg/kg	2.44E-02	Yes	4.62E-02 (N)	4.62E-02	4.62E-02	mg/kg	95% KM-% Btstrp	Test (1)
	Di-n-octylphthalate [5]	mg/kg	8.56E-02	Yes	1.17E-01 (NP)	2.00E-02	2.00E-02	mg/kg	Max	Test (2)
	Endosulfan II	mg/kg	8.44E-03	N/A	N/A	1.99E-02	1.99E-02	mg/kg	Max	Test (7)
	Endrin aldehyde	mg/kg	1.39E-02	N/A	N/A	3.34E-02	3.34E-02	mg/kg	Max	Test (7)
	Endrin Ketone	mg/kg	2.73E-03	N/A	N/A	4.46E-03	4.46E-03	mg/kg	Max	Test (7)
	Fluoranthene	mg/kg	2.81E-02	Yes	3.85E-02 (N)	5.35E-02	3.85E-02	mg/kg	95% KM-% Btstrp	Test (1)
	Fluorene	mg/kg	3.42E-03	Yes	5.67E-03 (N)	9.00E-03	5.67E-03	mg/kg	95% KM-t	Test (1)
	gamma-Chlordane	mg/kg	1.16E-03	N/A	N/A	2.81E-03	2.81E-03	mg/kg	Max	Test (7)
	Hexachlorobenzene [5]	mg/kg	8.44E-02	Yes	1.18E-01 (NP)	2.00E-02	2.00E-02	mg/kg	Max	Test (2)
	Hexachlorobutadiene	mg/kg	3.07E-02	Yes	5.32E-02 (N)	5.20E-02	5.20E-02	mg/kg	Max	Test (2)
	Hexachloroethane [5]	mg/kg	8.31E-02	Yes	1.16E-01 (NP)	1.30E-02	1.30E-02	mg/kg	Max	Test (2)
	Indeno(1,2,3-cd)pyrene	mg/kg	1.39E-02	Yes	1.98E-02 (N)	2.60E-02	1.98E-02	mg/kg	95% KM-t	Test (1)
	Isophorone	mg/kg	2.13E-02	Yes	4.46E-02 (N)	4.64E-02	4.46E-02	mg/kg	95% KM-t	Test (1)
	Nitrobenzene [5]	mg/kg	1.03E-01	Yes	1.38E-01 (NP)	3.50E-02	3.50E-02	mg/kg	Max	Test (2)
	N-nitrosodiphenylamine [5]	mg/kg	1.01E-01	Yes	1.27E-01 (NP)	1.50E-01	1.27E-01	mg/kg	95% UCL-Bst	Test (3)
	p-Chloro-m-cresol [5]	mg/kg	8.32E-02	Yes	1.17E-01 (NP)	1.40E-02	1.40E-02	mg/kg	Max	Test (2)
	Methoxychlor	mg/kg	4.69E-04	N/A	N/A	7.28E-04	7.28E-04	mg/kg	Max	Test (7)
	Naphthalene	mg/kg	1.99E-02	No	2.90E-02 (N)	3.40E-02	2.90E-02	mg/kg	95% KM-t	Test (4)
	Phenanthrene	mg/kg	2.73E-02	Yes	3.84E-02 (N)	5.50E-02	3.84E-02	mg/kg	95% KM-t	Test (1)
	Pyrene	mg/kg	3.06E-02	Yes	3.96E-02 (N)	5.05E-02	3.96E-02	mg/kg	95% KM-t	Test (1)
	Aluminum	mg/kg	2.02E+04	No	2.28E+04 (G)	4.78E+04	2.28E+04	mg/kg	95% Approx. Gamma	Test (6)
	Antimony	mg/kg	1.24E+01	Yes	7.25E+00 (G)	4.76E+01	7.25E+00	mg/kg	95% KM-t	Test (1)
	Arsenic	mg/kg	9.93E+00	No	1.40E+01 (L)	6.89E+01	1.40E+01	mg/kg	95% H-UCL	Test (5)
	Barium	mg/kg	4.12E+02	No	1.88E+03 (NP)	2.63E+03	1.88E+03	mg/kg	99% Cheby, Mean, SD	Test (3)
	Beryllium	mg/kg	1.01E+00	Yes	9.67E-01 (N)	1.72E+00	9.67E-01	mg/kg	95% KM-% Btstrp	Test (1)
	Cadmium	mg/kg	4.26E+00	Yes	3.27E+00 (G)	1.98E+01	3.27E+00	mg/kg	95% KM-t	Test (1)

Table 7-7
Medium-Specific Exposure Point Concentration Summary for the FLFA
Page 3 of 3

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No) [1]	95% UCL (Distribution) [2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale [4]
Surface Soil	Calcium	mg/kg	1.12E+04	No	1.59E+04 (G)	5.57E+04	1.59E+04	mg/kg	95% Approx. Gamma	Test (6)
	Chromium	mg/kg	5.71E+01	No	1.17E+02 (NP)	2.99E+02	1.17E+02	mg/kg	95% Cheby, Mean, SD	Test (3)
	Cobalt	mg/kg	1.35E+01	No	1.64E+01 (G)	4.70E+01	1.64E+01	mg/kg	95% Approx. Gamma	Test (6)
	Copper	mg/kg	1.55E+03	No	1.06E+04 (NP)	2.38E+04	1.06E+04	mg/kg	99% Cheby, Mean, SD	Test (3)
	Iron	mg/kg	2.98E+04	No	3.58E+04 (NP)	9.99E+04	3.58E+04	mg/kg	95% Modified-t	Test (3)
	Lead	mg/kg	1.21E+03	No	8.97E+03 (NP)	2.59E+04	8.97E+03	mg/kg	99% Cheby, Mean, SD	Test (3)
	Magnesium	mg/kg	1.19E+04	No	1.65E+04 (G)	6.04E+04	1.65E+04	mg/kg	95% Approx. Gamma	Test (6)
	Manganese	mg/kg	7.11E+02	No	9.05E+02 (G)	2.23E+03	9.05E+02	mg/kg	95% Approx. Gamma	Test (6)
	Mercury	mg/kg	3.34E-01	No	1.01E+00 (NP)	2.20E+00	1.01E+00	mg/kg	97.5% KM-Cheby	Test (3)
	Nickel	mg/kg	4.08E+01	No	1.06E+02 (NP)	4.04E+02	1.06E+02	mg/kg	95% Cheby, Mean, SD	Test (3)
	Potassium	mg/kg	2.34E+03	No	2.82E+03 (G)	7.87E+03	2.82E+03	mg/kg	95% Approx. Gamma	Test (6)
	Selenium	mg/kg	7.00E-01	Yes	7.28E-01 (G)	1.30E+00	7.28E-01	mg/kg	95% KM-t	Test (1)
	Silver	mg/kg	9.48E+00	Yes	3.63E+01 (L)	6.52E+01	3.63E+01	mg/kg	99% KM-Cheby	Test (1)
	Sodium	mg/kg	5.77E+02	No	8.83E+02 (G)	3.17E+03	8.83E+02	mg/kg	95% Approx. Gamma	Test (6)
	Thallium	mg/kg	1.85E-01	Yes	2.27E-01 (N)	3.16E-01	2.27E-01	mg/kg	95% KM-% Btstrp	Test (1)
	Vanadium	mg/kg	4.29E+01	No	4.62E+01 (N)	7.56E+01	4.62E+01	mg/kg	95% Student's-t	Test (4)
	Zinc	mg/kg	1.37E+03	No	7.44E+03 (NP)	1.52E+04	7.44E+03	mg/kg	99% Cheby, Mean, SD	Test (3)

Notes: N/A = Not applicable

[1] ProUCL software (version 4.0, USEPA, 2007) recommends use of Kaplan-Meier method if there are multiple detection limits.

[2] Statistical Distribution and 95% UCL as determined by ProUCL (unless otherwise noted): (G) the data were determined to follow gamma distribution; (L) the data were determined to follow lognormal distribution; (NP) the data were determined to be non-parametric; (N) the data were determined to be normally distributed.

[3] Statistic: Maximum Detected Value (Max); 95% KM Chebyshev (95% KM-Cheby); 97.5% KM Chebyshev (97.5% KM-Cheby); 99% KM Chebyshev (99% KM-Cheby); 95% KM Percentile Bootstrap (95% KM-% Btstrp); 95% KM-t (95% KM-t); 95% KM-BCA (95% KM-BCA); 95% H-UCL (95% H-UCL); 95% Chebyshev -Mean, SD- UCL (95% Cheby, Mean, SD); 97.5% Chebyshev -Mean, SD- UCL (97.5% Cheby, Mean, SD); 99% Chebyshev -Mean, SD- UCL (99% Cheby, Mean, SD); 95% UCL of Log-transformed Data (95% UCL-T) 95% Student's-t (95% Student's-t); 95% Modified-t (95% Modified-t); 95% UCL based on bootstrap statistic (95% UCL-Bst); 95% Approximate Gamma UCL (95% Approx. Gamma).

[4] Unless otherwise noted (see footnote 5), ProUCL EPC selection rationale based on, detection limit values, distribution, standard deviation, and sample size (see ProUCL output in appendix for further details):

Test (1): Kaplan-Meier method recommended by ProUCL due to multiple detection limits.
Test (2): 95% UCL recommended by ProUCL exceeds maximum detected concentration, therefore, maximum concentration used for EPC.
Test (3): Shapiro-Wilk W test, Kolmogorov-Smirnov (K-S), and Anderson-Darling (A-D) tests, indicate data follow nonparametric distribution.
Test (4): Shapiro-Wilk W test indicates data are normally distributed.
Test (5): Shapiro-Wilk W test indicates data are log-normally distributed.
Test (6): Kolmogorov-Smirnov (K-S) and/or Anderson-Darling (A-D) tests indicate data follow gamma distribution.
Test (7): Sample size is less than or equal to 5, therefore, maximum concentration used for EPC.

[5] Infrequent detection resulted in ProUCL modeling error for this constituent, therefore distribution, average, and UCL determined using non-ProUCL bootstrap method with random numbers for NDs (see text for details).

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. For this SLERA, the higher of the TEFs for mammals and birds was used, as a conservative approach (WHO, 1998, 2006). The TE procedure itself is described in the HHRA (*Section 6.1.1*).

It should be noted that USEPA recommends that aluminum should only be identified as a COPEC for those sites with soil with a pH less than 5.5 (USEPA, 2000c). The technical basis for this rationale is that soluble and toxic forms of aluminum are present in soil with soil pH values of less than 5.5. An analysis of FLFA surface soil revealed one sample with a soil pH of 7.57, so aluminum is likely not a concern for direct contact exposure, given the site's non-acidic soil conditions. However, as mentioned in *Section 7.5*, all COPECs are (initially) conservatively assumed to be 100% bioavailable.

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 MDC.
- Frequency of detection.
- Range of detection limits.
- COPEC selection conclusion: YES or NO.
- Rationale for selection or rejection of the COPEC.

Footnotes in the tables provide the rationale for selecting or rejecting a chemical as a COPEC.

Seventy-six COPECs (52 inorganic and 24 organic COPECs) have been selected for surface soil direct contact exposure (**Table 7-5**).

Forty-four COPECs (34 inorganic and 10 organic COPECs) have been selected for surface soil for food chain exposure (**Table 7-6**). Detected chemicals that are important bioaccumulative compounds (USEPA, 2000d) are considered final food chain exposure COPECs and have been quantitatively evaluated in this SLERA.

EPCs based on the statistical procedures discussed in *Section 6.2.3* are presented in **Table 7-7**. Arithmetic mean concentrations are presented for informational purposes.

7.3 Identification of Exposure Pathways and Potential Receptors for Analysis

RFAAP terrestrial and aquatic wildlife may be exposed to COPECs by several pathways, including: (1) the ingestion of impacted soil, sediment, surface water, or food while foraging; (2) dermal absorption of chemicals from soil, sediment, or surface water; and, (3) inhalation of chemicals that have been wind-eroded from soil or have volatilized from soil or water. Among these potential exposure pathways, the greatest potential for exposure to chemicals is likely to result from the ingestion of chemicals in food and surface water. The incidental ingestion of impacted soil or sediment (while foraging) is a less important exposure route. The ingestion of food, soil, sediment, and surface water, however, are viable exposure pathways and were considered in the SLERAs, if relevant. 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. Inhalation exposure would be expected to be minimal due to dilution of airborne COPECs in ambient air. Dermal exposure would also be expected to be minimal due to the expectation that wildlife fur or feathers would act to impede the transport the COPECs to the dermal layer.

The appropriate assessment receptors have been selected for evaluation in the SLERAs. In order to narrow the exposure characterization portion of the SLERAs on species or components that are the most likely to be affected, the SLERAs have focused the selection process on species, groups of species, or functional groups, rather than higher organization levels such as communities or ecosystems. Site biota are organized into major functional groups. For terrestrial communities, the major groups are plants and wildlife, including terrestrial invertebrates, mammals, and birds. For aquatic and/or wetland communities, the major groups are flora and fauna, including vertebrates (waterfowl and fish), aquatic invertebrates, and semi-aquatic mammals and birds. Species presence was assessed during a literature review and during the site reconnaissance 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).

7.3.1 Terrestrial Receptors

Five representative receptor species that are expected or possible in the area of the FLFA (*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*), as well as by comparing soil concentrations with conservative screening values. 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-3**.

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 on **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. Receptor profiles for these five selected species are presented in the following five sections.

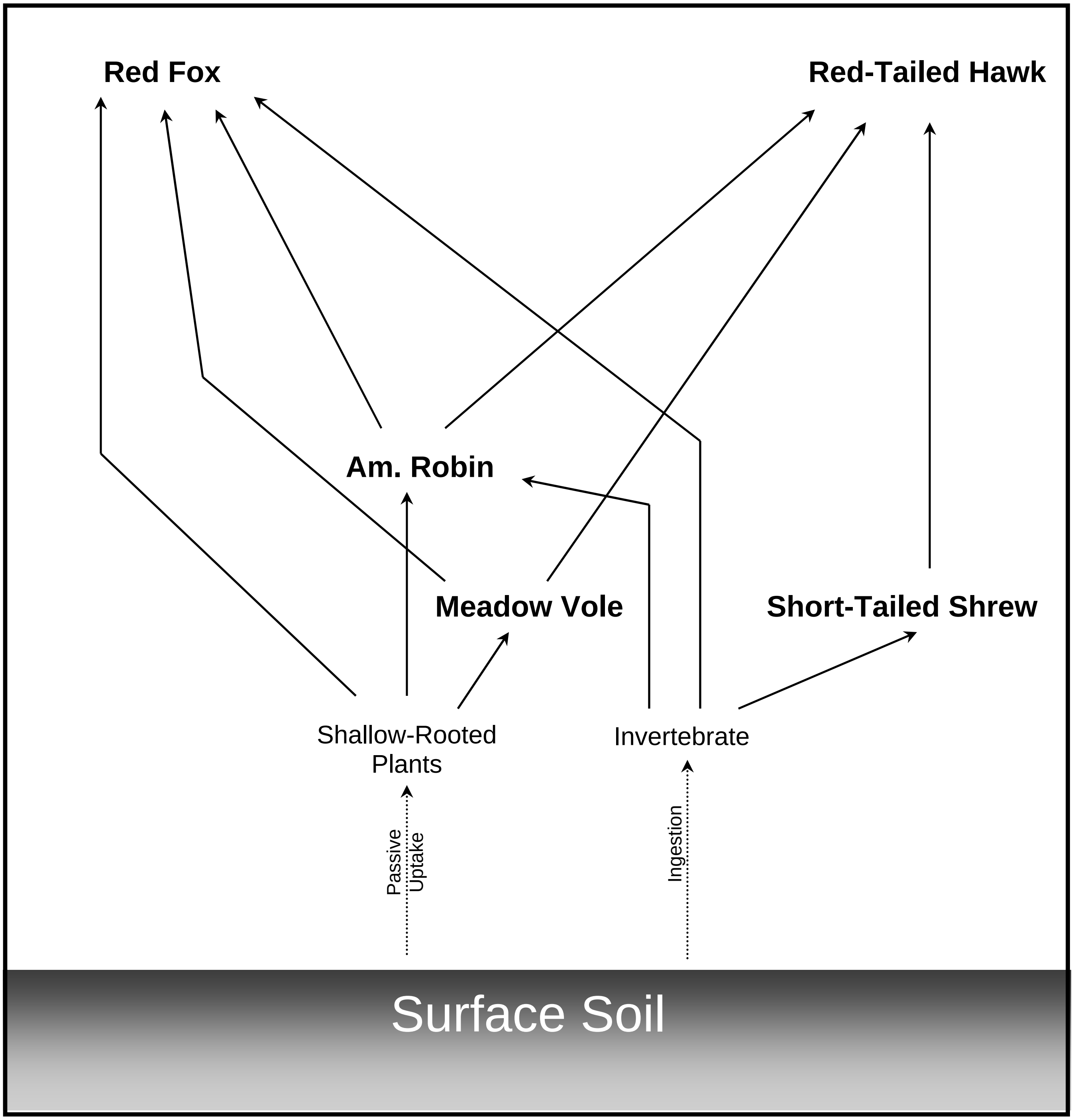
Meadow Vole. The meadow vole inhabits grassy areas (upland and wetland) and obtains a significant portion of its herbivorous diet from the site. The vole resides in every area of the United States and Canada where there is good grass cover, ranges in size from about 9 to 13 centimeters in length, and weighs between 17 and 52 grams (USEPA, 1993). 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 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-3**).

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).

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;

Figure 7-1
Simplified Terrestrial Food Web
Conceptual Site Exposure Model (CSEM)



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.

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). 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.

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. To assess whether the protection of these resources 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 HHRA 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.

Selected assessment endpoints reflect environmental values that are protected by law, are critical resources, and/or have relevance to ecological functions that may be impaired. Both the entity and attribute are identified for each assessment endpoint (Suter, 1993).

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.

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.

7.4.1 Assessment Endpoints

ERAGS (USEPA, 1997d) 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 selected assessment endpoints for the FLFA are stated as the protection of long-term survival and reproductive capabilities for populations of herbivorous, insectivorous, and carnivorous mammals, and omnivorous, piscivorous, and carnivorous birds. The corresponding null hypothesis (H_o) for each of the assessment endpoints is stated as: the presence of site contaminants within soil, surface water, sediment, vegetation, and prey will have no effect on the survival or reproductive capabilities of populations of herbivorous, insectivorous, and carnivorous mammals, and omnivorous, piscivorous, and carnivorous birds. In addition, assessment endpoints for the base of the food chain are stated as the protection of long-term survival and reproduction of terrestrial plants and soil invertebrates.

The food web CSEM was developed to illustrate how the selected terrestrial and aquatic species are ecologically linked. For terrestrial invertebrates, small prey items, fish, 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.

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 (USEPA, 1997d).

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

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. 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. In addition, as discussed in *Section 7.3*, dermal contact and inhalation exposures are considered insignificant compared to other quantified routes of exposure.

Bioavailability of a chemical is an important contaminant characteristic that influences the degree of chemical-receptor interaction. As discussed in *Section 7.2.5*, the surface soil pH at the FLFA is assumed to be approximately 7.57, based on results from one surface soil sample. For purposes of the SLERAs, bioavailability is conservatively assumed to be 100%.

For terrestrial and aquatic faunal receptors, calculation of exposure rates relies upon determination of an organism's exposure to COPECs found in surface soil, surface water, or sediment, and on transfer factors used for food-chain exposure. Exposure rates for terrestrial and aquatic wildlife receptors in these SLERAs are based solely 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 and aquatic 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 rates, 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**, **Tables F-5 through F-14**. For the SLERAs, conservative Tier 1 exposures are based on maximum dietary intake, maximum incidental soil intake, minimum body weight, 100% 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. The established FLFA site area was estimated to be 0.78 acres. These Tier 2 exposures may be considered as a portion of Step 3a of the ERAGS 8-step process.

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.

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. Where sediment ingestion rates could not be found, the animal-specific incidental soil ingestion rate is used for sediment ingestion as well, if the receptors life history profile suggests a significant aquatic component, and if sediment is a medium of concern at the site.

The estimated chemical intakes for the exposed receptors for the relevant pathway and scenario are presented in the risk characterization spreadsheets (an example calculation is presented in **Appendix F-2, Table F-4**, and the rest of the spreadsheets are presented in **Appendix F-2**, **Tables F-5 through F-14**).

7.5.2 Bioaccumulation and Bioconcentration Factors

For the current SLERAs, 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-15, F-16, and F-17**, 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, 2001b) and the *RFAAP Final MWP* (URS, 2003). The Tier 1 BAF/BCF is generally the upper-bound 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-15**) are based on information from Bechtel Jacobs (1998), USEPA (2008a), Efroymson (2001), Baes et al. (1984), International Atomic Energy Agency (IAEA) (1994), and Travis and Arms (1988). 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, a median value is used for the Tier 2 assessment (Note: the median is used for the Tier 2 because this is the reported BAF/BCF. It should be noted that as the Tier 2 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. For organic COPEC without available BAF/BCF values, the K_{ow} regression equation from Travis and Arms (1988) is used, as shown as follows:

$$Log\ BAF\ /\ BCF\ =\ -0.578\ \times\ Log\, K_{ow}\ +\ 1.588$$

where:

Log K_{ow} = log octanol-water partition coefficient (see **Appendix F-2, Table F-15**)

In order to estimate Tier 1 and Tier 2 BAF/BCF plant uptake values using the Travis and Arms (1988) regression equation, the lowest log K_{ow} from the literature was used (as plant uptake is inversely related to K_{ow}). For the Tier 2 approach, a more accurate (average) log K_{ow} value from the Syracuse Research Corporation (SRC) website (http://esc.syrres.com) was used. SRC's interactive website estimates log K_{ow} values for organic chemicals using an atom/fragment contribution method, based on the method developed by Meylan and Howard (1995). BAF/BCF values estimated for organics using the Travis and Arms (1988) equation ranged from 0.011 (for TCDD) to 0.49 (for 1,2-; 1,3-; and 1,4-Dichlorobenzene) for the Tier 1 approach; and 0.0039 (for TCDD) to 0.49 (for 1,2-; 1,3-; and 1,4-Dichlorobenzene) for the Tier 2 approach (**Appendix F-2**, **Table F-15**).

Soil-to-earthworm BAF/BCF values (**Appendix F-2**, **Table F-16**) are based on information from Sample et al. (1998a), Sample et al. (1999), and USEPA (2008a). 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 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.

Soil-to-small mammal and small bird BAF/BCF values (**Appendix F-2**, **Table F-17**) are based on information from USEPA (2008a) and Sample et al. (1998b). Tier 2 values are based on regression equations (USEPA, 2008a) or upper-bound BAF/BCF values if no regression equation is available.

For direct contact exposure for soil invertebrates to COPECs in surface soil, measured COPEC concentrations in this media were simply compared with direct contact benchmarks appropriate for the soil community.

7.6 Ecological Effects Characterization

This ecological effects characterization section presents the selection of literature benchmark values and the development of reference toxicity values, and the approach for evaluating direct contact toxicity.

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 (TRVs) for Conducting Ecological Risk Assessments at Naval Facilities in California (Engineering Field Activity, West, 1998); Review of the Navy - USEPA Region IX Biological Technical Assistance Group (BTAG) TRVs for Wildlife (CH2M-Hill, 2000); and, (2) LD50 values from data bases such as the Registry of Toxic Effects Concentrations [extrapolated to chronic NOAEL or lowest-observed-adverse-effect level (LOAEL) values using recommended Tri-Service (Wentsel et al., 1996) uncertainty factors].

7.6.2 Development of Toxicity Reference Values

TRVs were selected from available data for use in the FLFA SLERA. 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 below.

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.

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-18 and F-19** for NOAEL and LOAEL TRVs, respectively. As recommended by Hull et al. (2007), allometric dose scaling using body mass was not performed for chronic TRVs because this approach is not scientifically defensible and 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 were 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-10** 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*.

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*).

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 semi-quantitative 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*), and no obvious signs of vegetative stress were noted (**Appendix F-1**). The overall health of the grassland community at the site was comparable to the grasslands in the surrounding area. 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 (i.e., mowing on an infrequent basis to eliminate woody plants), potential risks to plants are not deemed a reason to recommend further action. However, it should be noted that a terrestrial plant impact screening assessment is presented in **Table 7-9**. It should be noted that 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.

7.7.2 Predictive Risk Estimation for Terrestrial Wildlife and Aquatic Wildlife

The potential wildlife risks associated with the FLFA are estimated in this SLERA. 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 (Allard et al., 2007; Tannenbaum, 2001; Bartell, 1996).

The simple HQ ratios are summed to provide conservative HI estimates for chemicals and exposure pathways for a given receptor. The criterion used to decide if HQ summation is appropriate and scientifically defensible includes 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 ranging from less than one to over 10,000 (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 and aquatic receptors at the FLFA are presented in risk characterization tables (**Appendix F-2, Tables F-5 through F-14**) for the five selected receptor species. The summed EEQs are presented in **Table 7-8** (generally rounded to two significant figures), along with the hazard driver [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 7-8**, Tier 1 total EEQs ranged from approximately 165 to 10,523 for the five receptor species, using TRVs based on either NOAEL or LOAEL values. The short-tailed shrew

Table 7-8
Wildlife EEQ Hazard Summary for the FLFA

Receptor	Tier 1[a]		Tier 2[b]	
	NOAEL-Based EEQ	LOAEL-Based EEQ	NOAEL-Based EEQ	LOAEL-Based EEQ
Meadow vole	606	257	91	45
Hazard Driver(s)[c]:	Copper and Lead - plant and soil ingestion		Copper and Lead - plant and soil ingestion	
Short-tailed shrew	10,523	3,052	486	225
Hazard Driver(s)[c]:	TCDD and Copper - terrestrial invertebrate ingestion		Copper - terrestrial invertebrate ingestion	
American robin	4,221	896	336	67
Hazard Driver(s)[c]:	Lead - terrestrial invertebrate ingestion		Copper and Lead - terrestrial invertebrate ingestion	
Red-tailed hawk	1,269	165	0.16	0.016
Hazard Driver(s)[c]:	4,4-DDE - small mammal ingestion		--	
Red fox	739	297	0.011	0.0036
Hazard Driver(s)[c]:	Selenium - small mammal 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 ≤ 1.

[c] Hazard drivers are those chemicals contributing the most to the total EEQ, and the primary route of exposure associated with the driver.

Notes:
EEQ = Ecological Effects Quotient
LOAEL = Lowest-Observed-Adverse-Effect Level
NOAEL = No-Observed-Adverse-Effect Level

was predicted to be the most impacted, followed by American robin, the meadow vole, the red fox, and the red-tailed hawk, respectively. Inorganic constituents including copper, lead, and selenium, and the organic constituents TCDD and DDE, were the COPECs contributing the most to the total EEQs for the receptors. Exposure pathways of most concern, based on the results of the food-chain modeling, were terrestrial invertebrate, small mammal, and incidental soil ingestion.

More realistic Tier 2 total EEQs were elevated, especially values based on NOAEL TRVs, which ranged from less than one to 486. However, Tier 2 total EEQs were much lower than Tier 1 total EEQs. NOAEL based Tier 2 total EEQs for the red-tailed hawk and red fox were less than one, but greater than one for the shrew, vole, and robin. Tier 2 LOAEL EEQs were less than one for the red-tailed hawk and red fox, but greater than one for the shrew, robin, and vole (**Table 7-8**), as discussed in more detail as follows.

Short-tailed Shrew. The total EEQ for the LOAEL TRV exceeded one (225). Seven COPECs had individual LOAEL-based EEQs that exceeded one (EEQ in parenthesis): copper (191), lead (12), hexachlorobenzene (4.5), TCDD TE (4.3), zinc (3.3), hexachlorobutadiene (2.1), and Aroclor-1254 (1.6). The primary exposure pathway was the ingestion of invertebrates.

American Robin. The total EEQ for the LOAEL TRV exceeded one (67). Six COPECs had individual LOAEL-based EEQs that exceeded one (EEQ in parenthesis): lead (22), copper (20), DDT (6.6), DDE (5.7), zinc (5.0), and chromium (3.8). The primary exposure pathway was the ingestion of invertebrates.

Meadow Vole. The total EEQ for the LOAEL TRV exceeded one (45). Three COPECs had individual LOAEL-based EEQs that exceeded one (EEQ in parenthesis): copper (37), lead (2.8), and zinc (2.3). The primary exposure pathway was the incidental ingestion of soil.

7.7.3 Approach for the Evaluation of Direct Contact Toxicity

To evaluate direct contact exposure, for those organisms that live within an environmental medium, COPEC media concentrations are compared with BTAG direct-contact screening values, and secondarily, a variety of additional appropriate direct-contact benchmarks. Intake is not calculated because potential adverse effects are assessed by evaluating the COPEC concentrations in soil. The results are summarized in **Table 7-9**.

7.7.3.1 Soil

A two-step process was used to assess direct contact soil toxicity. First, the maximum detected soil concentration was compared with the lowest available Ecological Soil Screening Level (EcoSSL) (USEPA, 2008a), or if an EcoSSL was not available, with the lowest BTAG (USEPA, 1995b) soil screening value (**Table 7-9**). A chemical was only retained as a COPEC if the MDC exceeded the EcoSSL, or, in the absence of an EcoSSL, if the MDC exceeded the BTAG soil screening value. If no EcoSSL or BTAG value was available, the value was also carried forward for comparison to other available screening values (see list below). Based on the results of this first step, 22 COPECs were selected based on an EcoSSL or BTAG exceedance while 23 additional chemicals were evaluated further because of the lack of available EcoSSL or BTAG screening values (**Table 7-9**). In the second step, the MDC of these 45 chemicals was compared with up to five individual soil screening values that are referenced on the USEPA Region III BTAG website for direct contact toxicity, listed as follows (in addition to the BTAG screening value, if one was available):

Table 7-9
Direct Toxicity Evaluation for Surface Soil at the FLFA
Page 1 of 2

Chemical (1)	Detection Frequency	Maximum Concentration	Exposure Point Concentration	Minimum Concentration	BTAG or USEPA EcoSSL Screening Toxicity Value (2)	Retain COPEC as Max Conc > BTAG or EcoSSL Value?	If Retained as COPEC, Comment on BTAG or EcoSSL Value	NOAA SQuiRT Value (3)	CCME Value (4)	USEPA EcoSSL Direct Contact Value (5)	ORNL Screening Benchmark for Plants (6)	ORNL Screening Benchmark for Invertebrates (7)	COPEC Weight of Evidence Summary - Number of Direct Contact Benchmarks Exceeded Using MDC	Comment
2,3,7,8-TCDD-TE	25 / 25	4.34E-05	1.98E-05	2.09E-07	1.00E-02	No								
1,2,4-Trichlorobenzene	3/9	5.45E-02	5.45E-02	1.20E-02	NVA	NVA		1.00E-01	5.00E-02	NVA	NVA	2.00E+01	1/3	CCME value for Ag land
1,2-Dichlorobenzene	2/9	5.10E-02	5.10E-02	3.00E-02	1.00E-01	No								
1,3-Dichlorobenzene	3/9	5.10E-02	5.10E-02	1.20E-02	NVA	NVA		NVA	1.00E-01	NVA	NVA	NVA	0/1	No exceedances
1,4-Dichlorobenzene	3/9	5.25E-02	5.25E-02	1.30E-02	1.00E-01	No								
2,4,5-Trichlorophenol	1/9	1.20E-02	1.20E-02	1.20E-02	1.00E-01	No								
2,4,6-Trichlorophenol	1/9	1.80E-02	1.80E-02	1.80E-02	1.00E-01	No								
2,4-Dichlorophenol	2/9	4.69E-02	4.69E-02	2.20E-02	1.00E-01	No								
2,4-Dinitrotoluene	2/9	1.20E-01	1.20E-01	8.10E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
2-Chloronaphthalene	3/9	4.80E-02	4.80E-02	8.00E-03	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
2-Chlorophenol	3/9	4.90E-02	4.90E-02	8.20E-03	1.00E-01	No								
2-Methylnaphthalene	7/9	6.20E-02	3.91E-02	4.20E-03	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
2-Nitrophenol	3/9	5.50E-02	5.47E-02	1.10E-02	NVA	NVA		NVA	1.00E-01	NVA	NVA	NVA	0/1	No exceedances
4,4'-DDD	3/3	5.93E-03	5.93E-03	4.23E-04	2.10E-02	No								
4,4'-DDE	2/2	4.93E-02	4.93E-02	2.32E-03	2.10E-02	Yes	Mammal tox	NVA	NVA	NVA	NVA	NVA	NVA	
4,4'-DDT	3/3	8.32E-02	8.32E-02	1.54E-02	2.10E-02	Yes	Mammal tox	NVA	7.00E-01	NVA	NVA	NVA	0/1	No exceedances
4-Chlorophenyl phenylether	1/9	1.20E-02	1.20E-02	1.20E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Acenaphthene	1/5	1.30E-02	1.30E-02	1.30E-02	2.9E+01 (LMW)	No								
Acenaphthylene	5/9	1.30E-02	7.28E-03	8.55E-04	2.9E+01 (LMW)	No								
Anthracene	5/9	5.60E-03	4.76E-03	1.90E-03	2.9E+01 (LMW)	No								
Aroclor 1254	17/18	1.58E+00	4.88E-01	1.35E-02	1.00E-01	Yes	Plant tox (no ref)	5.00E-01	5.00E-01	NVA	4.00E+01	NVA	2/3	EPC does not exceed
Aroclor 1260	8/18	1.09E+00	2.19E-01	3.73E-02	1.00E-01	Yes	Plant tox (no ref)	5.00E-01	5.00E-01	NVA	4.00E+01	NVA	2/3	EPC does not exceed
Benzo(a)anthracene	8/9	2.80E-02	2.02E-02	7.90E-03	1.1E+00 (HMW)	No								
Benzo(a)pyrene	6/9	2.80E-02	2.47E-02	9.70E-03	1.1E+00 (HMW)	No								
Benzo(b)fluoranthene	6/9	6.70E-02	4.82E-02	1.80E-02	1.1E+00 (HMW)	No								
Benzo(g,h,i)perylene	6/9	2.50E-02	1.85E-02	4.80E-03	1.1E+00 (HMW)	No								
Benzo(k)fluoranthene	6/9	1.85E-02	1.43E-02	5.90E-03	1.1E+00 (HMW)	No								
bis(2-Chloroethoxy)methane	2/9	4.90E-02	9.67E-01	1.30E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
bis(2-Chloroethyl)ether	1/9	1.90E-02	4.90E-02	1.90E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
bis(2-Chloroisopropyl)ether	3/9	4.95E-02	1.90E-02	8.80E-03	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Chrysene	6/9	3.70E-02	4.95E-02	1.20E-02	1.1E+00 (HMW)	No								
Dibenz(a,h)anthracene	3/9	3.50E-03	2.93E-02	2.60E-03	1.1E+00 (HMW)	No								
Dibenzofuran	3/9	4.62E-02	3.50E-03	1.30E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Di-n-octyl phthalate	1/9	2.00E-02	4.62E-02	2.00E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Endosulfan II	3/3	1.99E-02	2.00E-02	1.23E-03	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Endrin aldehyde	3/3	3.34E-02	1.99E-02	1.87E-03	1.00E-01	No								
Endrin ketone	1/3	4.46E-03	3.34E-02	4.46E-03	1.00E-01	No								
Fluoranthene	6/9	5.35E-02	4.46E-03	1.80E-02	1.1E+00 (HMW)	No								
Fluorene	6/9	9.00E-03	3.85E-02	1.20E-03	2.9E+01 (LMW)	No								
gamma-Chlordane	1/3	2.81E-03	5.67E-03	2.81E-03	1.00E+02	No								
Hexachlorobenzene	1/9	2.00E-02	2.81E-03	2.00E-02	NVA	NVA		5.00E-02	5.00E-02	NVA	NVA	NVA	0/2	No exceedances
Hexachlorobutadiene	3/9	5.20E-02	2.00E-02	1.00E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Hexachloroethane	1/9	1.30E-02	5.20E-02	1.30E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Indeno(1,2,3-cd)pyrene	6/9	2.60E-02	1.30E-02	6.30E-03	1.1E+00 (HMW)	No								
Isophorone	3/9	4.64E-02	1.98E-02	7.40E-03	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Methoxychlor	1/3	7.28E-04	4.46E-02	7.28E-04	1.00E-01	No								
Naphthalene	5/7	3.40E-02	3.50E-02	7.40E-03	2.9E+01 (LMW)	No								
Nitrobenzene	1/9	3.50E-02	1.27E-01	3.50E-02	NVA	NVA		NVA	NVA	NVA	NVA	4.00E+01	0/1	No exceedances
n-Nitrosodiphenylamine	1/9	1.50E-01	1.40E-02	1.50E-01	NVA	NVA		NVA	NVA	NVA	NVA	2.00E+01	0/1	No exceedances

Table 7-9
Direct Toxicity Evaluation for Surface Soil at the FLFA
Page 2 of 2

Chemical (1)	Detection Frequency	Maximum Concentration	Exposure Point Concentration	Minimum Concentration	BTAG or USEPA EcoSSL Screening Toxicity Value (2)	Retain COPEC as Max Conc > BTAG or EcoSSL Value?	If Retained as COPEC, Comment on BTAG or EcoSSL Value	NOAA SQuiRT Value (3)	CCME Value (4)	USEPA EcoSSL Direct Contact Value (5)	ORNL Screening Benchmark for Plants (6)	ORNL Screening Benchmark for Invertebrates (7)	COPEC Weight of Evidence Summary - Number of Direct Contact Benchmarks Exceeded Using MDC	Comment
p-Chloro-m-cresol	1/9	1.40E-02	7.28E-04	1.40E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Phenanthrene	6/9	5.50E-02	2.90E-02	1.40E-02	2.9E+01 (LMW)	No								
Pyrene	6/9	5.05E-02	3.84E-02	1.90E-02	1.1E+00 (HMW)	No								
Aluminum	27/27	4.78E+04	3.96E-02	9.77E+03	1.00E+00	Yes	pH < 5.5; Plant tox (OHMTADS)	NVA	NVA	pH < 5.5	5.00E+01	NVA	NA	Soil pH = 7.57 (No toxicity expected)
Antimony	7/26	4.76E+01	7.25E+00	4.30E-01	2.70E-01	Yes	Mammal tox	NVA	2.00E+01	7.80E+01	5.00E+00	NVA	2/3	EcoSSL not exceeded
Arsenic	27/27	6.89E+01	1.40E+01	1.79E+00	1.80E+01	Yes	Plant tox	NVA	1.20E+01	1.80E+01	1.00E+01	6.00E+01	4/4	
Barium	27/27	2.63E+03	1.88E+03	2.53E+01	3.30E+02	Yes	Invertebrate tox	NVA	5.00E+02	3.30E+02	5.00E+02	NVA	3/3	
Beryllium	9/27	1.72E+00	9.67E-01	4.00E-01	2.10E+01	No		NVA						
Cadmium	11/27	1.98E+01	3.27E+00	7.20E-02	3.60E-01	Yes	Mammal tox	NVA	1.40E+00	3.20E+01	4.00E+00	2.00E+01	2/4	
Calcium	27/27	5.57E+04	1.59E+04	1.28E+03	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Chromium (Cr III tox)	27/27	2.99E+02	1.17E+02	1.31E+01	2.60E+01	Yes	Bird tox (Cr III)	NVA	6.40E+01	NVA	1.00E+00	4.00E-01	3/3	EcoSSL says data insufficient to derive direct contact SSL
Chromium (Cr VI tox)	27/27	2.99E+02	1.17E+02	1.31E+01	8.10E+01	Yes	Mammal tox (Cr VI)	NVA	4.00E-01	NVA	NVA	NVA	1/1	EcoSSL says data insufficient to derive direct contact SSL
Cobalt	27/27	4.70E+01	1.64E+01	3.70E+00	1.30E+01	Yes	Plant tox	NVA	4.00E+01	1.30E+01	2.00E+01	NVA	3/3	
Copper	27/27	2.38E+04	1.06E+04	1.08E+01	2.80E+01	Yes	Bird tox	NVA	6.30E+01	7.00E+01	1.00E+02	5.00E+01	4/4	
Iron	27/27	9.99E+04	3.58E+04	1.41E+04	5 ≤ pH ≤ 8	No		NVA						Soil pH = 7.57
Lead	33/33	2.59E+04	8.97E+03	1.83E+01	1.10E+01	Yes	Bird tox	NVA	7.00E+01	1.20E+02	5.00E+01	5.00E+02	4/4	
Magnesium	27/27	6.04E+04	1.65E+04	1.07E+03	4.40E+03	Yes	No reference	NVA	NVA	NVA	NVA	NVA	NVA	
Manganese	27/27	2.23E+03	9.05E+02	1.37E+02	2.20E+02	Yes	Plant tox	NVA	NVA	2.20E+02	5.00E+02	NVA	2/2	Plant toxicity
Mercury	26/27	2.20E+00	1.01E+00	3.00E-02	5.80E-02	Yes	No reference	NVA	6.60E+00	NVA	3.00E-01	1.00E-01	3/4	
Nickel	27/27	4.04E+02	1.06E+02	7.50E+00	3.80E+01	Yes	Plant tox	NVA	5.00E+01	3.80E+01	3.00E+01	2.00E+02	4/4	
Potassium	27/27	7.87E+03	2.82E+03	7.12E+02	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Selenium	16/27	1.30E+00	7.28E-01	3.40E-01	5.20E-01	Yes	Plant tox	NVA	1.00E+00	5.20E-01	1.00E+00	7.00E+01	3/4	
Silver	19/27	6.52E+01	3.63E+01	1.10E-01	4.20E+00	Yes	Bird tox	NVA	2.00E+01	5.60E+02	2.00E+00	NVA	2/3	
Sodium	23/23	3.17E+03	8.83E+02	3.95E+01	NVA	NVA		NVA	NVA	NVA	NVA	NVA	NVA	
Thallium	9/20	3.16E-01	2.27E-01	9.90E-02	1.00E-03	Yes	Plant tox (no ref)	NVA	1.00E+00	NVA	1.00E+00	NVA	0/2	No exceedances
Vanadium	27/27	7.56E+01	4.62E+01	2.16E+01	7.80E+00	Yes	Bird tox	NVA	1.30E+02	NVA	2.00E+00	NVA	1/2	EcoSSL says data insufficient to derive direct contact SSL
Zinc	27/27	1.52E+04	7.44E+03	2.60E+01	4.60E+01	Yes	Bird tox	NVA	2.00E+02	1.20E+02	5.00E+01	2.00E+02	4/4	

All values presented in mg/kg.
NVA = No Value Available
LMW = Low Molecular Weight PAH
HMW = High Molecular Weight PAH
Surface soil pH of 7.57 based on one geochemical sample (LFSB12A) collected at the FLFA.

(1) COPECs from Table 7-5.
(2) Screening toxicity values from BTAG (1995) or EcoSSL (USEPA, 2007). EcoSSLs given highest priority as they are more definitive.
(3) NOAA SQuiRT (Buchman, 1999). Most conservative target value used.
(4) Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines, December 2003.
(5) Lowest EcoSSL value for direct contact toxicity for either plants or terrestrial invertebrates (USEPA, 2007).
(6) Screening benchmarks for plants from ORNL (1997, ES/ER/TM-85/R3).
(7) Screening benchmarks for earthworms from ORNL (1997, ES/ER/TM-126/R2).
(8) EcoSSL (USEPA, 2007) for LMW PAHs and HMW PAHs.
LMW and HMW PAHs based on the number of ring structures (less than 4 rings = LMW; 4 or more rings = HWM).

- National Oceanic and Atmospheric Administration Screening Quick Reference Table (SQuiRT) values (Buchman, 1999).
- Canadian Council of Ministers of the Environment (CCME) Environmental Quality Guideline values (CCME, 2003).
- EcoSSLs for invertebrate or plant toxicity (USEPA, 2008a).
- ORNL Benchmarks for Plants (ORNL, 1997a).
- ORNL Benchmarks for Soil Invertebrates (ORNL, 1997b).

The results of this second weight of evidence screening step are as follows:

- The 1,2,4-trichlorobenzene MDC exceeded the CCME screening value for the protection of agricultural soil. However, as the site is not used for agricultural purposes, the importance of this exceedance is deemed not significant enough to recommend further action at the FLFA.
- The Aroclor-1254 and -1260 MDCs exceeded the two of the three available benchmarks; however, the EPC did not exceed any of the benchmarks. As the EPC is deemed more representative of what a plant or invertebrate community would be exposed to (compared with the MDC), further action to address Aroclors is not recommended for the site.
- The aluminum MDC exceeded the two available benchmark; however, the soil pH at the FLFA is 7.57. USEPA (USEPA, 2008a) recommends that aluminum should only be identified as a COPEC in soils with a pH of less than 5.5. In addition, *Section 7.3* of the EcoSSL guidance (USEPA, 2008a) indicates that at a pH of 5.0 and higher, soluble aluminum does not occur and toxicity associated with aluminum is not expected. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at the FLFA.
- The antimony MDC exceeded two of the available three benchmarks. However, the EcoSSL for direct contact was not exceeded. Based on this finding, further action to address antimony is not recommended for the site.
- The arsenic MDC exceeded all four of the available benchmarks.
- The barium MDC exceeded all three of the available benchmarks.
- The cadmium MDC exceeded two of the four available benchmarks. However, the two benchmarks exceeded are for the protection of agricultural land and for plants. As discussed in *Section 7.7.1*, plant toxicity is not an overriding concern for the site. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at the FLFA.
- The chromium MDC exceeded all of the three available benchmarks for trivalent chromium, and exceeded the one available hexavalent benchmark; however, the EcoSSL guidance (USEPA, 2005b) says that data are insufficient to derive a direct contact benchmark for this inorganic constituent. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at the FLFA.
- The cobalt MDC exceeded all three of the available benchmarks.
- The copper MDC exceeded all four of the available benchmarks.

- The lead MDC exceeded all four of the available benchmarks.
- The manganese MDC exceeded the two available benchmarks from BTAG and ORNL; however, no reference is available to determine the basis or appropriateness of the BTAG value. The ORNL exceedance was for plant toxicity, and as discussed in *Section 7.7.1*, plant toxicity is not an overriding concern for the site. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at the FLFA.
- The mercury MDC exceeded three of the four available benchmarks.
- The nickel MDC exceeded all four of the available benchmarks.
- The selenium MDC exceeded three of the four available benchmarks.
- The silver MDC exceeded two of the three available benchmarks. However, the CCME benchmark exceeded was for the protection of agricultural land, and as the site is not used for this purpose, this exceedance is deemed not relevant. In addition, the ORNL benchmark for plant toxicity is exceeded; however, the EcoSSL plant toxicity benchmark (which is more recent and more accurate) is not exceeded by the MDC. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at the FLFA.
- The vanadium MDC exceeded one of the two available benchmarks; however, the EcoSSL guidance (USEPA, 2005c) says that data are insufficient to derive a direct contact benchmark for this inorganic constituent. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at the site.
- The zinc MDC exceeded all four of the available benchmarks.
- None of other COPECs selected in the first screening step had any benchmark exceedances.

These results suggest that direct contact toxicity in soil are a concern for the following seven COPECs:

- Arsenic
- Barium
- Copper
- Lead
- Nickel
- Selenium
- Zinc

It should also be noted that toxicity to terrestrial invertebrates is assessed indirectly, as terrestrial invertebrates such as earthworms are included in the food-chain models used in the assessments.

7.7.4 Background Metals Considerations

A background evaluation was conducted on the soil analytical results to determine if any inorganic COPEC drivers discussed in the previous sections were potentially related to naturally-occurring soil concentrations. From the Tier 2 LOAEL assessment, there were four inorganic COPEC drivers (chromium, copper, lead, and zinc) with EEQs greater than one for the food chain assessment. COPEC hazard drivers for the direct contact assessment were: arsenic, barium, copper, lead, nickel, selenium, and zinc. Inorganic COPECs that were not statistically different based on appropriate statistical tests are considered background related (see *Section 6.4.2* for details). Based on information presented in **Table 6-3**, arsenic, barium, chromium, copper, lead, nickel, and zinc are direct contact and/or COPECs in FLFA surface soil considered to be potentially site related and not attributed to background.

7.8 Uncertainty Analysis

The results of the SLERA are influenced to some degree by variability and uncertainty. In theory, investigators might reduce variability by increasing sample size of the media or species sampled. Alternatively, 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 null hypothesis) and simultaneously minimizing the likelihood of accepting a true negative (Type II error: the acceptance of a false null hypothesis).

The nickel BAF/BCF for soil to earthworms has been withdrawn by USEPA (2008a) due to a lack of sufficient data to support an uptake factor. Rather than have a data gap, this SLERA used the nickel BAF/BCF values from Sample et al. (1998a, 1999). This is some uncertainty associated with this approach.

The BAF/BCF values used for chromium uptake by earthworms in the current assessment are 11 for the conservative Tier 1 approach and 3.2 for the more realistic Tier 2 approach. An alternative chromium BAF/BCF value may be estimated from data presented in the *SLERA Protocol for Hazardous Waste Combustion Facilities* (USEPA, 1999a). This guidance presents an alternative chromium BAF/BCF of 0.01. The alternative BAF/BCF value for chromium is 1,100-fold and 320-fold lower than the Tier 1 and Tier 2 BAF/BCF values, respectively, used in the current assessment. This would reduce the American robin Tier 2 LOAEL-based chromium EEQ of 3.8 to less than 1.

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. 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.

The copper mammalian TRVs used in this SLERA are based on a 1982 mink study for reproductive effects, with the NOAEL = 11.7 mg/kg-day and the LOAEL = 15.1 mg/kg-day (Sample et al., 1996). It should be noted that the EcoSSL for copper (USEPA, 2008a) recommends and uses a mammalian NOAEL of 5.6 mg/kg-day (based on a 1961 swine study), and the associated LOAEL for the swine study is 9.34 mg/kg-day, both based on survival and growth endpoints. Due to the fact that the mink study is about 20 years more recent than the swine study, reproduction is viewed as an important biological endpoint, and a mink's feeding strategy is closer to our selected receptor species of most concern for copper (the shrew), compared with swine, the Sample et al. (1996) TRVs are retained for use in this SLERA.

There is considerable uncertainty in estimating COPEC concentrations in earthworms from soil, and as this exposure pathway is one of concern for the SLERA EEQs, it is possible the hazards have been overestimated. In particular, earthworm uptake for hexachlorobenzene and hexachlorobutadiene in soil are 149 and 93, respectively, based on a COPEC-specific K_{ow} regression equation (**Appendix F-2, Table F-16**) that may overestimate earthworm tissue concentrations. An overestimate of bioaccumulation is especially likely if soil organic carbon levels are actually greater than 0.374% measured in the one site surface soil sample (LFSB12C). The soil organic carbon in subsurface soil sample LFSB12A was 1.45%, and if this higher carbon concentration was used in the COPEC-specific K_{ow} regression equation for these two organics, the BAFs would drop from 149 to 38, and from 93 to 24, respectively (representing a reduction of about 75%). This in turn would reduce the estimate Tier 2 LOAEL-based EEQs for the shrew from 4.5 to 1.2 for hexachlorobenzene, and from 2.1 to 0.6 for hexachlorobutadiene. Both of these alternative EEQs are less than or equal to 1, when rounded to one significant figure.

There were 102 chemical constituents not detected in surface soil analytical samples. **Appendix F-2, Table F-1** 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 and presented in **Appendix F-2, Table F-2**.

Seventeen of the 102 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 7-10** 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, 1997d).

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% bioavailable.
- Using some laboratory-derived or empirically-estimated partitioning and transfer factors to predict COPEC concentrations in plants, invertebrates, prey species.
- Using toxicity data from laboratory studies not based on a chronic exposure period, and/or without an NOAEL endpoint, thereby requiring the use of large uncertainty factors.
- Use of the HQ method to estimate risks to populations or communities.

Table 7-10
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.
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/or other prey species	Would be costly to implement, but could significantly reduce EEQs.
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.

7.9 SLERA Results and Conclusions

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting the FLFA. 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 7-8**, and direct contact exposure results for terrestrial invertebrates, which may serve as a food source for wildlife are summarized in **Table 7-9** and discussed in *Section 7.7.3.1*.

The Tier 2 LOAEL-based food chain assessment results suggest potential adverse impacts to terrestrial wildlife (driver in parenthesis) such as the short-tailed shrew (copper, lead, hexachlorobenzene, TCDD TE, zinc, hexachlorobutadiene, and Aroclor-1254), American robin (lead, copper, DDT, DDE, zinc, and chromium), and meadow vole (copper, lead, and zinc), via incidental soil ingestion and/or terrestrial invertebrate ingestion, as estimated EEQs were all above 1.

The direct contact assessment results for soil invertebrates suggest that a reduction in wildlife food supply is possible due to the following COPECs in surface soil (arsenic, barium, copper, lead, nickel, and zinc).

Based on the results of the SLERA conducted at the FLFA, further action to address ecological concerns is recommended for surface soil. The recommended further action is to evaluate the residual ecological hazards that are estimated to remain at the site following proposed remedial actions to address human health concerns. It is anticipated that a cleanup to address human health concerns will reduce estimated ecological hazards to a significant degree, such that *additional* cleanup solely for ecological concerns is not warranted (see *Section 8.3.1*). This is predicated on an assumption that many ecological and human health COPECs/COPCs are collocated in soil at the site, and that the small size of the site (0.78 acres), even with some residual ecological hazard, is unlikely to have a significant ecological impact on wildlife populations.

The assessment results may serve as the foci of discussions with risk managers and regulatory agencies. 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 section 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. For the purpose of developing the CMOs, a COI is defined as a constituent that is present at concentrations corresponding to a cancer risk above a cancer risk of 1E-06 and/or an HI of 1.

8.1 Summary of Chemicals of Interest

The HHRA (*Section 6.0*) identified three COIs in soil (arsenic, lead, and dioxins/furans as TCDD TE) under an industrial future-use scenario and four COIs in soil (lead, copper, dioxins/furans as TCDD TE, and Aroclor-1254) under a residential future-use scenario. In addition, arsenic, thallium, and vanadium were selected as COIs for total soil under a residential scenario but were determined to be within background.

For groundwater, the HHRA selected PCE, chloroform, and vanadium as COIs for a residential and/or industrial future-use scenario. However, chloroform and PCE were not detected in the on-site well (LFMW01) and are present in upgradient wells from the FLFA, indicating that the FLFA is not the source of these constituents in groundwater. In addition, the low level chloroform detections (below MCL) are attributable to leaking potable water supply lines throughout the installation. Chloroform has also been detected at other sites downgradient from water supply lines at similar concentrations (Area O, for example). PCE was only detected in a single well (17MW-2), and the concentration was below its MCL. Based on the limited detections and low concentrations, additional groundwater investigation or remediation is not warranted at this site. For vanadium, a groundwater background concentration has not been established at RFAAP. Given the natural fluctuations observed in vanadium concentrations in soil in this region, the concentrations observed in groundwater samples from the FLFA are not considered to be anthropogenic. Therefore, CMOs for groundwater were not developed and these analytes are not discussed further in the CMS.

The SLERA (*Section 7.0*) identified thirteen COIs (arsenic, barium, copper, chromium, lead, nickel, zinc, Aroclor-1254, DDE, DDT, hexachlorobenzene, hexachlorobutadiene, and TCDD TE), but concluded that remedial measures to address human health COIs would likely be protective of ecological concerns because the majority of the constituents are collocated and due to the small size of the site (0.78 acres). The SLERA recommends that a residual risk calculation (*Section 8.2.1*) be performed for ecological concerns. 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 (RGs) were developed for arsenic, lead, copper, dioxins/furans, and Aroclor-1254.

8.2 Remedial Goals

Preliminary remedial goals (PRGs) were obtained from USEPA 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 RG for the analyte. The future land use identified for the FLFA study area is industrial. Future residential land use at the FLFA is highly unlikely due to its location within the installation and its topography. 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, 1998b, 2003c), Aroclor-1254 (USEPA, 1998c), and dioxins/furans (USEPA, 1998b) 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.

- Aroclor-1254:
    - Industrial: High Occupancy Area = 1 mg/kg
    - Residential: High Occupancy Area = 1 mg/kg

Background is not applicable to organic compounds. Cleanup requirements are based on whether the area is classified as high occupancy or low occupancy. As defined in 40 CFR 761.3, a High Occupancy Area is any area where PCB remediation waste has been disposed of on site and where occupancy for any individual not wearing dermal and respiratory protection for a calendar year is an average of 16.8 hours or more per week for non-porous surfaces and an average of 6.7 hours or more per week for bulk PCB remediation wastes. Since the future industrial land use scenario identified for the FLFA meets the definition of a high occupancy area, the industrial RG for PCBs at FLFA is 1 mg/kg for both surface and total soil. Although future land use at FLFA is unlikely to be residential, the residential RG for PCBs is also 1 mg/kg for total soil.

- 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 copper, RGs for arsenic and copper 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 copper in soil at the FLFA. The RG for arsenic in surface soil (18 mg/kg) has been based on a risk of 1E-05, which is the midpoint of USEPA's acceptable range of $1x10^{-4}$ to $1x10^{-6}$ for carcinogens and slightly above the 95% UTL for arsenic. Because copper was the only RG in total soil for which an RG was calculated, the (2,890 mg/kg) is based on an HI of 1.

Table 8-1
Identification of Remedial Goals for Arsenic and Copper in FLFA 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 Soil	Maintenance Worker	79	15.8	18	---*
	Surface Soil	Industrial Worker	18	15.8		
Residential Scenarios						
Copper	Total Soil	Child Resident	2890	53.5	---*	2890

*Arsenic is a COI only under the industrial scenario. Copper is a COI only under the residential scenario.

Details on the methodology used to calculate the RGs for arsenic and copper are presented in **Appendix G-2**.

8.2.1 Residual Ecological Hazards

As mentioned in *Section 7.0*, ecological EEQs estimated for several metals and some organics, including TCDD, in soil were found to be elevated. Specifically, wildlife receptors potentially at risk included the short-tailed shrew (for copper, lead, hexachlorobenzene, TCDD TE, zinc, hexachlorobutadiene, and Aroclor-1254), the American robin (for lead, copper, DDT, DDE, zinc, and chromium), and the meadow vole (for copper, lead, and zinc). The direct contact assessment results for soil invertebrates and plants suggested that a reduction in wildlife food supply is possible due to the following metals in surface soil: arsenic, barium, copper, lead, nickel, and zinc.

These ecological hazard 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 human health COPECs 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. The receptors with the highest (i.e., “critical”) EEQ or HQ value from the SLERA are shown in the table. Estimated post-remediation residual concentrations are based on the EPC for samples in areas not proposed for remediation; revised EEQ or HQ 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, or HQs based on the most conservative direct contact screening value, are obtained.

- FLFA residual surface soil concentrations, using the selected land use scenario for human health cleanup, result in predicted EEQ or HQ percent reductions that range from 0% (for hexachlorobutadiene) to 99% (for copper and DDE).
- Scaled food-chain EEQs or direct contact HQs are less than or equal to 1 when rounded to one significant figure for arsenic, (0.6), barium (0.6), chromium (1.1), lead (0.4),

Table 8-2
Ecological Implications of Human Health Soil RGs on Ecological Receptors

Chemical[a]	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]
Arsenic	18	5.7	1.4 Plant	14	0.6	59%
Barium	-	193	5.7 Earthworm	1,877	0.6	90%
Copper	2,890	107	191 Shrew	10,600	1.9	99%
Chromium [g]	-	34	3.8 Robin	117	1.1	71%
Lead	400	162	22 Robin	8,973	0.4	98%
Nickel	-	19	3.5 Plant	106	0.6	82%
Zinc	-	194	5 Robin	7,442	0.1	97%
Aroclor-1254	1.0 (surface)	0.23	1.6 Shrew	0.49	0.8	53%
DDE	-	0.00042	5.7 Robin	0.049	0.05	99%
DDT	-	0.015	6.6 Robin	0.083	1.2	82%
Hexachlorobenzene [g]	-	NA	4.5 Shrew	0.02	NA	NA
Hexachlorobutadiene [g, h]	-	0.052	2.1 Shrew	0.052	2.1	0%
TCDD TE	1.0E-3	1.58E-6	4.5 Shrew	1.98E-5	0.4	92%

[a] Chemicals shown are those having the highest ecological EEQ values in the SLERA (*Section 7.0*). Human health chemicals of concern 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 EPC 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 or direct contact HQ among receptors evaluated in the SLERA.

[d] Value shown is from the SLERA (i.e., the 95% UCL EPC for surface soil).

[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, or, for the direct contact pathway, by using the HQ.

[g] These three COPECs were determined to have EEQs less than 1 when alternative toxicity and/or bioaccumulation values were considered in the uncertainty section of the SLERA (*Section 7.8*).

[h] No change in residual concentration, as no "hot-spot" locations targeted for removal.

Notes:

HQ = Hazard quotient from SLERA (for direct contact pathway)

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 (for food-chain pathway)

LOAEL = Lowest-Observed-Adverse-Effect Level

NA = Not Applicable; All samples with hexachlorobenzene are expected to be removed; therefore, no EPC could be calculated.

RG = Remedial Goal

nickel (0.6), zinc (0.1), Aroclor-1254 (0.8), DDE (0.05), DDT (1.2), and TCDD TE (0.4) (**Table 8-2**).

- For the shrew, the estimated residual concentration of copper in surface soil is expected to reduce this receptors' EEQ from 191 to 1.9, or by 99%. This percentage reduction is considered significant.
- Although the hexachlorobutadiene EEQ for the shrew remains at 2.1 (as the sample location with the maximum concentration of hexachlorobutadiene was not contained in the proposed excavation footprint) the biological significance of this finding is minimal. This is because, as discussed in the SLERA uncertainty section (*Section 7.8*), use of an alternative hexachlorobutadiene BAF for soil to invertebrates is expected to result in an EEQ less than 1 for the shrew based on an expected higher TOC concentration in soil.

While the food-chain hazard-driver copper is still estimated to have a potential EEQ greater than 1.0, this finding is not considered significant for the following reasons:

- The estimated ecological hazards in **Table 8-2** (including copper) incorporate additional safety factors, such as the use of an 8-fold modifying factor to account for species-to-species extrapolation.
- 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 of 1 or lower 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, given the reasons presented above, the proposed human health RGs in **Table 8-1** are expected to result in residual COPEC concentrations in surface soil that are protective of the environment.

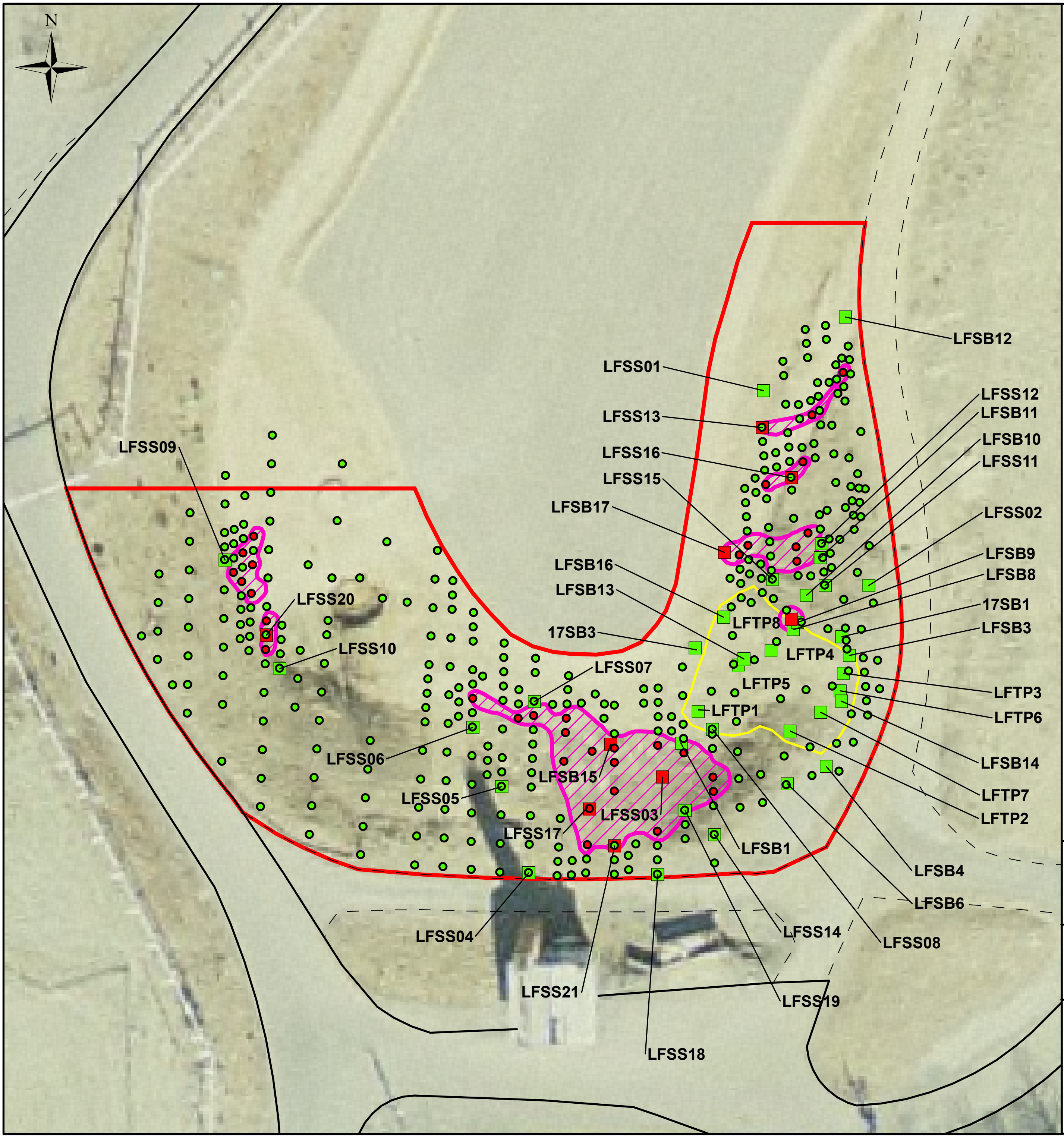
8.3 Site-Specific Corrective Measures Objectives

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, contaminants in impacted soil in the study area are 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 above residential use scenarios, but below the CMOs of industrial/commercial use. 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 closure; therefore, a discussion of whether the proposed alternatives protect residential receptors is presented in the evaluation of alternatives. Clean closure has cost advantages over waste in place closure 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 FLFA soil investigations indicate that lead, arsenic, and dioxin/furans are present in surface soil at concentrations exceeding the Industrial RG (see **Figure 8-1**). No COIs were detected above the Industrial RG at depths greater than 0.5 ft bgs, with the exception of one soil sample. One soil sample in the area near the 1998 RFI Soil Excavation Area (LFTP8 at a depth of 5-6 ft) exceeded the Industrial RG for lead. Therefore, it was assumed that additional excavation at depth to 7 ft bgs was required to reduce contaminant concentrations to Industrial RGs. The calculated area of contamination (2,972 ft^2), presented as **Figure 8-1**, most likely defines the limit of contamination. This area consists of three general locations near the former FLFA structure and SWMU 17A that are within the defined FLFA boundary. The depth of soil to be removed to reduce the contaminant concentrations to less than their respective Industrial RGs was assumed to be 1.5 ft bgs, with the exception of the one location near the former excavation area. Based on the assumed area and depth of contamination, the total estimated volume of contaminated soil is 166 yd^3.

The results of the FLFA soil investigations indicate that lead, copper, dioxins/furans, and Aroclor-1254 are present in surface soil at concentrations exceeding the Residential RG (see **Figure 8-2**). However, due to the fact that future land use at the FLFA is unknown; arsenic levels must be cleaned to their respective Industrial RG (18 mg/kg). The area and volume of contamination for clean closure (i.e., exceeding the Residential RG) was similarly calculated. One soil sample in the area near the 1998 RFI soil excavation area (LFTP8 at a depth of 5-6 ft) exceeded the Residential RG for lead. Therefore, it was assumed that additional excavation at depth to 7 ft bgs was required to reduce contaminant concentrations to Residential RGs. It should be noted that there is one location in close proximity to the FLFA where Aroclor-1248 was detected at depth above the Residential High Occupancy Level but below the Residential Low Occupancy Level. Based on the depth of the detection (5.5-7.0 ft bgs), the low occupancy level was determined to be appropriate (40 CFR 761). Therefore, the total area of soil contamination, also presented on **Figure 8-2**, is estimated as 6,790 ft^2. The depth of contamination was assumed to be 1.5 ft bgs (with the exception of the one location near the former excavation area); therefore, the estimated volume of soil exceeding the Residential RGs is 379 yd^3.



ArcGIS File: RFAAP_Fig8-1_FLFA_COI_Indus_Soil_Results.mxd (1/29/2008 11:17:57 AM)

LEGEND

●	Sample Location (XRF Lead Result Below Industrial Remedial Goal)
●	Sample Location (XRF Lead Result Above Industrial Remedial Goal)
🟩	Sample Location (Contaminants of Interest Below Industrial Remedial Goal)
🟥	Sample Location (Contaminants of Interest Above Industrial Remedial Goal)
- - -	Dirt Road
―	Paved Road
▨	Industrial Remedial Goal Excavation Area
☐	1998 RFI Soil Excavation Area
☐	Former Lead Furnace Area Boundary

Notes:
1) Aerial photo, dated 25 May 2000, was obtained from the Army Topographic Engineering Center.

Scale:
0 25 50 100
Feet

U.S. Army Corps of Engineers

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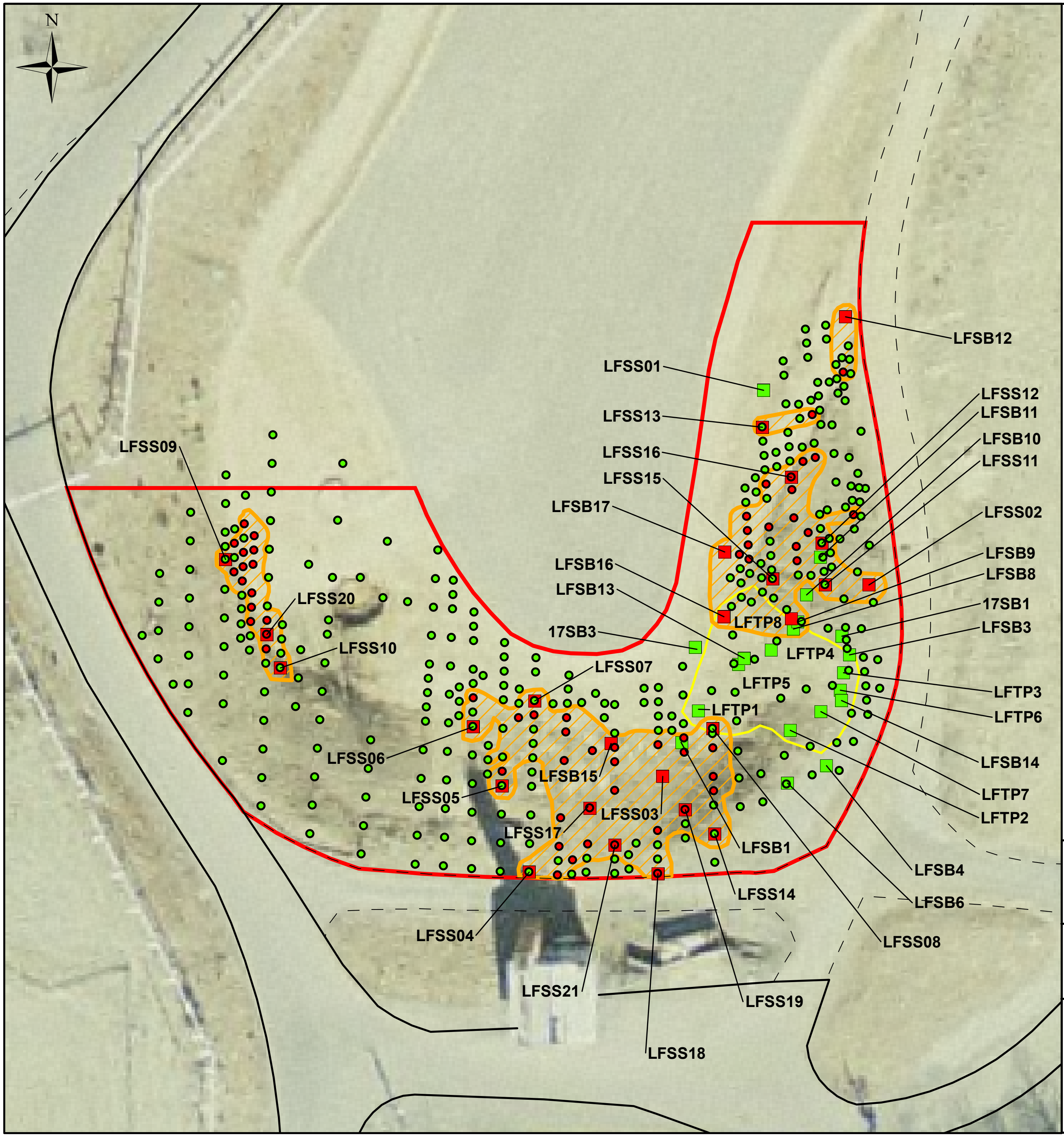
FIGURE 8-1
Former Lead Furnace Area
Area of Soil Contamination
Above Industrial Remedial Goals

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: RFAAP_Fig8-2_FLFA_COI_Res_Soil_Results.mxd (1/29/2008 11:01:18 AM)



LEGEND

● Sample Location (XRF Lead Result Below Residential Remedial Goal)

● Sample Location (XRF Lead Result Above Residential Remedial Goal)

🟩 Sample Location (Contaminants of Interest Below Residential Remedial Goal)

🟥 Sample Location (Contaminants of Interest Above Residential Remedial Goal)

– – – Dirt Road

— Paved Road

▨ Residential Remedial Goal Excavation Area

☐ 1998 RFI Soil Excavation Area

☐ Former Lead Furnace Area Boundary

Notes:
1) Aerial photo, dated 25 May 2000, was obtained from the Army Topographic Engineering Center.

Scale:
0 25 50 100
Feet

U.S. Army Corps of Engineers

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FIGURE 8-2
Former Lead Furnace Area
Area of Soil Contamination
Above Residential Remedial Goals

Radford Army Ammunition Plant,
Radford, VA

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 the FLFA, 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 SWMU 17A. Therefore, technologies that require extensive on-site management/testing are not implementable.

The following four corrective measure alternatives were developed for the FLFA 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 (Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring)
- Alternative Three: Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring)
- Alternative Four: Excavation of Soil for Clean Closure (Residential Use) 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 (Industrial/Commercial Use Scenario 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.

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**.

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 burn pad located near the area).

Table 9-1
Cost for Alternative Two: Institutional Controls (Industrial/Commercial Use Scenario 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
Subtotal				**$6,000.00**
		SUBTOTAL		**$6,000.00**
		SUPERVISION AND ADMIN @ 8%		$480.00
		CONTINGENCY @ 30%		$1,800.00
TOTAL CAPITAL COSTS				**$8,280.00**
O&M COSTS				
Administrative Actions[1]				
Periodic Reviews	Report	$30,000	0.2	$6,000
Institutional Controls/Oversight	Lump Sum	$5,000	0.2	$1,000
Subtotal				**$7,000.00**
Long-Term Maintenance				
Semi Annual Analyses[2]	Sample	$991	18	$17,838
Sample Labor, Preparation, Reporting	Episode	$8,000	2	$16,000
Maintenance of Fence/Warning Signs	Lump Sum	$200	1	$200
Subtotal				**$34,038.00**
		SUBTOTAL (ANNUALLY)		**$41,038.00**
		CONTINGENCY @ 30%		$12,311.40
		TOTAL ANNUAL O&M COSTS		**$53,349.40**
PRESENT WORTH (30 YEARS AT 5%)				**$828,391.04**

[1] Costs assigned on a annual basis

[2] Two sampling events per year with analysis for arsenic, lead, vanadium, and dioxin/furans 7 samples + 1 dup + 1 rinse blank)

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 the FLFA 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 seven existing monitoring wells (LFMW01, 17MW2, 17PZ1, 40MW6, 40MW5, 40MW3, and 17MW3) displayed on **Figure 2-7**. The rationale as to the selection of these monitoring wells is as follows:

- Wells 17PZ1 and 17MW2 are located hydraulically upgradient of the contaminated soil. These wells would be used to monitor changes in background conditions at the site.
- Well LFMW01 is screened in the aquifer beneath of the contaminated soil source area. This well would be used to monitor migration of contaminants from soil to groundwater in the source area.
- Wells 40MW5 and 40MW5 are located hydraulically downgradient of the contaminated soil. These wells would be used to monitor for contaminants downgradient of the source area.
- Wells 17MW3 and 40MW3 are located hydraulically crossgradient of the contaminated soil source. These wells would be used to monitor for contaminants crossgradient of the source area.

The wells would be sampled twice a year for arsenic, lead, copper, dioxins/furans, and Aroclor-1254. A monitoring plan would be developed which would detail the sampling of these wells. Seven groundwater samples, one duplicate sample, and one rinse blank would be collected biannually for a period of 30 years. If the sampling indicates that groundwater quality has been impacted, evaluation of additional corrective measures may 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 (Industrial/Commercial Use Scenario 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 off-site landfill for disposal. Depending upon the waste characterization results (e.g., TCLP, RCRA waste characteristics), the material will be transported off site to either a hazardous waste or solid waste landfill. Seven samples (17SB1, 17SB1, 17SB2, 17SB2, 17SB3, 17SB3, and LFSB8A) were analyzed for TCLP metals during the 1992 VI and 1998 RFI (ICF KE). TCLP results (**Table 2-2 and Table 2-6c**) indicated that lead was detected at concentrations below the TCLPRL with the exception of samples collected from boring 17SB2. Boring 17SB2 was advanced within the 1998 RFI excavation area. Since that area was excavated and replaced with clean fill, 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 166 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 233 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 above the CMO (industrial/commercial); therefore, clean closure will not be achieved and land use controls will be required to prevent the property from being used for activities other than those to support the current Army mission. In addition, soil sampling will be performed every 5 years to demonstrate that conditions at the site have not changed.

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, 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 250-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 for containment purposes. This decontamination station should be bermed to ensure containment of decontamination liquids.
- A 250-gallon tank will be used throughout the duration of the corrective measure activities to store water for use in the decontamination station.

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 on **Figure 8-1** where contamination was previously determined to be above RGs. The entire area will be delineated to assess the area that needs remediation. Fixed-based laboratory samples will be collected and analyzed to vertically and horizontally delineate the contamination at the site. A grid sampling program will be developed around the areas where these analytes were detected above RGs during the previous sampling events. For the purpose of this study, it is assumed that surface soil samples would be collected from a total of 71 locations and analyzed for arsenic and lead. Lead is the most widespread COI at the site and its presence will be used as a marker for the organic constituents (dioxins/furans). Details on sample locations, sample depths, etc. will be developed during the work planning phase.

Table 9-2
Cost for Alternative Three: Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring)

ITEM	UNITS	UNIT COST	NUMBER	TOTAL
CAPITAL COSTS[1]				
Reporting/Workplans				
Health and Safety Plan	Report	$8,000.00	1	$8,000.00
Quality Assurance Project Plan	Report	$8,000.00	1	$8,000.00
Work Plan	Report	$15,000.00	1	$15,000.00
Corrective Measures Summary Report	Report	$20,000.00	1	$20,000.00
Subtotal				**$51,000.00**
Site Set-Up				
250-gallon Storage Tank	Lump Sum	$300.00	1	$300.00
Decontamination Pad	Site	$1,500.00	1	$1,500.00
Subtotal				**$1,800.00**
Contamination Delineation				
Chemist (Mid)	Hour	$72.42	100	$7,242.00
Laborer (Field Sampling Tech Mid)	Hour	$35.75	100	$3,575.00
Per Diem	Day	$131.00	20	$2,620.00
Off-Site Laboratory (arsenic, lead)	Sample	$121.00	71	$8,591.00
Off-Site Laboratory (dioxins/furans)	Sample	$870.00	24	$20,880.00
Rental Truck	Week	$363.00	2	$726.00
Subtotal				**$43,634.00**
Health and Safety				
Site Health and Safety Officer/QC (Mid)	Hour	$89.65	70	$6,275.50
Subtotal				**$6,275.50**
Excavation				
Project Chemist (1)	Hour	$72.42	70	$5,069.40
Field Supervisor (1)	Hour	$68.58	70	$4,800.60
Field Technician (1)	Hour	$35.75	70	$2,502.50
Equipment Operators (1)	Hour	$33.33	70	$2,333.10
Project Manager (1)	Hour	$124.75	40	$4,990.00
Per Diem[2]	Day	$131.00	49	$6,419.00
3 CY Trackhoe (includes mob/demob)	Week	$650.38	2	$1,300.76
3 CY Front End Loader (includes mob/demob)	Week	$1,174.88	2	$2,349.76
Water Truck (includes mob/demob)	Month	$1,940.65	1	$1,940.65
Rental Truck (3)	Week	$1,089.00	2	$2,178.00
Subtotal				**$33,883.77**
Confirmational Sampling				
Off-Site Laboratory (arsenic, lead)	Sample	$121.00	15	$1,815.00
Off-Site Laboratory (dioxins/furans)	Sample	$870.00	5	$4,350.00
Project Chemist (1)	Hour	$51.34	9	$462.06
Subtotal				**$6,627.06**
Waste Characterization				
Off-Site Lab Analytical (TCLP metals, RCRA Char, Dioxin/Furans, PCBs)	Sample	$1,129.00	2	$2,258.00
Decon Water Sample (TAL metals, COD, pH)	Sample	$156.50	1	$156.50
Subtotal				**$2,414.50**
Waste Transportation/Disposal				
Non-Hazardous Waste Transportation/Disposal	Ton	$50.00	233	$11,650.00
Subtotal				**$11,650.00**
Site Restoration				
Seeding, Vegetative Cover	Acre	$3,528.00	0.15	$529.20
Survey Equipment/Team	Lump Sum	$1,500.00	1.0	$1,500.00
Subtotal				**$2,029.20**
		SUBTOTAL		**$159,314.03**
		SUPERVISION AND ADMIN @ 8%		$12,745.12
		CONTINGENCY @ 30%		$47,794.21
TOTAL CAPITAL COSTS				**$219,853.36**
O&M COSTS				
Administrative Actions[3]				
Periodic Reviews	Report	$30,000	0.2	$6,000
Institutional Controls/Oversight	Lump Sum	$5,000	0.2	$1,000
Subtotal				**$7,000.00**
Long-Term Maintenance				
Semi Annual Analyses[4]	Sample	$768	18	$13,824
Sample Labor, Preparation, Reporting	Episode	$8,000	2	$16,000
Subtotal				**$29,824.00**
		SUBTOTAL (ANNUALLY)		**$36,824.00**
		CONTINGENCY @ 30%		$11,047.20
		TOTAL ANNUAL O&M COSTS		**$47,871.20**
PRESENT WORTH (30 YEARS AT 5%)				**$955,751.04**

[1] The estimated length of time is as follows: delineation 10 days, mobilization/site set-up 2 days, excavation 2 days, site restoration 1 days, confirmation 1 day, decon/demob 3 days

[2] Per diem costs for 9 days for H&S/QC officer, field super, field tech, project chemist, and equipment operator, 4 days for PM

[3] Costs assigned on a annual basis

[4] Two sampling events per year with analysis for arsenic, lead, vanadium, and dioxin/furans (7 samples + 1 dup + 1 rinse blank)

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 personal protective equipment 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. 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. A front-end loader (3-yd^3 bucket) will then be used to load the soil into tri-axle dump trucks. Excavated soil will be loaded and hauled off site the same day it is excavated, so that there will be no stockpiling of soil at the site. 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 SWMU 17A 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 2 days. A water truck will be required on site during excavation activities for dust suppression purposes. Oversight personnel assumed for this alternative include one health and safety/QC officer, one field supervisor, one chemist, one field technician, one equipment operator, 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 15 samples will be collected from the bottom and sides of the excavation areas and sent to an off-site laboratory for arsenic, copper, and lead. Lead is the most widespread COI and its removal will indicate the removal of secondary COIs (dioxins/furans). Thirty-three percent of the confirmation samples will be analyzed for these COIs to ensure that they have also been removed.

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 per 1,000 cubic yards of soil; therefore, it is assumed that one composite sample will be collected from the excavated materials to assess whether the soil is a hazardous waste. In addition, investigation-derived media will be sampled prior to disposal for RCRA waste characteristics.

Waste Transportation and Disposal. Corrective measure activities are expected to generate approximately 233 tons of non-hazardous soil and 250 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 capacity to accommodate incoming waste.
- Solicitation of bids using applicable Federal Acquisition Regulations.
- Verification of permits and insurance (at time of award).
- 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 Capitol 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 areas will be regraded, seeded, and a vegetative cover will be added. Erosion control measures will be implemented. Upon completion of site restoration operations, the contractor will remove any 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 an active burn pad 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 the FLFA 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 seven existing monitoring wells (LFMW01, 17MW2, 17PZ1, 40MW6, 40MW5, 40MW3, and 17MW3) displayed on **Figure 2-7**. The rationale as to the selection of these monitoring wells is as follows:

- Wells 17PZ1 and 17MW2 are located hydraulically upgradient of the contaminated soil. These wells would be used to monitor changes in background conditions at the site.
- Well LFMW01 is screened in the aquifer beneath of the contaminated soil source area. This well would be used to monitor migration of contaminants from soil to groundwater in the source area.
- Wells 40MW5 and 40MW5 are located hydraulically downgradient of the contaminated soil. These wells would be used to monitor for contaminants downgradient of the source area.
- Wells 17MW3 and 40MW3 are located hydraulically crossgradient of the contaminated soil source. These wells would be used to monitor for contaminants crossgradient of the source area.

The wells would be sampled twice a year for arsenic, lead, copper, dioxins/furans, and Aroclor-1254. A monitoring plan would be developed which would detail the sampling of these wells. Seven groundwater samples, one duplicate sample, and one rinse blank would be collected biannually for a period of 30 years. If the sampling indicates that groundwater quality has been impacted, evaluation of additional corrective measures may 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.

9.4 Alternative Four – Excavation of Soil for Clean Closure (Residential Use) and Off-site Disposal

This alternative involves excavation of soil containing concentrations of COIs above the CMO (see *Section 8.0*) to facilitate clean closure of the FLFA study area. The estimated area to be excavated is presented on **Figure 8-2**, as the area containing COIs above the Residential RG. Alternative Four includes the cost items (up to site restoration) discussed in Alternative Three (*Section 8.3*) above, with longer durations for the additional volume of soil to be excavated.

Since the Residential COIs for the FLFA are different than the Industrial, delineation and confirmation samples will be analyzed for the Residential COIs (lead, copper, dioxins/furans, and Aroclor-1254) as well as arsenic, an additional industrial COI. Once soil containing COIs at concentrations exceeding the RGs are removed, clean closure of the site will be achieved and land use controls, long-term monitoring, and the 5-year sampling/reporting is not required.

The estimated volume of the materials to be excavated is 379 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 530 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 (**Table 2-2 and Table 2-6c**), it was assumed that the materials present are non-hazardous and will be disposed in a RCRA Subtitle D Landfill.

The costs for Alternative Four are presented in **Table 9-3**.

Table 9-3
Cost for Alternative Four: Excavation of Soil for Clean Closure (Residential Use) and Off-site Disposal

ITEM	UNITS	UNIT COST	NUMBER	TOTAL
CAPITAL COSTS[1]				
Reporting/Workplans				
Health and Safety Plan	Report	$8,000.00	1	$8,000.00
Quality Assurance Project Plan	Report	$8,000.00	1	$8,000.00
Work Plan	Report	$15,000.00	1	$15,000.00
Corrective Measures Summary Report	Report	$20,000.00	1	$20,000.00
Subtotal				**$51,000.00**
Site Set-Up				
250-gallon Storage Tank	Lump Sum	$300.00	1	$300.00
Decontamination Pad	Site	$1,500.00	1	$1,500.00
Subtotal				**$1,800.00**
Contamination Delineation				
Chemist (Mid)	Hour	$72.42	100	$7,242.00
Laborer (Field Sampling Tech Mid)	Hour	$35.75	100	$3,575.00
Per Diem	Day	$131.00	20	$2,620.00
Off-Site Laboratory (arsenic, lead, copper, PCBs)	Sample	$187.00	71	$13,277.00
Off-Site Laboratory (dioxins/furans)	Sample	$870.00	24	$20,880.00
Rental Truck	Week	$363.00	2	$726.00
Subtotal				**$48,320.00**
Health and Safety				
Site Health and Safety Officer/QC (Mid)	Hour	$89.65	80	$7,172.00
Subtotal				**$7,172.00**
Excavation				
Project Chemist (1)	Hour	$72.42	80	$5,793.60
Field Supervisor (1)	Hour	$68.58	80	$5,486.40
Field Technician (1)	Hour	$35.75	80	$2,860.00
Equipment Operators (1)	Hour	$33.33	80	$2,666.40
Project Manager (1)	Hour	$124.75	40	$4,990.00
Per Diem[2]	Day	$131.00	54	$7,074.00
3 CY Trackhoe (includes mob/demob)	Week	$650.38	2	$1,300.76
3 CY Front End Loader (includes mob/demob)	Week	$1,174.88	2	$2,349.76
Water Truck (includes mob/demob)	Week	$650.38	2	$1,300.76
Rental Truck (3)	Week	$1,089.00	2	$2,178.00
Subtotal				**$35,999.68**
Confirmational Sampling				
Off-Site Laboratory (arsenic, lead, copper, PCBs)	Sample	$187.00	15	$2,805.00
Off-Site Laboratory (dioxins/furans)	Sample	$870.00	5	$4,350.00
Project Chemist (1)	Hour	$51.34	9	$462.06
Subtotal				**$7,617.06**
Waste Characterization				
Off-Site Lab Analytical (TCLP metals, RCRA Char, Dioxin/Furans, PCBs)	Sample	$1,129.00	3	$3,387.00
Decon Water Sample (TAL metals, COD, pH)	Sample	$156.50	1	$156.50
Subtotal				**$3,543.50**
Waste Transportation/Disposal				
Non-Hazardous Waste Transportation/Disposal	Ton	$50.00	530	$26,500.00
Subtotal				**$26,500.00**
Site Restoration				
Seeding, Vegetative Cover	Acre	$3,528.00	0.2	$705.60
Survey Equipment/Team	Lump Sum	$1,500.00	1.0	$1,500.00
Subtotal				**$2,205.60**
		SUBTOTAL		**$184,157.84**
		SUPERVISION AND ADMIN @ 8%		$14,732.63
		CONTINGENCY @ 30%		$55,247.35
TOTAL CAPITAL COSTS				**$254,137.82**
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%)				**$254,137.82**

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[1] The estimated length of time is as follows: delineation 10 days, mobilization/site set-up 2 days, excavation 3 days, site restoration 2 days, confirmation 1 day, decon/demob 3 days

[2] Per diem costs for 10 days for H&S/QC officer, site super, field techs, and equipment operators, 4 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.
- 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.
- 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% to minus 30%). 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.
- 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 with COI 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 the FLFA, it allows the site to be closed without use restrictions. In addition, as discussed in *Section 7.2.1*, 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 closure 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 National Environmental Policy Act 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, 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 both the Industrial and Residential RGs (lead, copper, arsenic, dioxins/furans, and Aroclor-1254), 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 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 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
FLFA 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 (Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring)	$8,280	$53,350	$820,111	$828,391
3 – Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls	$219,853	$47,871	$735,898	$955,751
4 – Excavation of Soil for Clean Closure (Residential Use) and Off-site Disposal	$254,137	$0	$0	$254,137

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. The 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 RGs protective of ecological receptors are not required, as the application of alternative (as opposed to worse-case) toxicity and BAFs 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*).

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 Closure (Residential Use) and Off-site Disposal is the selected corrective measure alternative for the FLFA.

Table 11-1
Ranking Assessment of Corrective Measures Alternatives

Alternative	Effectiveness	Implementability	Cost (30-year 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 (Industrial/Commercial Use Scenario 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	$828,391 2 1X 2	18
Alternative 3 – Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Industrial/Commercial Use Scenario 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	$955,751 1 1X 1	23
Alternative 4 – Excavation of Soil for Clean Closure (Residential Use) and Off-site Disposal	Contaminant concentrations above the Residential RG would be removed from the site facilitating clean closure. 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	$254,137 4 1X 4	29

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 FLFA RFI/CMS identified three COIs (lead, copper, and dioxins/furans as TCDD TE) for the industrial future-use scenario and five COIs (arsenic, copper, lead, Aroclor-1254, and dioxins/furans as TCDD TE) for the residential future-use scenario as being a potential concern to human health and the environment (see *Section 6.0*). The CMO for the FLFA 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 closure 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 (Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring)
- Alternative Three: Excavation of Soil with Waste in Place, Off-site Disposal, and Institutional Controls (Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring)
- Alternative Four: Excavation of Soil for Clean Closure (Residential Use) 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 the FLFA 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 closure. By achieving clean closure, Alternative Four exceeds the CMO for this RFI/CMS. 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 1 year. This timeframe 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, copper, lead, Aroclor-1254, 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.
- Site restoration activities.

Implementation of this alternative will reduce the concentrations of COIs to levels below the Residential RGs and facilitate clean closure of the site. In addition, implementation of this alternative meets the corrective action objective and is protective of human health and the environment.

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The appendices for this report are included on a CD following this page.