

# **RADFORD ARMY AMMUNITION PLANT, VIRGINIA**

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## **SWMU 51 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**

**July 2008**



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



received  
10-16-08

08-104

October 16, 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.  
Solid Waste Management Unit (SWMU) 51  
Review of the Army's RCRA Facility Investigation (RFI) / Corrective Measures Study (CMS)  
Report

Dear Mr. McKenna and Ms. Holt:

The U.S. Environmental Protection Agency (EPA) has reviewed the U.S. Army's (Army's) August, 2008 Final RFI/CMS Report for SWMU 51, located at the Radford Army Ammunition Plant (RFAAP). 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





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

www.atk.com

October 16, 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,  
Revised Section 9 for SWMU 51 RCRA Facility Investigation/Corrective Measures Study Report,  
Final Document, July  
EPA ID# VA1 210020730

Dear Mr. Geiger and Mr. Cutler:

Enclosed is the certification for the revised Section 9 that was sent to you on October 14, 2008. Please replace the entire section. The replacement section is provided per attached emails dated October 6, 2008 and October 1, 2008 from EPA and DEQ respectively.

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) 731-5782.

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

Rich Mendoza  
U.S. Army Environmental Command  
1 Rock Island Arsenal  
Bldg 90, 3<sup>rd</sup> 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

Concerning the following:

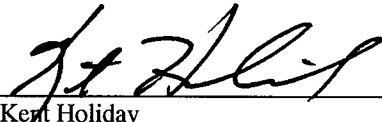
Radford Army Ammunition Plant  
Revised Section 9 for SWMU 51 RCRA Facility Investigation/Corrective Measures Study  
Report,  
Final Document, July 2008

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:  
TITLE:

  
Jon R. Drushal  
Lieutenant Colonel, US Army  
Commanding

SIGNATURE:  
PRINTED NAME:  
TITLE:

  
Kent Holiday  
Vice President and General Manager  
ATK Energetics Systems

## Greene, Anne

---

**From:** McKenna, Jim  
**Sent:** Tuesday, October 14, 2008 4:13 PM  
**To:** Greene, Anne; ealohman@deq.virginia.gov; dennis.druck@us.army.mil; diane.wisbeck@arcadis-us.com; durwood willis2; Geiger.William@epamail.epa.gov; Redder, Jerome; jim spencer; jlcutler@deq.virginia.gov; Llewellyn, Tim; Mendoza, Richard R Mr CIV USA IMCOM; Parks, Jeffrey N; Timothy.Leahy@shawgrp.com; Tina\_Devine@URSCorp.com; Tom.Meyer@nab02.usace.army.mil  
**Subject:** RE: Page changes for SWMU 51 Final RFI/CMS (UNCLASSIFIED)  
**Importance:** High

**Classification:** UNCLASSIFIED  
**Caveats:** NONE

All:

Note the contractor will ship the revised pages from the subject document with a copy of this email to the POCs and tracking numbers below. Please replace the entire Section 9 in the August 2008 Final version of the SWMU 51 RFI/CMS with the enclosed replacement pages. The revised Section 9 incorporates changes to Section 9.3 resulting from the discussion in the June 2008 EPA/VDEQ/RFAAP partnering meeting. Once the revised pages are approve, the electronic document (with revised pages and the approval letter) can be sent out.

Certification letter will follow from Radford AAP under separate cover.

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

Jim McKenna

540 731 5782

Immediately below are the POCs with tracking numbers:

Will Geiger - 1Z63V8840190570914

Jim Cutler - 1Z63V8840193588525

Rich Mendoza - 1Z63V8840193824304

Tom Meyer - 1Z63V8840190248693

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<http://www.shawgrp.com>

Classification: UNCLASSIFIED

Caveats: NONE

## Greene, Anne

---

**From:** Geiger.William@epamail.epa.gov  
**Sent:** Monday, October 06, 2008 2:12 PM  
**To:** Cutler,Jim  
**Cc:** Greene, Anne; dennis.druck@us.army.mil; Willis,Durwood; diane.wisbeck@arcadis-us.com; Lohman,Elizabeth; jim spencer; Parks, Jeffrey N; Redder, Jerome; McKenna, Jim; Mendoza, Richard R Mr CIV USA IMCOM; Timothy.Leahy@shawgrp.com; Llewellyn, Tim; Tina\_Devine@URSCorp.com; Tom.Meyer@nab02.usace.army.mil  
**Subject:** RE: SWMU 51 RFI/CMS final report and 18 Aug 2008 cert letter and attachments. (UNCLASSIFIED)

yeah, Jim, replacement pages are fine

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

"Cutler,Jim"  
<jlcutler@deq.virginia.gov>

10/01/2008 04:40  
PM

To  
"McKenna, Jim J Mr CIV USA AMC"  
<jim.mckenna@us.army.mil>,  
<anne.greene@atk.com>,  
"Lohman,Elizabeth"  
<ealohman@deq.virginia.gov>,  
<dennis.druck@us.army.mil>,  
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William Geiger/R3/USEPA/US@EPA,  
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<Timothy.Leahy@shawgrp.com>,  
<Tina\_Devine@URSCorp.com>,  
<Tom.Meyer@nab02.usace.army.mil>  
cc

Subject  
RE: SWMU 51 RFI/CMS final report  
and 18 Aug 2008 cert letter and  
attachments. (UNCLASSIFIED)

Jim,

VDEQ had previously concurred with the changes and would prefer replacement pages instead of another complete report.

Thanks,

Jim C.

-----Original Message-----

From: McKenna, Jim J Mr CIV USA AMC [mailto:jim.mckenna@us.army.mil]

Sent: Wednesday, October 01, 2008 4:19 PM

To: anne.greene@atk.com; Lohman,Elizabeth; dennis.druck@us.army.mil;

diane.wisbeck@arcadis-us.com; Willis,Durwood; Geiger.William@epamail.epa.gov;

jerome.redder@atk.com; jim spencer; Cutler,Jim; Llewellyn, Tim; Mendoza, Richard R Mr CIV

USA IMCOM; Parks, Jeffrey N; Timothy.Leahy@shawgrp.com; Tina\_Devine@URSCorp.com;

Tom.Meyer@nab02.usace.army.mil

Subject: SWMU 51 RFI/CMS final report and 18 Aug 2008 cert letter and attachments.

(UNCLASSIFIED)

Importance: High

Classification: UNCLASSIFIED

Caveats: NONE

All:

Resending the subject letter as it has come to my attention some do not have it.

BTW. I'm ok with email approvals for work plans but decision documents such as the final SWMU 51 RFI/CMS report need a letter.

Note the SWMU 51 RFI/CMS report doesn't address the 08/06/2008 comment as it was Fed Ex'd on 07/31/2008. If DEQ is ok with our proposed revision, we can provide replacement pages or another complete report.

Thanks,

Jim

Classification: UNCLASSIFIED

Caveats: NONE

## 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 SWMU 51, no technologies involving treatment were evaluated in detail. The first limitation to utilizing treatment technologies is that technologies capable of treating the contaminants present in the sludge (i.e., lead, aluminum, explosives, 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 lead in soil, but does not address the explosives or dioxins/furans. Therefore, technologies that require extensive on-site management/testing are not implementable.

The following three corrective measure alternatives were developed for SWMU 51 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 Sludge and Grossly Contaminated Soil and Off-site Disposal.

A detailed description of these 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, groundwater monitoring, and periodic reviews. The various components of this alternative are discussed below.

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.

**Long-Term Monitoring of Site Conditions.** Long-term monitoring of groundwater would be conducted to evaluate the potential migration of contaminants into groundwater. A long-term sampling plan would be developed for SWMU 51 by the Army, USEPA, and VDEQ, to monitor the levels of contaminants in the groundwater. This would include the semiannual monitoring of

**Table 9-1**  
**Cost for Alternative Two: Institutional Controls**  
**(Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring)**

| ITEM                                      | UNITS    | UNIT COST  | NUMBER | TOTAL               |
|-------------------------------------------|----------|------------|--------|---------------------|
| <b>CAPITAL COSTS</b>                      |          |            |        |                     |
| <b>Reporting/Workplans</b>                |          |            |        |                     |
| Long-term Sampling Plan                   | Report   | \$6,000.00 | 1      | \$6,000.00          |
| <b>Subtotal</b>                           |          |            |        | <b>\$6,000.00</b>   |
| <b>SUBTOTAL</b>                           |          |            |        | <b>\$6,000.00</b>   |
| SUPERVISION AND ADMIN @ 8%                |          |            |        | \$480.00            |
| CONTINGENCY @ 30%                         |          |            |        | \$1,800.00          |
| <b>TOTAL CAPITAL COSTS</b>                |          |            |        | <b>\$8,280.00</b>   |
| <b>O&amp;M COSTS</b>                      |          |            |        |                     |
| <b>Administrative Actions<sup>1</sup></b> |          |            |        |                     |
| Periodic Reviews                          | Report   | \$30,000   | 0.2    | \$6,000             |
| Institutional Controls/Oversight          | Lump Sum | \$5,000    | 0.2    | \$1,000             |
| <b>Subtotal</b>                           |          |            |        | <b>\$7,000.00</b>   |
| <b>Long-Term Maintenance</b>              |          |            |        |                     |
| Semi Annual Analyses <sup>2</sup>         | Sample   | \$1029     | 28     | \$14,316            |
| Sample Labor, Preparation, Reporting      | Episode  | \$8,000    | 2      | \$16,000            |
| <b>Subtotal</b>                           |          |            |        | <b>\$30,316.00</b>  |
| <b>SUBTOTAL (ANNUALLY)</b>                |          |            |        | <b>\$37,316.00</b>  |
| CONTINGENCY @ 30%                         |          |            |        | \$11,194.80         |
| <b>TOTAL ANNUAL O&amp;M COSTS</b>         |          |            |        | <b>\$48,510.80</b>  |
| <b>PRESENT WORTH (30 YEARS AT 5%)</b>     |          |            |        | <b>\$754,009.90</b> |

<sup>1</sup> Costs assigned on a annual basis

<sup>2</sup> Two sampling events per year with analysis for lead, aluminum, explosives, and dioxins/furans (11 samples + 2 dups + 1 rinse blank)

groundwater collected from 11 existing monitoring wells displayed on **Figure 2-12**. The wells and the rationale as to their selection is as follows:

- 51MW1 (downgradient and slightly crossgradient to the west).
- 51MW2 (downgradient).
- 59MW01 (downgradient).
- 48MW1 (downgradient).
- 48MW2 (downgradient).
- 48MW3 (downgradient).
- 49MW01 (downgradient).
- 48MW06 (downgradient and slightly crossgradient to the west).
- 48MW07 (downgradient and slightly crossgradient to the west).
- 16-4 (upgradient/ crossgradient to the east).
- C1 (upgradient).

The wells would be sampled twice a year for lead, aluminum, explosives, and dioxins/furans. A monitoring plan would be developed which would detail the sampling of these wells. Eleven groundwater samples and two duplicate samples 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 will be required.

**Periodic Reviews.** Although this alternative does not allow for unrestricted use and exposure, available data would be analyzed as part of the periodic review process to assess whether additional remedial actions or site controls are required.

### **9.3 Alternative Three – Excavation of Sludge and Grossly Contaminated Soil and Off-site Disposal with Land Use Controls and No Long-Term Monitoring**

This alternative involves excavation of sludge and grossly contaminated soil (see *Section 8.0*). The results of the SWMU 51 soil investigations indicate that the trench sludge material consisted of a black, paste-like sludge material that was very evident when encountered. It is a very sticky substance that exhibits a sweet odor. Therefore, identification and removal of the sludge material and grossly contaminated soil will be based on visual observations during excavation. Remedial Goals, as defined in *Section 8.2*, will be used to verify the concentrations of the COIs in confirmation samples after removal of the trench sludge and grossly contaminated soil. The estimated area to be excavated is presented on **Figure 2-3** as the trench boundary. Excavated materials will be shipped to an off-site landfill for disposal. The Hazardous Remediation Waste Management Requirements (HWIR) pertaining to land disposal of contaminated media would pertain to this site. The sludge present in the SWMU 51 disposal pit is a wastewater treatment sludge from the manufacturing and processing of explosives, and therefore, meets the definition of a RCRA source-specific waste (K044 listed waste). However, this listing is based on a determination that these wastes are reactive. On 16 May 2001, the EPA issued the final HWIR rule that allows more wastes to take advantage of exclusions from hazardous waste regulation. With the new changes, all wastes listed solely for the characteristics of ignitability, corrosivity, and/or reactivity (ICR) are not considered hazardous wastes if they no longer exhibit any of these

characteristics. The EPA states that when a waste has been listed solely for ICR characteristics, and that waste does not exhibit any hazardous characteristics at the point of generation, then that waste is not subject to Land Disposal Restrictions (LDR) standards. However, if the characteristic is removed after the point of generation, the waste is still subject to all applicable LDR requirements in 40 CFR 268. As the K044 listed wastes are listed solely for the characteristic of reactivity, these exclusions apply. Therefore, if sampling during the excavation determines that the waste is no longer reactive, the soil will not be considered to be a K044 waste and will be disposed as either a hazardous, non-listed waste or a non-hazardous waste based on the RCRA waste characteristics. As the soil does not contain greater than 10% explosives, it is not likely that the soil will be determined to be reactive so it is not likely to be classified as a K044 waste. The hazardous waste determination would therefore be based on the Toxicity Characteristic Leachate Procedure (TCLP) sample results. If the TCLP results indicate that the soil is a toxic waste (i.e., TCLP result greater than the 40 CFR 261.30(b) standards) it will be disposed per RCRA Subtitle C requirements. For cost-estimating purposes in this RFI/CMS, it was assumed that the sludge meets the definition of hazardous waste and will be disposed in a RCRA Subtitle C landfill.

The estimated volume of the materials to be excavated is 662 yd<sup>3</sup>. The density of the waste material was assumed to be 1.4 tons/yd<sup>3</sup>; therefore, the total quantity of waste material to be excavated will be approximately 927 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. As described in *Sections 4.1 and 8.1*, soil above and surrounding the sludge has been determined to be clean fill and/or native material. Therefore, this soil would be removed and stored during waste excavation and used as fill material.

This alternative entails removing all waste materials from the site. As COIs were not selected for the soil beneath the waste, clean closure will be achieved and land use controls will not be required.

The components of the excavation of sludge and grossly contaminated soil and off-site disposal alternative used for costing purposes are detailed below. The costs for this alternative are presented as **Table 9-2**.

**Reporting/Design Work Plans.** The contractor will prepare site-specific work plans prior to excavation activities that will include a QA planning component, health and safety component, Work Plan, and field procedures. The work plans will be reviewed and approved by the USEPA and VDEQ prior to removal activities.

After the corrective measures have been completed and the final inspection approved by the USEPA and VDEQ, a Corrective Measures Summary Report will be completed. Writing and compilation of the information for the report will occur throughout the duration of the remedial action. The report will include site drawings, sample data, copies of manifests, and a detailed narrative of the corrective measures.

**Site Set-up.** Site set-up for the excavation will consist of setting up a decontamination station, mobilization of equipment and personnel, and setting up staging areas. It should be noted that mobilization costs are included with the excavation costs in **Table 9-2**. The water needs of the

**Table 9-2**  
**Cost for Alternative Three: Excavation of Sludge and Grossly Contaminated Soil**  
**and Off-site Disposal**

| ITEM                                                                         | UNITS    | UNIT COST   | NUMBER | TOTAL               |
|------------------------------------------------------------------------------|----------|-------------|--------|---------------------|
| <b>CAPITAL COSTS<sup>1</sup></b>                                             |          |             |        |                     |
| <b>Reporting/Workplans</b>                                                   |          |             |        |                     |
| Health and Safety Plan                                                       | Report   | \$10,000.00 | 1      | \$10,000.00         |
| Quality Assurance Project Plan                                               | Report   | \$10,000.00 | 1      | \$10,000.00         |
| Work Plan                                                                    | Report   | \$15,000.00 | 1      | \$15,000.00         |
| Corrective Measures Summary Report                                           | Report   | \$20,000.00 | 1      | \$20,000.00         |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$55,000.00</b>  |
| <b>Site Set-Up</b>                                                           |          |             |        |                     |
| 1000-gallon Storage Tank                                                     | Lump Sum | \$500.00    | 5      | \$2,500.00          |
| 55-gallon drums                                                              | Each     | \$86.74     | 100    | \$8,674.00          |
| Decontamination Pad                                                          | Site     | \$1,500.00  | 1      | \$1,500.00          |
| Poly Sheeting                                                                | Roll     | \$145.73    | 4      | \$582.92            |
| Silt Fence w/ Stakes 3' x 800'                                               | Roll     | \$28.24     | 32     | \$903.68            |
| Safety Fence 4' x 800'                                                       | Roll     | \$66.81     | 32     | \$2,137.92          |
| Geotextile, Mirafi Filterweave 700                                           | SF       | \$0.29      | 3200   | \$928.00            |
| Lumber 4"x6", 12ft                                                           | Each     | \$24.50     | 160    | \$3,920.00          |
| Decon Soap                                                                   | Gallon   | \$22.50     | 5      | \$112.50            |
| Misc Supplies (brushes, shovels, etc)                                        | Lump Sum | \$250.00    | 1      | \$250.00            |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$21,509.02</b>  |
| <b>Contamination Delineation</b>                                             |          |             |        |                     |
| Direct Push Rig (Geoprobe)                                                   | Day      | \$1,500.00  | 3      | \$4,500.00          |
| Oversight (Geologist)                                                        | Hour     | \$65.00     | 30     | \$1,950.00          |
| Per Diem                                                                     | Day      | \$131.00    | 4      | \$524.00            |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$6,974.00</b>   |
| <b>Health and Safety</b>                                                     |          |             |        |                     |
| Site Health and Safety Officer                                               | Hour     | \$90.00     | 200    | \$18,000.00         |
| Safety Supplies (tyvex, gloves, etc.)                                        | Lump Sum | \$500.00    | 1      | \$500.00            |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$18,500.00</b>  |
| <b>Excavation</b>                                                            |          |             |        |                     |
| QC Personnel (1)                                                             | Hour     | \$70.00     | 200    | \$14,000.00         |
| Field Supervisor (1)                                                         | Hour     | \$60.00     | 200    | \$12,000.00         |
| Field Technician (2)                                                         | Hour     | \$37.75     | 400    | \$15,100.00         |
| Equipment Operators (2)                                                      | Hour     | \$50.00     | 400    | \$20,000.00         |
| Project Manager (1)                                                          | Hour     | \$124.75    | 120    | \$14,970.00         |
| Per Diem <sup>2</sup>                                                        | Day      | \$131.00    | 150    | \$26,986.00         |
| Project Business Administrator                                               | Hour     | \$81.00     | 40     | \$3,240.00          |
| Truck (3)                                                                    | Month    | \$1,175     | 3      | \$3,525.00          |
| Excavator - Cat 330 or equivalent (includes mob/demob)                       | Month    | \$9,350.00  | 1      | \$9,350.00          |
| Pressure Washer (includes mob/demob)                                         | Month    | \$600.00    | 1      | \$600.00            |
| Roller - Vibratory Compactor (includes mob/demob)                            | Week     | \$875.00    | 1      | \$875.00            |
| Water Truck, 2000 gallon (includes mob/demob)                                | Month    | \$2,480.00  | 1      | \$2,480.00          |
| 4" Dry-Prime Pump with Generator                                             | Month    | \$1,965.00  | 1      | \$1,965.00          |
| FOGM (total work hrs * 2.5)                                                  | Hour     | \$23.40     | 206    | \$4,680.00          |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$129,771.00</b> |
| <b>Waste Characterization &amp; Confirmation Sampling</b>                    |          |             |        |                     |
| Off-Site Lab Analytical (TCLP metals, RCRA Char, Explosives, Dioxins/Furans) | Sample   | \$1,533.00  | 50     | \$76,650.00         |
| Decon Water Sample (RCRA Waste Characterization)                             | Sample   | \$1,410.00  | 1      | \$1,410.00          |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$78,060.00</b>  |

**Table 9-2 (Continued)**  
**Cost for Alternative Three: Excavation of Sludge and Grossly Contaminated Soil**  
**and Off-site Disposal**

| ITEM                                    | UNITS    | UNIT COST  | NUMBER | TOTAL               |
|-----------------------------------------|----------|------------|--------|---------------------|
| <b>CAPITAL COSTS<sup>1</sup></b>        |          |            |        |                     |
| <b>Waste Transportation/Disposal</b>    |          |            |        |                     |
| Hazardous Waste Transportation/Disposal | Ton      | \$ 173.53  | 927    | \$160,862.31        |
| <b>Subtotal</b>                         |          |            |        | <b>\$160,862.31</b> |
| <b>Site Restoration</b>                 |          |            |        |                     |
| D5 Bulldozer (includes mob/demob)       | Month    | \$3,800.00 | 1      | \$3,800.00          |
| Clean Fill                              | CY       | \$25.00    | 1256   | \$31,400.00         |
| Seeding, Vegetative Cover               | Acre     | \$3,528.00 | 1.0    | \$3,528.00          |
| Survey Equipment/Team                   | Lump Sum | \$1,500.00 | 1.0    | \$1,500.00          |
| <b>Subtotal</b>                         |          |            |        | <b>\$40,228.00</b>  |
| <b>CAPITAL COSTS<sup>1</sup></b>        |          |            |        |                     |
| <b>SUBTOTAL</b>                         |          |            |        | <b>\$450,275.33</b> |
| SUPERVISION AND ADMIN @ 8%              |          |            |        | \$36,022.03         |
| CONTINGENCY @ 30%                       |          |            |        | \$135,082.60        |
| <b>TOTAL CAPITAL COSTS</b>              |          |            |        | <b>\$675,030.96</b> |
| <b>O&amp;M COSTS</b>                    |          |            |        |                     |
| None                                    |          |            |        |                     |
| <b>SUBTOTAL (ANNUALLY)</b>              |          |            |        | <b>\$0.00</b>       |
| CONTINGENCY @ 30%                       |          |            |        | \$0.00              |
| <b>TOTAL ANNUAL O&amp;M COSTS</b>       |          |            |        | <b>\$0.00</b>       |
| <b>PRESENT WORTH (30 YEARS AT 5%)</b>   |          |            |        | <b>\$675,030.00</b> |

<sup>1</sup> The estimated length of time is as follows: delineation 3 days, mobilization/site set-up 2 days, excavation 12 days, site restoration 3 days, decon/demob 3 days

<sup>2</sup> Per diem costs for 28 days for H&S and QC officers, site super, field techs, and equipment operators, 10 days for PM

process are for decontamination; therefore, water will be trucked to the site and stored in a 500-gallon tank. The cost elements for preparing the work zone are presented below:

- The equipment decontamination station will be constructed with material such as high-density polyethylene for containment purposes. This decontamination station should be bermed to ensure containment of decontamination liquids.
- A 500-gallon tank will be used throughout the duration of the corrective measure activities to store water for use in the decontamination station.
- A silt fence will be constructed for erosion control and a safety fence will be constructed around the perimeter of the work site to prevent unauthorized personnel and wildlife from entering the work zone.

**Contamination Delineation.** The area to be excavated will be delineated prior to mobilization of the excavation personnel. For the purpose of this study, it is assumed that 30 soil borings would be completed to delineate the areal extent and depth to the top of the waste. The soil would be continuously evaluated using visual observations for sludge and grossly contaminated soil. Details on boring locations will be developed during the work planning phase.

**Health and Safety.** Health and safety measures will be taken to protect on-site workers during excavation activities. For cost-estimating purposes, modified Level D 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 CAT 330 or equivalent excavator (trackhoe) will be used to excavate the contaminated area into a stockpile. Clean/native soil from above and around the sludge will be removed and stored along one side of the trench. Sloping or benching will be performed as required to prevent cave-in from occurring as the excavation proceeds. Contaminated soil will be directly loaded into dump trucks and transported from the site. It is assumed that the excavation will proceed at a maximum rate of 10-12 trucks per day (22 tons/truck). The estimated length of time for the excavation is 12 working days. A water truck will be required on site during excavation activities for dust suppression purposes. Personnel assumed for this alternative include one QC Engineer, one field supervisor, two field technicians, two equipment operators, and one project manager.

**Waste Characterization & Confirmation Sampling.** For the purposes of this document, analysis for the following waste characteristics is assumed for composite samples collected from excavated soil prior to excavation. The receiving facility requires that one composite sample be collected from the waste materials per 1,000 tons. For the purposes of this CMS, it is assumed that two composite samples will be collected from the delineated waste materials to assess whether the soil is a hazardous waste prior to excavation. In addition, investigative-derived materials will be sampled prior to disposal for RCRA waste characteristics. It is also assumed that confirmation samples will be collected to ensure that trench sludge and grossly contaminated soil has been removed. For the purposes of this document, it is assumed that 45 samples will be sufficient to ensure removal. The Interim Measures Work Plan will provide more detail on the number and location of samples, as well as the chemical analysis for each sample.

| Test                              | Media | Method           |                   | Price* |
|-----------------------------------|-------|------------------|-------------------|--------|
|                                   |       | Preparation      | Analysis          |        |
| Corrosivity, pH, 3 day TAT        | Solid | NA               | SW846 9045D       | \$13   |
| Flash Pt. Ignitability, 3 day TAT | Solid | NA               | SW846 1010        | \$26   |
| Reactivity, 3 day TAT             | Solid | SW846 Chap 7.3   | SW846 Chap 7.3    | \$91   |
| Dioxins/furans, 7 day TAT         | Solid | SW846 8290       | SW846 8290        | \$1050 |
| Explosives, 7 day TAT             | Solid | SW846 3550B      | SW846 8330B       | \$260  |
| TCLP Metals, 3 day TAT            | Solid | SW846 1311/3010A | SW846 6010B/7470A | \$133  |
| Total Cost                        |       |                  |                   | \$1573 |

\* Based on laboratory alliance (2007) and 30% markup for 7-day turnaround time (TAT).

**Waste Transportation and Disposal.** Corrective measure activities are expected to generate approximately 1,236 tons of hazardous soil and 1,000 gallons of decontamination water. Excavated soil is anticipated to be classified as hazardous waste, so will be disposed in a RCRA Subtitle C 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 hazardous waste will be transported to EQ – Belleville Michigan facility 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 clean materials from the top of the excavation will be placed back in the trench using a D5 bulldozer. Additional soil will be added such that the trench matches the surrounding grade. Approximately 6 inches of topsoil will then be applied and the area will be graded. Erosion control measures will be implemented and excavation areas will be seeded. Upon completion of site restoration operations, the contractor will remove the temporary facilities from the area.

Prior to adding the soil, all clean/native fill will be sampled at a rate of 1 composite sample per 1,000 cubic yards. Four aliquots from separate areas will be composited into each sample. The samples will be analyzed for TAL metals, TCL VOCs, TCL SVOCs, pesticides/PCBs, and explosives. Results will be compared to residential RBCs and RFAAP 95% UTL background levels to ensure that the fill is acceptable. If the native fill does not pass the screening, additional fill will be brought on site from an off-site source and will be analyzed in the same manner.

After the site restoration activities are completed, Shaw will demobilize all equipment off site.

**Land Use Controls.** SWMU 51 is located in an active magazine area and several other SWMUs are in the immediate vicinity, making any development of this area extremely unlikely. In addition, RFAAP is revising its policy to enhance the use of management controls in conjunction with physical controls that can further limit access to this portion of the installation.

***Long-Term Monitoring.*** Based on the analysis of groundwater data at the site and the distribution of COIs in the soil; and, per agreements with the USEPA and VDEQ, no long-term monitoring is required at this site.



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

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August 18, 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,  
SWMU 51 RCRA Facility Investigation/Corrective Measures Study Report, Final Document, July  
2008 and SWMU 51 Interim Measures Work Plan, Draft Document, July 2008  
EPA ID# VA1 210020730

Dear Mr. Geiger and Mr. Cutler:

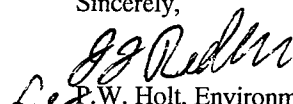
Enclosed is the certification for the subject documents that were sent to you on July 31, 2008.

Also enclosed are copies of the July 31, 2008 email messages that transmitted the subject documents and a consolidated and revised set of responses to comments from the Environmental Protection Agency, Region III (EPA) dated February 25, 2008 and June 13, revised June 17, 2008 and from the Virginia Department of Environmental (DEQ) dated February 25 and August 6, 2008 on the SWMU 51 RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) Report, Draft Final January 2008.

The RFI/CMS report has been revised per these responses except of course with respect to the DEQ comment of August 6, 2008. Once DEQ confirms our response is acceptable we can provide revised pages or a complete report. With the exception of the August DEQ comment, these responses have been discussed with you and your staff on several occasions with the most recent occurred on June 11, 2008 at the partnering meeting held at the Crowne Plaza Hotel in Philadelphia.

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) 731-5782.

Sincerely,

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

08-815-131  
JMcKenna

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

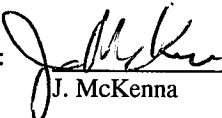
E. A. Lohman  
Virginia Department of Environmental Quality  
West Central Regional Office  
3019 Peters Creek Road  
Roanoke, VA 24019

Rich Mendoza  
U.S. Army Environmental Command  
1 Rock Island Arsenal  
Bldg 90, 3<sup>rd</sup> 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

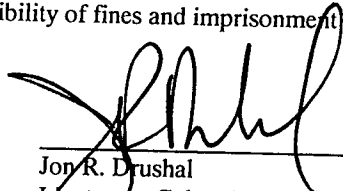
  
M. A. Miano

Concerning the following:

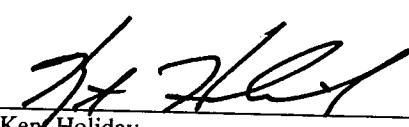
Radford Army Ammunition Plant  
SWMU 51 RCRA Facility Investigation/Corrective Measures Study Report,  
Final Document, July 2008  
and  
SWMU 51 Interim Measures Work Plan,  
Draft Document, July 2008

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:  
TITLE:

  
Jon R. Drushal  
Lieutenant Colonel, US Army  
Commanding

SIGNATURE:  
PRINTED NAME:  
TITLE:

  
Ken Holiday  
Vice President and General Manager  
ATK Energetics Systems

## Greene, Anne

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**From:** McKenna, Jim  
**Sent:** Thursday, July 31, 2008 1:45 PM  
**To:** Greene, Anne; beth lohman; dennis.druck@us.army.mil; diane.wisbeck@arcadis-us.com; durwood willis2; Geiger.William@epamail.epa.gov; Redder, Jerome; jim spencer; jlcutler@deq.virginia.gov; Llewellyn, Tim; Mendoza, Richard R Mr CIV USA IMCOM; Parks, Jeffrey N; Timothy.Leahy@shawgrp.com; Tina\_Devine@URSCorp.com; Tom.Meyer@nab02.usace.army.mil  
**Subject:** Radford AAP - Final SWMU 51 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 Radford AAP under separate cover.

Immediately below are the POCs with tracking numbers:

Rich Mendoza, USAEC-RIA, 1 hard copy, 1 CD, 1Z63V8840192263467  
Margaret Howard, USAEC-Legal, 1 CD, 1Z63V8840191021630  
William Geiger, US EPA Region III, 1 hard copy, 1 CD, 1Z63V8840192086079  
Jim Cutler, VDEQ, 1 hard copy, 1 CD, 1Z63V8840191779680  
Elizabeth Lohman, VDEQ, 1 CD, 1Z63V8840194683027  
Tom Meyer, USACE-Baltimore, 1 hard copy, 1 CD, 1Z63V8840194211858  
Dennis Druck, USACHPPM, 1 CD, 1Z63V8840192715415

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

Jim McKenna  
540 731 5782  
Classification: UNCLASSIFIED  
Caveats: NONE

**Response to USEPA Comments, Dated 25 February 2008,  
VDEQ Comments, Dated 25 February 2008,  
USEPA Ecological RA comment, Dated 13 June, 2008, revised 17 June 2008  
And  
VDEQ Verbal comment on 6 August, 2008  
for  
Draft Final SWMU 51 RFI/CMS Report  
Dated January 2008**

*Comments from Will Geiger, USEPA and Jim Cutler, VDEQ*

**Note:** Jim Cutler's comment is located after USEPA comment #3 since they are similar

## **GENERAL COMMENTS**

### **Comment 1**

The geologic cross sections provided as Figures 2-4 through 2-11 include the letters A, B, C, and/or D on several of the borings. The legends of the figures do not describe the meanings of these letters. Subsequent sections of the RFI/CMS Report appear to indicate that these letters correspond to samples that were collected from the borings. However, for clarity, please define the meaning of the letters A through D in the legends of the geologic cross section figures.

#### **Response**

The meaning of letters A through D will be defined in the legends of Figures 2-4 through 2-11 as requested.

### **Comment 2**

Section 4.0, Nature and Extent of Contamination, does not include any visual representations of the nature and extent of contamination at SWMU 51. A plan view map with concentrations of contaminants identified by sample location would be useful to show the horizontal distribution of contaminants within the trench. Vertical profiles or cross-sections may be useful to show the distribution of contaminants at depth. A similar approach would also be useful for depicting groundwater contamination. Please revise the RFI/CMS Report to include figures or other visual representations of the nature and extent of contamination at the SWMU 51. Assessment and determination of nature and extent of contamination may not be possible until the requested figures are provided.

#### **Response**

Figure 4-1 does provide a visual representation of the nature and extent of contamination. Residential and Industrial RBC exceedances are depicted with red and orange squares, respectively. The three tables at the top of the figure indicate number and type (metals, explosives, etc) of exceedances. Tables 4-1 through 4-9 provide sample depths and sample results for detected chemicals and exceedances are indicated with shading, bold outline or bold text.

A figure similar to Figure 4-1 will be created for groundwater results, as requested.

For the vertical distribution of contaminants, intervals where analytical samples were collected are indicated on the borings with letters "A", "B", "C" and "D" (see comment 1) in the geologic cross-sections. Cross section A-A' (the long cross section N-S through the site) will be reproduced in Section

4 with concentrations of 2,4,6-TNT, 2,4-DNT, and 2,6-DNT shown next to the sample intervals. These three explosives-related compounds give a good representation of the extent of the trench sludge and the dramatic decrease in concentration below the trench sludge.

### Comment 3

The RFI/CMS Report proposes a site-specific corrective measure objective in Section 8.3 on page 8-2 of an excavation standard consisting of the visual observation of the black, paste-like sludge material which exhibits a sweet odor. Although initial excavation limits may be able to be achieved via a visual standard, definitive remedial objectives need to be established so that the excavation limits may be sampled to verify achievement of the stated remedial standard. Please revise the RFI/CMS Report to establish a definitive remedial standard.

### VDEQ Comment #1

Based on my review of the RFI/CMS for SWMU 51 I concur with the proposed remedy. The characterization of soil and groundwater appears to be sufficient. My main concern involves the implementation of the remedy.

On Figure 2-4 some of the "c" labeled samples (B2, B3, B4) are categorized as sludge material and/or grossly contaminated soil. Other "c" samples (B5, B6) are grouped as below sludge or deep soil. The report indicates that this distinction was made based on visual observation at the time the samples were collected. The proposed remedy involves soil removal based on visual observation. I think some confirmation sampling should be required especially in light of the fact that most of these samples were collected from the river jack layer. I would expect that visual delineation in this gravel/sand would be difficult since you would expect contamination to be easily transported through this material.

### Response

The report will be revised to include Remedial Goals (RGs) for the Contaminants of Interest (COIs) identified in *Section 8 – Development of Corrective Measures Objectives*.

These RGs will be used to compare results from confirmation samples collected after removal of the trench sludge and grossly contaminated soil immediately below the sludge. The CMS portion of the report will be modified to include the collection of confirmation samples. The tentative locations of the confirmation samples will be shown in the *SWMU 51 Interim Measures Work Plan*. Final locations will be selected based on the actual size and shape of the excavation. Risk-based RGs were calculated for use down to 15 feet below ground surface (bgs) based on the lower of a carcinogenic risk of 10<sup>-5</sup> or an apportioned total HI of 1. The calculated RGs for each risk assessment scenario are presented in the **Table 1a (cancer) and Table 1b (noncancer)** below and will be referred to as "shallow RGs". **Table 1c** shows the lowest value from the cancer and noncancer calculations and selects the lower of the two values. The lowest value for each chemical was selected for cancer and non-cancer risk and lower of these two values was selected as the final shallow RG. A description of the methodology used to calculate the shallow RGs is presented in **Attachment 1**. This attachment will also be presented in **Appendix G** of the RFI/CMS report (The current **Appendix G** will become **Appendix H**). Fifteen feet was selected as the cutoff depth based on exposure depths used in standard risk assessment scenarios.

At depths below 15 ft bgs, RGs were selected according to **Table 2** below and will be referred to as "deep RGs". Residential RBCs Industrial RBCs, metals 95% background UTLs, maximum concentrations in the deep soil grouping and minimum concentrations in the sludge sample grouping were considered. The rationale for each deep RG is presented below. These deep RGs are non-risk based and are intended to demonstrate that, at depths greater than 15 ft, the sludge layer and grossly contaminated soil have been removed.

- For 1,3,5-DNB 2-NT and 4-NT, the residential RBC was selected since the r-RBC was higher than the min sludge concentration. The r-RBC is considered a conservative value given the depth of the samples and the absence of explosives related constituents in groundwater.
- For aluminum, the 95% background UTL was selected since this was higher than the min sludge concentration, the max deep concentration and the r-RBC.
- For 2,4,6-TNT, 2,4-DNT and 2,6-DNT, the midpoint between the minimum sludge concentration and the maximum deep soil concentration was selected since the minimum sludge concentration was greater than the maximum deep soil concentration and concentrations were fairly close. As discussed during the February 2008 EPA/VDEQ/RFAAP partnering meeting, the trench sludge and grossly contaminated soil are below the exposure depth for residential scenarios (typically 15 ft; although 20 ft was used for SWMU 51 to be more conservative). These deep RGs were selected to ensure that the trench sludge and grossly contaminated soil immediately below the sludge have been removed. As noted above, the CMS will be changed to include the collection of confirmation samples and the results of these samples will be compared to the RGs. Excavation will continue until COI concentrations in the confirmation samples are less than the RGs.
- For NG, a value of 10 times the deep soil maximum was used. There was a single detection of NG in the sludge (3300 mg/kg) out of 8 samples and a single detection of NG in the deep soil (6.7 mg/kg) out of 13 samples. Due to the low frequency of detection (Frequency of Detection (FOD) = 0.125 in the sludge and FOD = 0.077 in the deep soil) and the large range between the two detections, 10 times the deep soil concentration is more protective than the midpoint.
- For lead, the USEPA interim lead cleanup goal for un-restricted re-use of 400 mg/kg was selected.
- For dioxin/furans as TE, the residential value of 1 ug/kg from OSWER directive 9200.4-26 (*Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites*. April, 1998) was selected.

Confirmation samples will be collected from the side walls and bottom of the excavation after visual signs of sludge have been removed and concentrations will be compared to the shallow RGs at depths less than 15 feet bgs and to the deep RGs at depths greater than 15 feet bgs to confirm that the sludge and grossly contaminated soil have been removed. Excavation will continue until confirmation sample concentrations are below the RGs.

Table 1a  
Summary of Remedial Goals<sup>a</sup>  
Based on Cancer Risk  
Total Soil - SWMU 51  
July 2008

| Chemical                       | Future                |                       |                       |                       |                       |                       | Future                         |                       |                       |                       |                       |                       |
|--------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
|                                | Maintenance Worker    |                       |                       | Industrial Worker     |                       |                       | Excavation Worker <sup>b</sup> |                       |                       | Lifetime Resident     |                       |                       |
|                                | TR = 10 <sup>-6</sup> | TR = 10 <sup>-5</sup> | TR = 10 <sup>-4</sup> | TR = 10 <sup>-6</sup> | TR = 10 <sup>-5</sup> | TR = 10 <sup>-4</sup> | TR = 10 <sup>-6</sup>          | TR = 10 <sup>-5</sup> | TR = 10 <sup>-4</sup> | TR = 10 <sup>-6</sup> | TR = 10 <sup>-5</sup> | TR = 10 <sup>-4</sup> |
| 1,3-Dinitrobenzene             | NA                    | NA                    | NA                    | NA                    | NA                    | NA                    | NA                             | NA                    | NA                    | NA                    | NA                    | NA                    |
| 2,4-Dinitrotoluene             | 2.1                   | 20.6                  | 206.0                 | 0.5                   | 4.6                   | 46.4                  | 17.1                           | 171.0                 | 1710.0                | 0.1                   | 1.2                   | 12.0                  |
| 2,6-Dinitrotoluene             | 2.1                   | 21.1                  | 211.0                 | 0.5                   | 4.6                   | 46.3                  | 17.1                           | 171.0                 | 1710.0                | 0.1                   | 1.2                   | 12.0                  |
| Dioxins (TCDD TE) <sup>c</sup> | 0.005                 | 0.005                 | 0.005                 | 0.005                 | 0.005                 | 0.005                 | NA                             | NA                    | NA                    | 0.001                 | 0.001                 | 0.001                 |
| Lead                           | NA                    | NA                    | NA                    | NA                    | NA                    | NA                    | NA                             | NA                    | NA                    | NA                    | NA                    | NA                    |
| Nitroglycerin                  | 83.7                  | 837.0                 | 8370.0                | 18.8                  | 188.0                 | 1880.0                | NA                             | NA                    | NA                    | NA                    | NA                    | NA                    |
| 2-Nitrotoluene                 | NA                    | NA                    | NA                    | NA                    | NA                    | NA                    | NA                             | NA                    | NA                    | 4.8                   | 47.7                  | 477.0                 |
| 4-Nitrotoluene                 | 92.4                  | 924.0                 | 9240.0                | 20.0                  | 200.0                 | 2000.0                | 713.0                          | 7130.0                | 71300.0               | 5.1                   | 51.0                  | 510.0                 |
| 2,4,6-Trinitrotoluene          | 63.8                  | 638.0                 | 6380.0                | 14.6                  | 146.0                 | 1460.0                | 458.0                          | 4580.0                | 45800.0               | 3.2                   | 31.9                  | 319.0                 |
| Aluminum                       | NA                    | NA                    | NA                    | NA                    | NA                    | NA                    | NA                             | NA                    | NA                    | NA                    | NA                    | NA                    |
| Arsenic <sup>d</sup>           | Bkgd                  | Bkgd                  | Bkgd                  | Bkgd                  | Bkgd                  | Bkgd                  | NA                             | NA                    | NA                    | Bkgd                  | Bkgd                  | Bkgd                  |
| Iron                           | NA                    | NA                    | NA                    | NA                    | NA                    | NA                    | NA                             | NA                    | NA                    | NA                    | NA                    | NA                    |
| Manganese                      | NA                    | NA                    | NA                    | NA                    | NA                    | NA                    | NA                             | NA                    | NA                    | NA                    | NA                    | NA                    |
| Vanadium                       | NA                    | NA                    | NA                    | NA                    | NA                    | NA                    | NA                             | NA                    | NA                    | NA                    | NA                    | NA                    |

Bkgd = Within Background

COI = Chemical of Interest; exceeded risk = 1.0E-06 in the baseline risk assessment.

NA = Not Applicable

TR = Target Cumulative Risk

All values are presented in milligrams per kilogram (mg/kg).

Shaded cells indicate COIs for each receptor group.

<sup>a</sup> For each receptor, the target risks for each COI are based on apportioning the cumulative risk across the total number of COIs with the exception of metals that were found to be within background concentrations.

<sup>b</sup> Due to the size of SWMU 51 (0.16 acres), RGs for the excavation worker are based on an exposure frequency of 90 days/year and exposure duration of 1 year.

<sup>c</sup> Dioxins were included in the apportionment of risk. RGs will be based, however, on USEPA industrial and residential cleanup levels for dioxins/furans (see text).

<sup>d</sup> COI was within background concentrations for total soil at SWMU 51.

Table 1b

**Summary of Remedial Goals<sup>a</sup>  
Based on Noncancer Hazard  
Total Soil - SWMU 51  
July 2008**

| Chemical               | Future Maintenance Worker |          |          | Future Industrial Worker |          |          | Future Excavation Worker <sup>b</sup> |          |          | Future Adult Resident |          |          | Future Child Resident |          |          |
|------------------------|---------------------------|----------|----------|--------------------------|----------|----------|---------------------------------------|----------|----------|-----------------------|----------|----------|-----------------------|----------|----------|
|                        | HI = 1.0                  | HI = 0.5 | HI = 0.1 | HI = 1.0                 | HI = 0.5 | HI = 0.1 | HI = 1.0                              | HI = 0.5 | HI = 0.1 | HI = 1.0              | HI = 0.5 | HI = 0.1 | HI = 1.0              | HI = 0.5 | HI = 0.1 |
| 1,3-Dinitrobenzene     | NA                        | NA       | NA       | 9.8                      | 4.9      | 1.0      | 9.4                                   | 4.7      | 0.9      | 7.4                   | 3.7      | 0.7      | 0.9                   | 0.4      | 0.1      |
| 2,4-Dinitrotoluene     | 1540.0                    | 770.0    | 154.0    | 195.0                    | 97.5     | 19.5     | 189.0                                 | 94.5     | 18.9     | 148.0                 | 74.0     | 14.8     | 17.6                  | 8.8      | 1.8      |
| 2,6-Dinitrotoluene     | 802.0                     | 401.0    | 80.2     | 97.8                     | 48.9     | 9.8      | 96.2                                  | 48.1     | 9.6      | 74.5                  | 37.3     | 7.5      | 8.8                   | 4.4      | 0.9      |
| Dioxins (TCDD TE)      | NA                        | NA       | NA       | NA                       | NA       | NA       | NA                                    | NA       | NA       | NA                    | NA       | NA       | NA                    | NA       | NA       |
| Lead <sup>c</sup>      | NA                        | NA       | NA       | NA                       | NA       | NA       | NA                                    | NA       | NA       | NA                    | NA       | NA       | NA                    | NA       | NA       |
| Nitroglycerin          | 77.4                      | 38.7     | 7.7      | 9.8                      | 4.9      | 1.0      | 9.5                                   | 4.8      | 1.0      | 7.5                   | 3.8      | 0.8      | 0.9                   | 0.5      | 0.1      |
| 2-Nitrotoluene         | NA                        | NA       | NA       | 1340.0                   | NA       | NA       | 1140.0                                | 570.0    | 114.0    | 937.0                 | NA       | NA       | 104.0                 | 52.0     | 10.4     |
| 4-Nitrotoluene         | NA                        | NA       | NA       | 396.0                    | 198.0    | 39.6     | 376.0                                 | 188.0    | 37.6     | 302.0                 | 151.0    | 30.2     | 35.2                  | 17.6     | 3.5      |
| 2,4,6-Trinitrotoluene  | 526.0                     | 263.0    | 52.6     | 66.9                     | 33.5     | 6.7      | 56.1                                  | 28.1     | 5.6      | 46.3                  | 23.2     | 4.6      | 5.0                   | 2.5      | 0.5      |
| Aluminum               | NA                        | NA       | NA       | NA                       | NA       | NA       | NA                                    | NA       | NA       | NA                    | NA       | NA       | NA                    | NA       | NA       |
| Arsenic <sup>d</sup>   | NA                        | NA       | NA       | NA                       | NA       | NA       | NA                                    | NA       | NA       | NA                    | NA       | NA       | NA                    | NA       | NA       |
| Iron <sup>d</sup>      | NA                        | NA       | NA       | NA                       | NA       | NA       | NA                                    | NA       | NA       | NA                    | NA       | NA       | NA                    | NA       | NA       |
| Manganese <sup>d</sup> | NA                        | NA       | NA       | NA                       | NA       | NA       | Bkgd                                  | Bkgd     | Bkgd     | NA                    | NA       | NA       | Bkgd                  | Bkgd     | Bkgd     |
| Vanadium <sup>d</sup>  | NA                        | NA       | NA       | NA                       | NA       | NA       | NA                                    | NA       | NA       | NA                    | NA       | NA       | Bkgd                  | Bkgd     | Bkgd     |

Bkgd = Within Background

COI = Chemical of Interest; exceeded HI = 1 in the baseline risk assessment.

HI = Target Cumulative Hazard Index

NA = Not Applicable

All values are presented in milligrams per kilogram (mg/kg).

Shaded cells indicate COIs for each receptor group.

<sup>a</sup> For each receptor, the target risks for each COI are based on apportioning the cumulative risk across the total number of COIs with the exception of metals that were found to be within background concentrations.

<sup>b</sup> Due to the size of SWMU 51 (0.16 acres), RGs for the excavation worker are based on an exposure frequency of 90 days/year and exposure duration of 1 year (see text).

<sup>c</sup> Lead is not included in the apportionment of risk. RGs will be based on USEPA industrial and residential cleanup levels for lead (see text).

<sup>d</sup> COI was within background concentrations for total soil at SWMU 51.

**Table 1c**  
**Selection of Corrective Measures Objectives**  
**Based on Lowest Value for each Chemical**  
**Total Soil - SWMU 51 - Radford AAP**  
**June 2008**

| Chemical              | Selected cancer<br>RG (TR =10 <sup>-5</sup> ) | Selected NC<br>Hazard (HI=1) | Selected RG (0-<br>15 ft bgs<br>interval) |
|-----------------------|-----------------------------------------------|------------------------------|-------------------------------------------|
| 1,3-Dinitrobenzene    | na                                            | 0.8                          | 0.8                                       |
| 2,4-Dinitrotoluene    | 1.2                                           | 15.4                         | 1.2                                       |
| 2,6-Dinitrotoluene    | 1.2                                           | 7.7                          | 1.2                                       |
| Dioxins (TCDD TE)     | na*                                           | na*                          | 0.001                                     |
| Lead                  | na*                                           | na*                          | 400                                       |
| Nitroglycerin         | 47.7                                          | 0.76                         | 0.8                                       |
| 2-Nitrotoluene        | na                                            | 91                           | 91.0                                      |
| 4-Nitrotoluene        | 51.0                                          | 31                           | 30.8                                      |
| 2,4,6-Trinitrotoluene | 31.9                                          | 4.4                          | 4.4                                       |
| Aluminum              | na                                            | 1180                         | 40041 <sup>d</sup>                        |
| Arsenic               | bkgd                                          | na                           | 15.8                                      |
| Iron                  | na                                            | bkgd                         | 50962                                     |
| Manganese             | na                                            | bkgd                         | 2543                                      |
| Vanadium              | na                                            | bkgd                         | 108                                       |

Bkgd = Within Background

NA = Not Applicable

TR = Target Cumulative Risk

<sup>d</sup> Aluminum background level is higher than calculated RG  
All values are presented in milligrams per kilogram (mg/kg).

Table 2

| Analyte                       | Residential RBC | Industrial /commercial RBC | RFAAP Background | Maximum Deep Soil Concentration        | Minimum Sludge Concentration | Selected RG                 | RG source                                 |
|-------------------------------|-----------------|----------------------------|------------------|----------------------------------------|------------------------------|-----------------------------|-------------------------------------------|
| <b>Explosives (mg/kg)</b>     |                 |                            |                  |                                        |                              |                             |                                           |
| 1,3-Dinitrobenzene            | 7.8             | 100                        | na               | 0.32                                   | 0.1                          | 7.8                         | r-RBC                                     |
| 2,4,6-Trinitrotoluene         | 21              | 95                         | na               | 22                                     | 64                           | 43                          | Avg of Min Sludge and Max Deep Soil       |
| 2,4-Dinitrotoluene            | 0.95            | 4.2                        | na               | 42                                     | 79                           | 60.5                        | Avg of Min Sludge and Max Deep Soil       |
| 2,6-Dinitrotoluene            | 0.95            | 4.2                        | na               | 11                                     | 17                           | 14                          | Avg of Min Sludge and Max Deep Soil       |
| 2-Nitrotoluene                | 780             | 10000                      | na               | 93                                     | 100                          | 780                         | r-RBC                                     |
| 4-Nitrotoluene                | 310             | 1800                       | na               | 45                                     | 60                           | 310                         | r-RBC                                     |
| Nitroglycerin                 | 7.8             | 100                        | na               | 6.7                                    | 3300                         | 67                          | 10X Max deep soil                         |
| <b>Metals (mg/kg)</b>         |                 |                            |                  |                                        |                              |                             |                                           |
| Aluminum                      | 78000           | 1000000                    | 40041            | 27700                                  | 8620                         | 40041                       | Background                                |
| Lead                          | 400             | 800                        | 26.8             | 18.3                                   | 10.4                         | 400                         | USEPA Interim Lead Clean-up Goal          |
| <b>Dioxins/Furans (ng/kg)</b> |                 |                            |                  |                                        |                              |                             |                                           |
| 2,3,7,8-TCDD TE               | 4.3             | 19                         | na               | Deep Soil Range<br>2.24-44.15<br>ng/kg | Sludge Range<br>2.36-148.2   | 1000 (or<br>0.001<br>mg/kg) | OSWER Directive 9200.4-26<br>(USEPA 1998) |

Notes: Red font in the RBC column indicates a carcinogen.

2,4,6-TNT reverts to carcinogenic value when unadjusted.

DNT mix RBC value was used.

**Comment 4**

The RFI/CMS Report proposes the re-use of the "Clean Fill and/or Native Soil" in Section 9.3, on Page 9-8, under the heading "Site Restoration." The RFI/CMS Report indicates that clean materials from the top of the excavation will be placed back in the trench. Section 9.3 further indicates on page 9-4 that the excavation alternative will not require land use controls. It is unclear if this statement applies to industrial or residential exposures.

Figure 4-1 identifies all the sample locations where residential or industrial screening levels were exceeded. Four locations are identified on Figure 4-1 for the clean fill and/or native soil horizon with one or more exceedance. All of the data used for the assessment of the clean fill and/or native soil horizon was collected from the initial 1 foot of soil, while the thickness of this clean fill and/or native soil horizon could be upwards of 10 feet in some places.

The Nature and Extent Conclusions presented in Section 4.4.2.4, on page 4-42 indicate that there is a single industrial exceedance of manganese in native soil outside of the trench.

The RFI/CMS Report does not substantiate that the clean fill/native soils proposed for reuse are sufficiently delineated, clean, or protective. Please revise the RFI/CMS Report to propose additional characterization of the soils to be reused either in place or after excavation but prior to reuse. Additionally, the RFI/CMS Report needs to clearly define the proposed reuse scenarios of which the proposed remedy will be protective. Finally, the RFI/CMS Report needs to present acceptable contaminant levels and basis for those site soils with contaminants above screening criteria to establish a definition for the term "clean."

**Response**

This level of detail is typically provided in the Interim Measures Work Plan (IMWP), rather than the Corrective Measures Study (CMS). The same strategy will be employed at SWMU 51 that was used in the EPA/VDEQ approved Building 4343 IMWP. Clean fill brought on to the site for site restoration was sampled at a rate of 1 composite sample per 1000 cubic yards. Four aliquots from separate areas were composited into each sample. The samples will be analyzed for TAL metals, TCL VOCs, TCL SVOCs, pesticides/PCBs and explosives. Results will be compared to residential RBCs and RFAAP 95% UTL background levels to ensure that the fill is acceptable. On site cover material will be sampled, analyzed and screened according to the same methodology. If the on site cover material does not pass the screening, additional fill will be brought onsite from an offsite borrow source (which will also be sampled, analyzed and screened in the same manner). The RFI/CMS is intended to address the investigation and/or remediation of a site to the current or reasonable anticipated future reuse of the property. The current and reasonably anticipated future reuse of the property is Industrial/Commercial. However, as part of the RFI/CMS, the Army will review analytical results and conduct a comparison to both industrial/commercial RBCs and unrestricted RBCs which will then be outlined in the CMS.

#### **Comment 5**

In the human health risk assessment (HHRA), risks and hazards associated with the cover soil and deep soil were apparently calculated in relation to the total soil risks and hazards (as noted in Appendix E-6, Tables E-6.2 through E-6.12.) It is not clear why separate risks and hazard estimates, including those for the separate exposure routes, were not calculated for the cover soil and deep soil. Please revise the HHRA to provide justification for calculating risks and hazards for the cover soil and deep soil only in relation to total soil, or revise the RFI/CMS Report to include the risk calculations for the individual exposure routes.

#### **Response**

The risks and hazards associated with the cover soil and deep soil were not intended to be part of the baseline risk assessment. The baseline risk assessment was based on exposures to surface and total soil (i.e., surface and subsurface soil down to depths typically contacted by residents). For SWMU 51, the total soil was defined as depths from 0 to 20 feet to conservatively include the samples collected from the sludge layer.

As proposed in the CMS, the remedy for SWMU 51 will be to remove the sludge layer. The cover soil is to be used as backfill and the deep soil is to remain in place. Therefore, the calculations for the cover soil and deep soil were provided as additional information for the CMS to demonstrate that the cover soil and deep soil would not pose unacceptable risk once the sludge layer was removed. Total risk and hazard were calculated for each receptor in proportion to the total baseline risk and hazards. By demonstrating that total risk and hazard were within acceptable limits, it was assumed that risk and hazard associated with individual exposure pathways were also acceptable.

#### **Comment 6**

The uncertainty section for the HHRA has not discussed uncertainties and/or limitations associated with several models that were used in this risk assessment, and in particular, the Johnson and Ettinger (J&E) model used to estimate indoor air concentrations from groundwater. Appendix G of the OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils, November 2002, describes a number of conditions that under most scenarios, would preclude use of the J&E model as implemented by EPA. One of these conditions includes contaminated groundwater sites with large fluctuations in the water table elevation. In these cases, the capillary fringe is likely to be contaminated, whereas in the groundwater source spreadsheets, the capillary fringe is assumed to be uncontaminated. Groundwater at the site was stated to fluctuate between 11 and 15 feet (ft) (Section 2.5, Site Hydrogeology, Page 2-14). 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. Additionally, please provide further justification for use of the J&E model for a site at which groundwater levels have fluctuated significantly in the past.

#### **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.” It is stated in Comment 6 that conditions at contaminated groundwater sites with large fluctuations in the water table elevation preclude the use of the J&E model because the capillary fringe is likely to be contaminated under such conditions. There are also several other assumptions, however, that are not likely to be met at SWMU 51. 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). These same conditions would likely preclude the use of the J&E model for SWMU 51 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.

**Comment 7**

Confirm that the Screening Level Ecological Risk Assessment (SLERA) applied Steps 1, 2, and 3a from the 1997 EPA Ecological Risk Assessment Guidance for Superfund as outlined in the “Final Process for Ecological Risk Assessment” (June 22, 2006).

**Response**

Comment Dropped per Will Geiger email on 2/29/08.

**Comment 8**

A two-tiered approach was used to calculate Exposure Point Concentrations (EPCs) in the SLERA. The first tier used “worst case” exposure and toxicity assumptions, whereas the second tier used less conservative parameters such as setting the chemicals of potential ecological concern (COPEC) EPCs equal to 95% Upper Confidence Limits (UCLs). Confirm that this follows the “Final Process for Ecological Risk Assessment, June 22, 2006 proposal.

**Response**

Comment Dropped per Will Geiger email on 2/29/08.

**Comment 9**

The RFI/CMS Report provided multiple statements about aquatic habitats and their receptors. However, all of the ecological receptors evaluated at SWMU 51 are terrestrial, not aquatic. Please review and update the text to eliminate all references to aquatic habitats or receptors in order to focus only on the receptors evaluated in this SLERA.

**Response**

Comment Dropped per Will Geiger email on 2/29/08. However, information about aquatic receptors will be removed from the report.

**SPECIFIC COMMENTS**

**Comment 10**

**Section 2.5, Site Hydrogeology, Page 2-14:** The first paragraph notes that the depth to groundwater at the site fluctuated between 11 and 15 feet during the period of July 2002 and

September 2003. The highest groundwater elevation provided in this paragraph is 1804.61 feet mean sea level (msl), recorded in well 51MW1 in July 2002. According to Figure 2-4, SWMU 51 Geologic Cross Section Line 1 – Line 1', the bottom of the sludge material is recorded at approximately 1810 feet msl. The RFI/CMS Report does not present groundwater elevation data for years other than 2002 and 2006, so it is unclear whether the groundwater table may have ever contacted the sludge at SWMU 51. Furthermore, the groundwater elevation data for the contours depicted on Figure 2-12, SWMU 51 Groundwater Contour Map, have not been provided. To substantiate the contours depicted on Figure 2-12 and to provide further clarity regarding the historical elevation of groundwater in relation to the elevation of the sludge, please provide a table summarizing historical and current groundwater elevation data for the SWMU 51 wells and those wells used to develop the contours on Figure 2-12. Additionally, please discuss why groundwater levels fluctuated as significantly as they did between 2002 and 2003, discuss rainfall totals for these 2 years with respect to the average rainfall total (i.e., discuss whether this was an average, wet, or dry year), and indicate whether such fluctuations have been noted in more recent years.

#### **Response**

Groundwater elevations will be added to Figure 2-12. A table with available groundwater elevation data will be added to the report. Groundwater was monitored monthly for one year as part of the *Current Conditions Report* in 2002 and 2003. This dataset is the most complete groundwater data available. Extremely heavy rainfall in June and July 2003 account for the highest water levels. A brief description will be added to the text and the *Current Conditions Report* will be referenced for a more detailed discussion of long term water level monitoring, rainfall and water budgets for Radford AAP. This information is not specific to SWMU 51; however, two of the wells used in that study are in similar geologic settings (B-3 and 74MW-7). The study includes hydrographs presenting water level elevation, precipitation, conductivity and temperature that demonstrates the relationship between precipitation and water levels.

#### **Comment 11**

**Section 2.6.3, RCRA Facility Investigation, Dames & Moore, 1992, Page 2-16:** The first paragraph mentions several wells that were sampled as part of the 1992 RFI, but several of these wells (such as wells 16-1, 16-3, MW9, etc.) are not shown on Figure 2-12. Since these wells are not shown, their relation to the site is unclear. Please revise the RFI/CMS Report to include a figure that shows the locations for all of those wells mentioned in Section 2.6.3, or for which analytical data have been provided.

#### **Response**

The text mentions all wells sampled by Dames and More during the 1992 RFI at SWMUs 28, 51 and 52. The tables provide results for wells that are relevant to SWMU 51. The text will be modified to only mention wells that are relevant to SWMU 51.

#### **Comment 12**

**Section 2.6.4, Facility-Wide Background Study, IT Corporation 2001, Page 2-16:** This section describes the facility-wide background study that characterized naturally-occurring inorganic concentrations in background soils and established a baseline for inorganic compounds of concern at the site. It is recommended that this section describe the number and location of background samples collected during this study. This information would ensure that the

background dataset used to calculate 95% Upper Tolerance Levels (UTLs) for the risk assessments was large enough to represent background conditions. In addition, contaminants that are present above screening concentrations (but below site-specific background concentrations) should be carried through the risk assessment. A comparison to background concentrations can be included in the risk characterization section.

**Response**

The background study has been reviewed and approved by EPA and VDEQ. This section does not state that that constituents were dropped from the risk assessment due to background. The risk assessments do not use background concentrations as criteria for dropping constituents. To avoid further confusion, the last sentence of the section will be changed

- from: *Inorganics detected at concentrations less than background levels are not considered site-related constituents in the Nature and Extent of Contamination Assessment (Section 4.0).*
- to: *Inorganics detected at concentrations less than background levels are not considered site-related constituents in the Nature and Extent of Contamination Assessment (Section 4.0), but are carried through the risk assessment process (Sections 6 and 7).*

**Comment 13**

**Section 3.1.1, Borings for Chemical Analysis, Page 3-2:** The second paragraph states that surface samples for volatile organic compound (VOC) analysis were collected from 0 to 1 feet below ground surface (bgs). This depth differs from that presented in the notes section of Table 3-1, 2004 RFI Environmental Samples and Analyses, which states that "VOCs were collected from a depth of 0.5-1.0 ft." Please revise the RFI/CMS Report to address this discrepancy.

**Response**

VOCs were collected from a depth of 0.5 to 1 ft bgs in surface soil samples. The text in Section 3.1.1 will be revised to correct this discrepancy.

**Comment 14**

**Section 3.1.6, Modifications to the Sampling Plan, Page 3-4:** This section describes "qualitative borings" that were advanced to delineate the northern and southern horizontal extents of the trench boundary. Boring logs and/or other field documentation for these borings have not been provided. Please provide field documentation for these borings to substantiate their use in defining the extent of the trench boundary.

**Response**

These borings were additions to the sampling plan and were simply advanced to visually assess whether trench sludge was present. They were stepped out from the trench until sludge was no longer present and the location of the last sample with sludge was noted. These borings were not continuously logged for lithologic purposes.

**Comment 15**

**Section 3.2, Eastern Horseshoe Area Groundwater Investigation, Shaw, 2006, and Section 3.3, 2007 Investigation Groundwater Sampling, Shaw, 2007, Pages 3-4 and 3-5:** Sample

logs from these groundwater sampling events have not been provided in the RFI/CMS Report. Typically, data and observations recorded on these logs may provide information relative to groundwater conditions at the site not necessarily discussed in the RFI/CMS Report. Further, sample logs can show that low-flow sampling techniques were adequately followed. Please provide the groundwater sample logs for the 2006 and 2007 groundwater sampling events.

**Response**

Monitoring well purge forms from these sampling events used to assess SWMU 51 groundwater will be added as Appendix B-4.

**Comment 16**

**Table 4-1, Analytes Detected in Clean Fill and/or Native Soil:** The laboratory qualifier designation for several inorganic analytes is shown as an asterisk (\*), but the legend for this table does not define the meaning of the asterisk. Please define the meaning of the asterisk in Table 4-1, and any other tables that utilize this symbol.

**Response**

The asterisk, as a laboratory qualifier, indicates that the laboratory duplicate was not within control limits. The meaning of the asterisk will be added to the table legend.

**Comment 17**

**Section 4.4.2.1, Eastern Horseshoe Area Groundwater Sampling, and Section 4.4.2.2, 2007 Investigation Groundwater Sampling, Page 4-39:** The last sentence for each of these sections states that dioxins/furans do not appear to be a concern in groundwater at the site, but the rationale for these statements has not been substantiated as risk associated with these contaminants had not been presented in the RFI/CMS Report at that point. Dioxin/furan congeners were detected in a site well (51MW1) and a downgradient well (48MW07), but screening criteria were not available for the congeners identified. Lack of screening criteria is not adequate justification for stating that dioxins/furans are not of concern. Please revise the RFI/CMS Report to reserve statements about the level of concern for dioxins/furans until after the risk assessment discussion is presented in the text.

**Response**

The sentences will be removed, as requested.

**Comment 18**

**Section 4.4.2.4, Nature and Extent Conclusions, Soil, Page 4-42:** It is stated that the "screening level of exceedances of explosives detected in soil below the trench sludge material are attributed to drag down of the paste-like sludge while advancing the direct push macrocore through the sludge layer." While this is a possibility, it is also possible that contaminants have migrated through the sludge layer over time. The RFI/CMS Report needs to acknowledge the possible migration of contaminants via means other than the direct push macrocore, or provide compelling data that documents the presented "drag-down" theory. Please revise the RFI/CMS Report to acknowledge potential vertical migration of the site contaminants beneath the sludge layer.

**Response**

The text regarding drag-down will be removed. The absence of explosives-related constituents in any of the downgradient groundwater monitoring wells is fairly compelling evidence that if any downward migration has occurred, it has been minor.

**Comment 19**

**Section 4.4.2.4, Nature and Extent Conclusions, Groundwater, Page 4-42:** It is stated that "concentrations of metals detected in downgradient wells are consistent with those detected in upgradient wells and do not appear to be a concern in groundwater at SWMU 51." The nature and extent evaluation has not included any groundwater data from upgradient wells, so this statement appears unsupported. Only 2006 and 2007 data from site wells 51MW1 and 51MW2 and downgradient wells 48MW07 and 59MW01 have been provided. Please revise the nature and extent evaluation to include recent groundwater data from upgradient wells to support the statement above.

**Response**

This sentence will be removed from Section 4.4.2.4. A more complete analysis of groundwater is provided in the Fate and Transport section of the report in Section 5.2.2. This section does include upgradient wells.

**Comment 20**

**Section 6.0, Table 6-1, SWMU 51 Samples:** It appears that the sample nomenclature included for the Deep Soil samples are incorrect. According to the data presented in Table 4-7, Analytes Detected in Soil Below Sludge Material and/or Deep Soil, the soil samples should all begin with "51SB" versus "515B." Additionally, samples 525B4D and 525B5D, noted in Table 6-1, could not be found in Table 4-7. It appears that these samples may actually be 51SB4D and 51SB5D. Please revise the nomenclature of the deep soil samples included in Table 6-1 to accurately reflect the sample IDs presented earlier in the RFI/CMS Report.

**Response**

The typographical error will be corrected.

**Comment 21**

**Section 6.1.1.1, Surface Soil and Total Soil, Page 6-3:** It is noted that surface soil includes those samples collected from 0 to 1 feet bgs and total soil includes those samples collected from 1 to 20 feet bgs. First, since the total soil includes both surface and subsurface soil, the depth for total soil should be described as 0 to 20 feet bgs. Additionally, it does not appear that all soil samples collected shallower than 20 feet bgs were included in the total soil grouping. Table 4-7 notes that sample 51SB5C was collected at a depth of 16 to 18 feet bgs, and sample 51SB6C was collected at a depth of 9 to 11 feet bgs but neither of these samples was included in the Total Soil grouping in Table 6-1. While it is noted that these samples were collected below the sludge layer, they were also collected at depths that may be accessible to a future receptor during construction or land development activities, as noted for the Total Soil grouping. Please revise the risk assessment to address how risk associated with these two samples (51SB5C and 51SB6C) will be adequately evaluated, if they are not included in the Total Soil grouping.

**Response**

Samples 51SB5C and 51SB6C were not included in the "total soil" group because they were collected below the sludge layer. The analytical results for these samples, however,

were evaluated to determine whether their inclusion in the "total soil" data set would have impacted the COPC selection process or the conclusions of the HHRA. It was determined that neither of these samples would have resulted in additional COPCs. The majority of the detected concentrations were below the respective screening criterion. For those results that exceeded screening criteria, the concentrations were well below the maximum detected concentration for that constituent in the data set. This explanation will be added to the text in Section 6.1.2.

#### **Comment 22**

**Section 6.1.2, Identification of COPCs, Page 6-4:** The third paragraph states that "analytes detected a maximum concentration greater than the corresponding adjusted RBC or screening values identified above (or those for which no screening criteria exists) were selected as COPCs." It is not clear what is meant by "screening values identified above" in this sentence. Detection limits for those constituents that were non-detect are compared to applicable screening criteria in Tables E1-3, E1-5, and E1-7, but the end-use of this evaluation is not clear. The text does not discuss this evaluation nor are those constituents for which screening criteria exceeded detection limits included as chemicals of potential concern (COPCs). Please revise the risk assessment to clarify how the evaluation of detection limits was used in this risk assessment and in particular, for selection of COPCs.

#### **Response**

The phrase "screening values above" refers to the discussion regarding screening values for nutrients and lead. Therefore, the first sentence in the third paragraph will be expanded to read: "Analytes detected in concentrations greater than the corresponding adjusted RBC or screening values for nutrients and lead identified above were selected as COPCs. Analytes for which no screening criteria exist were also selected as COPCs."

A discussion will be added regarding the detection limits that exceeded the screening criteria. This discussion will consider the potential impacts of high detection limits on the COPC selection process as well as the final conclusions.

#### **Comment 23**

**Section 6.2.3, Calculation of EPCs, Page 6-8:** It is noted that the volatilization model outlined in the American Society for Testing and Materials (ASTM) Risk-Based Corrective Action Guidance was used to calculate exposure point concentrations for VOCs in air. The input parameters and calculations for this model are presented in Appendix E-1, Table E.1-28; however, the sources for some of the site-specific parameters have not been provided. For example, values are provided for depth to groundwater, thickness of capillary fringe, and the width of the source area parallel to wind, but the sources for these values are not indicated. Additionally, the spreadsheet in Appendix E-1 titled "E1-28 table" presents a different depth to groundwater (1265 cm) than the depth to groundwater presented in spreadsheet "E1-28" (457 cm). Please revise the risk assessment to document the sources for the site-specific information that was used in the derivation of ambient air concentrations, and to address the discrepancy regarding the depth to groundwater values used in the calculations.

**Response**

The sources for site-specific parameters used in the ASTM Model will be provided. In addition, the input variable for depth to groundwater (457 cm) that is shown in the spreadsheet for Table E.1-28 will be corrected to match the input variable for depth to groundwater shown in Table E.1-28 (1,265 cm).

**Comment 24**

**Section 6.2.3, Calculation of EPCs, Page 6-8:** The depth to groundwater used in the derivation of indoor air concentrations with the J&E model (1003 cm) differs from that used in the derivation of ambient air concentrations with the ASTM Risk-Based Corrective Action Guidance (either 1265 cm or 457 cm, depending on the table). Please revise the risk assessment to address this discrepancy. Additionally, please provide sources for the site-specific information used in the J&E model.

**Response**

The depth to groundwater at SWMU 51 was measured from 32.91 ft to 50.07 ft. The J&E model was used to estimate concentrations of volatile COPCs in indoor air as a result of migration from groundwater into the building via vapor intrusion. For the J&E model, it was conservatively assumed that a building could hypothetically be constructed in an area with the shallower groundwater (e.g., 32.91 ft or 1,003 cm). Because the ASTM model estimates concentrations of volatile COPCs that have migrated from groundwater into ambient air, exposures could vary across SWMU 51 due to the differences in depths to groundwater. Therefore, the average depth to groundwater (41.5 ft or 1,265 cm) was used for the ASTM model. As stated in the response to Comment 23, the input variable for depth to groundwater (457 cm) that is shown in the spreadsheet for Table E.1-28 will be corrected to match the input variable for depth to groundwater shown in Table E.1-28 (1,265 cm).

**Comment 25**

**Section 6.2.4, Quantification of Exposures: Calculation of Daily Intakes, Page 6-8:** The intake calculation for the dermal absorption pathway requires a chemical-specific dermal absorption factor ( $ABS_d$ ). Table E1-25 of Appendix E includes a list of the dermal absorption factors, but it does not appear to include all COPCs that were evaluated in the risk characterization. For example, dermal absorption factors are not provided for 2-amino-4,6-dinitrotoluene and 4,6-dinitro-o-cresol, both of which were identified as COPCs for total soil (Table E1-9). Chemical intakes have been calculated for these two constituents, but without the dermal absorption factors used for these constituents, the intakes could not be replicated. Please revise the risk assessment to provide dermal absorption factors for 2-amino-4,6-dinitrotoluene and 4,6-dinitro-o-cresol.

**Response**

Dermal absorption factors for 2-amino-4,6-dinitrotoluene (0.6%) and 4,6-dinitrocresol (10%) will be added to Table E.1-25.

**Comment 26**

**Appendix E-6, Tables E-6.2 through E-6.6:** These tables are supposed to summarize the risks and hazards associated with the cover soil. However, the last two columns in these tables, "Cover Soil Risk" and "Cover Soil HI" (hazard index), are both marked with notes that refer to

the calculation of the deep soil Risk and HI. A description of how the cover soil risk and cover soil HI were calculated has not been provided. Please revise Tables E-6.2 through E-6.6 to clarify this discrepancy, and provide a description of how the cover soil risk and HI were calculated.

**Response**

In Tables E.6-2 through E.6-6, both notes "a" and "b" should refer to cover soil rather than deep soil. The typographical error will be corrected. As described in the response to General Comment 5, the risks and hazard indices for the cover soil were calculated proportionally to the risks and hazard indices for total soil.

**Comment 27**

**Table 6-4, Summary of Risks and Hazards, SWMU 51 – Deep Soil:** This table summarizes risk and HI for the future maintenance worker, future industrial worker, and future excavation worker, but it does not include all of the receptors that were evaluated in Appendix E-6, Tables E-6.8 through E-6.12. These tables also include risk and HI calculations for the future lifetime resident and child resident, yet these results are not included in the Table 6-4 summary. In particular, the HI for the future child resident is 4.1. Please revise the HHRA to address this oversight.

**Response**

The depths that were evaluated at SWMU 51 for the residential scenario were 0 to 20 feet. With the exception of samples 51SB5C and 51SB6C, deep soil samples were collected from 30 to 38 feet. The results were not shown in Table 6-4 because residents would not be expected to contact the deep soil at SWMU 51. Summaries of risk and hazards associated with hypothetical exposures to deep soil (Tables E.6-11 and E.6-12), however, were included for completeness. While the total hazard associated with child resident exposures to deep soil (4.1) exceeded 1.0, none of the HIs for individual COPECs exceeded 1.

**Comment 28**

**Section 6.6, HHRA Summary and Conclusions, Page 6-28:** The last sentence of this page states, "Because the deep soil is below 15 feet, no residential exposure to deep soil is anticipated." As previously noted, sample 51SB6C was collected at a depth of 9 to 11 feet bgs, but was included as a deep soil sample for the risk calculations since it was collected below the sludge layer. Please revise the conclusions to acknowledge that not all of the deep samples were collected below 15 feet. Exposures should be evaluated accordingly.

**Response**

The conclusions will be revised to acknowledge that sample 51SB6C was collected at a depth of 9 to 11 feet bgs because it was collected at a location below the sludge layer.

**Comment 29**

**Section 7.2.5, Selection of COPECs, 1st paragraph, Page 7-13:** The last sentence in this paragraph states, "For food chain exposure pathways, detected COPECs were selected unless they were not important bioaccumulative constituents." This sentence was followed by a citation for the EPA 2001 document, Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. A review of this guidance document found no reference to removing chemicals from food chain modeling based on whether or not they were bioaccumulative

compounds. More fundamentally, the chemicals assessed in the food chain modeling should be those identified as COPECs, irrespective of bioaccumulation concerns. Please revise the text and update the food chain modeling accordingly.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 30**

**Section 7.5.2, Bioaccumulation and Bioconcentration Factors, 2<sup>nd</sup> paragraph, Page 7-20:**

This paragraph states that the soil-to-plant BAF/BCF (bioaccumulation factors/bioconcentration factors) were based on information from six different literature sources. However, there was no explanation on how a specific value was selected. For example, if more than one source had a value for a particular chemical, a set of criteria must have been used to select one value over the others. The 1997 EPA Ecological Risk Assessment Guidance for Superfund states that the most conservative (i.e., highest) bioaccumulation factor reported in the literature should be used in a SLERA. Please add a table that summarizes the values available from each source and highlight the values chosen for use in the risk assessment. Text also needs to be added to Section 7.5.2 explaining the selection hierarchy and decision points.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 31**

**Section 7.2.5, Selection of COPECs, Page 7-13:** This section needs to clearly state that the COPEC selection process being performed is a two track process. One track selects COPECs for food chain modeling and the other track selects COPECs for direct contact exposure. Please revise this section to more clearly explain the two methods used for COPEC selection.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 32**

**Section 7.2, Identification of COPECs and Concentration Statistics, Table 7-4 (Surface Soil Samples used in the SWMU 51 SLERA), Page 7-6:** Table 7-4 summarizes all of the soil samples used in the SLERA. Two duplicate samples (TMSB1A and TMSB8A) listed in Table 7-4 were not found in Table 4-1, Analytes Detected in Clean Fill and/or Native Soil. Also, Section 7.2 does not discuss how duplicate samples were handled during the COPECs selection process (e.g., averaged with the original sample). Please add these samples to Table 4-1 and include an explanation to Section 7.2 on how duplicate samples were handled.

**Response**

Comment Dropped per Will Geiger email on 2/29/08. In the HHRA and SLERA, duplicate/sample pairs are averaged in accordance with established methodologies. Duplicate samples are considered QC samples (along with rinse blanks, trip blanks, MS/MSDs, etc.) and are used as part of the data validation process to apply validation qualifiers to the data. Results from QC samples are reported in the **Appendix A – Quality Assurance/Quality Control**. Because they are not environmental samples, they are not discussed in the Nature and Extent of Contamination section.

**Comment 33**

**Section 7.4, Identification of Assessment and Measurement Endpoints, Page 7-17:** This section describes the assessment and measurement endpoints selected for this SLERA. This section could be significantly improved by adding a table that clearly organizes the assessment endpoints and the associated measurement endpoints selected for each ecological receptor evaluated in the SLERA.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 34**

**Section 7.5.1, Intake, Page 7-20:** This section states that, "conservative Tier 1 exposures were based on maximum dietary intake, maximum incidental soil intake, minimum body weight, 100 percent site exposure, and the use of the maximum detected concentrations." The 1997 EPA Ecological Risk Assessment Guidance states that for species that feed on more than one type of food, the screening-level assumption should be that the diet is composed entirely of whichever type of food is most contaminated. Please revise the food chain modeling for the American Robin and Red Fox in light of this guidance.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 35**

**Section 7.5.1, Intake, Equation, Page 7-20:** The dose equation shown on page 7-20 is missing the soil ingestion rate exposure parameter. Please correct this equation. It was noted that the exposure equations used in Tables F-5 through F-14 did incorporate the soil ingestion rate.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 36**

**Section 7.2.2, Descriptive Statistical Calculations, Page 7-6:** This section indicates that the 95% UCL of the mean was calculated for chemicals selected as COPECs. However, there was no discussion on how these values were calculated (i.e., Pro UCL 4.0 software or other means). Text needs to be added describing how the 95% UCL values were obtained. In addition, a new summary table should be provided that shows all of the calculated 95% UCL values and the statistical test used to derive each value. It is important to make sure the data sets have less than 70% non-detects and a minimum of eight detected values if a software program like Pro UCL 4.0 is used to calculate the 95% UCL. The 95% UCL value is considered unreliable if the data set does not meet both of these conditions.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 37**

**Section 7.7.2, Predictive Risk Estimation for Terrestrial Wildlife and Aquatic Wildlife, Page 7-23:** This section states that, "the criterion used to decide if HQ summation is appropriate and scientifically defensible includes those chemicals that have a similar mode of toxicity." The

summation of HQs was not based on chemicals with similar modes of toxicity, but in fact were simply the sum of all HQs calculated for a particular receptor. Please remove this statement.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 38**

**Tables F-5 through F-14, Chemicals of Potential EEQs and Hazard Indices:** All of these tables contain a column titled "Chemical-Specific Toxicity Value UF" and the values in this column are used to adjust the NOAEL and LOAEL values. A footnote is not provided describing the source for these values. There is also no discussion of these values in Section 7.6.2, Development of TRVs. Please add a footnote to these tables supplying the source and a detailed explanation of the "Chemical-Specific Toxicity Value UF" and its purpose to Section 7.6.2.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 39**

**Section 7.3.1, Terrestrial Receptors, 1<sup>st</sup> paragraph, Page 7-15:** This paragraph introduces the five representative wildlife receptor species for the site. There was a note referring to terrestrial plants. However, plants are not discussed in detail until Section 7.7.1, Terrestrial Plant Impact Assessment. Please add text stating that terrestrial plants will be discussed in a later section of the SLERA.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 40**

**Table 7-8, Wildlife EEQ Hazard Summary for SWMU 51, Page 7-25:** This table summarizes the HIs calculated by Tier 1 and Tier 2 methods for each receptor. The column headings under Tier 1 and Tier 2 were labeled as "NOAEL-Based EEQ" and "LOAEL-Based EEQ", however the values in these columns are the total EEQ or HI for each receptor. The column heading would be more accurate if "EEQ" was changed to either "total EEQ" or "Hazard Index." Please make the change indicated.

**Response**

Comment Dropped per Will Geiger email on 2/29/08

**Comment 41**

**List of Acronyms and Abbreviations, Page viii:** The list of acronyms and abbreviations defines "EEQ" as "environmental effects quotient" but several tables such as Table 7-8, Wildlife EEQ Hazard Summary for SWMU 51, have a footnote that defines "EEQ" as "ecological effects quotient." Please ensure that the acronym is consistent throughout the tables and text.

**Response**

Comment Dropped per Will Geiger email on 2/29/08; however, EEQ will be consistently defined in the list of acronyms and the tables.

**Comment 42**

**Table 7.2, Species Inventory within RFAAP's Grassland Community Type, Page 7-5:** Please remove fish from this table because it is not a species found in the grasslands.

**Response**

Comment Dropped per Will Geiger email on 2/29/08; however, fish will be removed from the table.

**Comment 43**

**Pagination between page 7-6 and 7-13:** Section 7.2.2, Descriptive Statistical Calculations, begins on page 7-6 and continues onto the next page which is number 7-13. Please fix the pagination in this section.

**Response**

A review of the pagination between page 7-6 and 7-13 indicates that the pagination is correct. Tables and figures are counted in the pagination. No changes in pagination are necessary.

**Comment 44**

**Section 9.2, Alternative Two – Institutional Controls (Land Use Controls, Groundwater Monitoring), Page 9-1:** The first paragraph indicates that the components of alternative two would include monitoring well installation. This activity does not appear to have been included in costs associated with this alternative, as shown on Table 9-1. Please revise the RFI/CMS Report to address this discrepancy.

**Response**

The phrase "monitoring well installation" will be removed from the text. Section 9.2 – subsection *Long Term Monitoring of Site Conditions* lists the existing monitoring wells that will be used as monitoring points. Note that alternative 2 was not the selected remedy based on cost and this change will not affect the outcome of the selection process.

**Comment 45**

**Section 9.2, Alternative Two – Institutional Controls (Land Use Controls, Groundwater Monitoring), Page 9-1:** The last paragraph on Page 9-1 indicates that the long-term sampling plan for SWMU 51 would include annual monitoring of groundwater collected from existing wells. However, later paragraphs describe bi-annual monitoring, and Table 9-1 includes cost estimates for semi-annual monitoring. Please revise the RFI/CMS Report to consistently report the proposed groundwater monitoring schedule, and assure that the cost estimate reflects the proposed schedule. Please also provide rationale for the proposed monitoring schedule.

**Response**

The last paragraph on Page 9-1 will be changed to read semiannual monitoring instead of annual monitoring. According to the Houghton Mifflin e-Reference Online Dictionary, biannual and semiannual both refer to an event that happens twice a year. As noted above, Alternative 2 was not the selected remedy for the site.

**Response to Comments**  
**from Ruth Prince, USEPA Ecological Risk Assessor**  
**Dated 17 June 2008**  
**for**

**Draft Final SWMU 51 RFI/CMS Report**  
**Dated January 2008**

***Comment 1 Tables 7-6, Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at SWMU 51 and 7-9, Direct Toxicity Evaluation for Surface Soil at SWMU 51***

A number of explosives were detected in the SWMU 51 surface soil, some at fairly high concentrations, which are characteristic of the waste that was disposed of in SWMU 51. However, they were not evaluated in this ecological risk assessment because there were no identified wildlife Toxicity Reference Values (TRVs) or readily available screening values for direct toxicity to soil organisms or plants. However, despite the apparent lack of screening values, these chemicals which are truly SWMU-specific must still be evaluated for direct and wildlife toxicity. Besides literature searches and/or the use of surrogates, the U.S. Army Center for Health Promotion and Prevention Medicine has developed wildlife TRVs for numerous contaminants including the explosives and nitroglycerin. Please revise accordingly; the TRVs may be accessed at <http://chppm-www.apgea.army.mil/crawg/tox/>.

**Response**

The CMS portion of the report recommends a remedial action at the site. The selected remedy is removal of the trench sludge and grossly contaminated soil with offsite disposal. Some of the clean cover material will be used as fill for the excavation once the RGs have been met. The soil used to backfill the excavation (both the clean cover material and offsite borrow material) will be sampled prior to backfilling to ensure that only clean fill is used. Since the explosive compounds were detected within the footprint of the proposed excavation, the proposed remediation is expected to be protective of environment as well as human health.

Plant and invertebrate eco-SLs in the attached table, prepared by URS for the similar Radford SWMU 54 RFI ecological risk assessment comment, will be used to evaluate explosives in the direct contact assessment in future RFI reports for sites where explosives have been detected.

In the food chain model portion of the SLERA, only those chemicals identified as bioaccumulators, per USEPA's (2000) list of recommended bioaccumulators are included. Explosives are not on this list; therefore they are not included in the food chain model. The agreement between the Army and EPA/VDEQ to only model bio-accumulators was reached while the EPA CERCLA division and BTAG were involved in the project.

Please note that the ecological risk assessment for the SWMU 48 RFI, which will be submitted to EPA/VDEQ for review in August 2008, has already been completed. In order to maintain the project schedule, we would prefer to submit this draft 48 RFI/CMS for review and make this change prior to submittal of the final RFI if a No Further Action alternative is selected for this site.

*Comments from Jim Cutler, VDEQ* [Note: This comment was received verbally during a discussion between Jim Cutler, VDEQ and Tim Leahy, Shaw Environmental on 8/6/2008]

**Comment 1** –Some of the language regarding Land Use controls that was discussed in the June 2008 Partnering Meeting did not make it into the text of Section 9.3 of the RFI/CMS.

**Response**

The following changes (noted in italics) will be made to Section 9.3 to reflect the Partnering Meeting discussion.

- 1) Section Title will be changed to: **Alternative Three – Excavation of Sludge and Grossly Contaminated Soil and Off-site Disposal with Land Use Controls and no Long Term Monitoring**
- 2) The following will be added to the first paragraph of Section 9.3:

This alternative involves excavation of sludge and grossly contaminated soil (see *Section 8.0*). The results of the SWMU 51 soil investigations indicate that the trench sludge material consisted of a black, paste-like sludge material that was very evident when encountered. It is a very sticky substance that exhibits a sweet odor. Therefore, identification and removal of the sludge material and grossly contaminated soil will be based on visual observations during excavation. *Remedial Goals, as defined in Section 8.2, will be used to verify the concentrations of the COIs in confirmation samples after removal of the trench sludge and grossly contaminated soil.*
- 3) The following subsections will be added to the end of section 9.3:

**Land Use Controls.** *SWMU 51 is located in an active magazine area and several other SWMUs are in the immediate vicinity, making any development of this area extremely unlikely. In addition, RFAAP is revising its policy to enhance the use of management controls in conjunction with physical controls that can further limit access to this portion of the installation.*

**Long Term Monitoring.** *Based on the analysis of groundwater data at the site and the distribution of COIs in soil; and, per agreements with the USEPA and VDEQ, no long term monitoring is required for this site.*

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

**SUBJECT:** Radford Ammunition Plant SWMU 51                      June 13, 2008  
RFI/CMS Ecological Risk Assessment                      Revised June 17, 2008  
**FROM:** Ruth Prince, Toxicologist  
Technical Support Branch  
**TO:** Will Geiger, RPM  
General Operations Branch

Tables 7-6, Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at SWMU 51 and 7-9, Direct Toxicity Evaluation for Surface Soil at SWMU 51 –

A number of explosives were detected in the SWMU 51 surface soil, some at fairly high concentrations, which are characteristic of the waste that was disposed of in SWMU 51. However, they were not evaluated in this ecological risk assessment because there were no identified wildlife Toxicity Reference Values (TRVs) or readily available screening values for direct toxicity to soil organisms or plants. However, despite the apparent lack of screening values, these chemicals which are truly SWMU-specific must still be evaluated for direct and wildlife toxicity. Besides literature searches and/or the use of surrogates, the U.S. Army Center for Health Promotion and Prevention Medicine has developed wildlife TRVs for numerous contaminants including the explosives and nitroglycerin. Please revise accordingly; the TRVs may be accessed at <http://chppm-www.apgea.army.mil/erawg/tox/>.



## Leahy, Timothy

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**From:** Geiger.William@epamail.epa.gov  
**Sent:** Friday, February 29, 2008 2:02 PM  
**To:** McKenna, Jim J Mr CIV USA AMC; Geiger.William@epamail.epa.gov; anne.greene@atk.com; dennis.druck@us.army.mil; beth lohman; jim spencer; Parks, Jeffrey; jerome.redder@atk.com; jlcutler@deq.virginia.gov; Mendoza, Richard R Mr CIV USA SA; Leahy, Timothy; Tina\_Devine@URSCorp.com; Llewellyn, Tim  
**Subject:** SWMU 51

Here is the written form of Jim's comment for SWMU 51, I wasn't sure if everyone saw it. As I said, you can pretty much combine this with your response to Comment #3 on the other sheet.

I guess for now, we'll take the eco comments off the table (7,8,9, 29-40, pretty much anything to do with Section 7) until I can get that whole issue resolved. Feel free to respond to the others though.

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

----- Forwarded by William Geiger/R3/USEPA/US on 02/29/2008 01:51 PM

"Cutler,Jim"  
<jlcutler@deq.virginia.gov>  
To  
William Geiger/R3/USEPA/US@EPA  
02/25/2008 04:28 PM  
cc  
Subject  
SWMU 51

Will,

Based on my review of the RFI/CMS for SWMU 51 I concur with the proposed remedy. The characterization of soil and groundwater appears to be sufficient. My main concern involves the implementation of the remedy. On Figure 2-4 some of the "c" labeled samples (B2, B3, B4) are categorized as sludge material and/or grossly contaminated soil. Other "c" samples (B5, B6) are grouped as below sludge or deep soil. The report indicates that this distinction was made based on visual observation at the time the samples were collected. The proposed remedy involves soil removal based on visual observation. I think some confirmation sampling should be required especially in light of the fact that most of these samples were collected from the river jack layer. I would expect that visual delineation in this gravel/sand would be difficult since you would expect contamination to be easily transported

through this material.

Thanks,

Jim

James L. Cutler Jr.  
Federal Facilities Project Manager  
Office of Remediation Programs  
Virginia Dept. of Environmental Quality  
804-698-4498

2/25/08

Draft EPA comments on the *SWMU 51 RCRA Facility Investigation / Corrective Measures Study Report, Draft Final Document*, Radford Army Ammunition Plant, Virginia, dated January 2008 (RFI/CMS Report).

## **GENERAL COMMENTS**

1. The geologic cross sections provided as Figures 2-4 through 2-11 include the letters A, B, C, and/or D on several of the borings. The legends of the figures do not describe the meanings of these letters. Subsequent sections of the RFI/CMS Report appear to indicate that these letters correspond to samples that were collected from the borings. However, for clarity, please define the meaning of the letters A through D in the legends of the geologic cross section figures.
2. Section 4.0, Nature and Extent of Contamination, does not include any visual representations of the nature and extent of contamination at SWMU 51. A plan view map with concentrations of contaminants identified by sample location would be useful to show the horizontal distribution of contaminants within the trench. Vertical profiles or cross-sections may be useful to show the distribution of contaminants at depth. A similar approach would also be useful for depicting groundwater contamination. Please revise the RFI/CMS Report to include figures or other visual representations of the nature and extent of contamination at the SWMU 51. Assessment and determination of nature and extent of contamination may not be possible until the requested figures are provided.
3. The RFI /CMS Report proposes a site-specific corrective measure objective in Section 8.3 on page 8-2 of an excavation standard consisting of the visual observation of the black, paste-like sludge material which exhibits a sweet odor. Although initial excavation limits may be able to be achieved via a visual standard, definitive remedial objectives need to be established so that the excavation limits may be sampled to verify achievement of the stated remedial standard. Please revise the RFI/CMS Report to establish a definitive remedial standard.
4. The RFI/CMS Report proposes the re-use of the "Clean Fill and/or Native Soil" in Section 9.3, on Page 9-8, under the heading "Site Restoration." The RFI/CMS Report indicates that clean materials from the top of the excavation will be placed back in the trench. Section 9.3 further indicates on page 9-4 that the excavation alternative will not require land use controls. It is unclear if this statement applies to industrial or residential exposures.

Figure 4-1 identifies all the sample locations where residential or industrial screening levels were exceeded. Four locations are identified on Figure 4-1

for the clean fill and/or native soil horizon with one or more exceedance. All of the data used for the assessment of the clean fill and/or native soil horizon was collected from the initial 1 foot of soil, while the thickness of this clean fill and/or native soil horizon could be upwards of 10 feet in some places.

The Nature and Extent Conclusions presented in Section 4.4.2.4, on page 4-42 indicate that there is a single industrial exceedance of manganese in native soil outside of the trench.

The RFI/CMS Report does not substantiate that the clean fill/native soils proposed for reuse are sufficiently delineated, clean, or protective. Please revise the RFI/CMS Report to propose additional characterization of the soils to be reused either in place or after excavation but prior to reuse. Additionally, the RFI/CMS Report needs to clearly define the proposed reuse scenarios of which the proposed remedy will be protective. Finally, the RFI/CMS Report needs to present acceptable contaminant levels and basis for those site soils with contaminants above screening criteria to establish a definition for the term “clean.”

5. In the human health risk assessment (HHRA), risks and hazards associated with the cover soil and deep soil were apparently calculated in relation to the total soil risks and hazards (as noted in Appendix E-6, Tables E-6.2 through E-6.12.) It is not clear why separate risks and hazard estimates, including those for the separate exposure routes, were not calculated for the cover soil and deep soil. Please revise the HHRA to provide justification for calculating risks and hazards for the cover soil and deep soil only in relation to total soil, or revise the RFI/CMS Report to include the risk calculations for the individual exposure routes.
6. The uncertainty section for the HHRA has not discussed uncertainties and/or limitations associated with several models that were used in this risk assessment, and in particular, the Johnson and Ettinger (J&E) model used to estimate indoor air concentrations from groundwater. Appendix G of the *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*, November 2002, describes a number of conditions that under most scenarios, would preclude use of the J&E model as implemented by EPA. One of these conditions includes contaminated groundwater sites with large fluctuations in the water table elevation. In these cases, the capillary fringe is likely to be contaminated, whereas in the groundwater source spreadsheets, the capillary fringe is assumed to be uncontaminated. Groundwater at the site was stated to fluctuate between 11 and 15 feet (ft) (Section 2.5, Site Hydrogeology, Page 2-14). 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. Additionally, please provide further justification for use of the

J&E model for a site at which groundwater levels have fluctuated significantly in the past.

7. Confirm that the Screening Level Ecological Risk Assessment (SLERA) applied Steps 1, 2, and 3a from the 1997 EPA Ecological Risk Assessment Guidance for Superfund as outlined in the “Final Process for Ecological Risk Assessment” (June 22, 2006).
8. A two-tiered approach was used to calculate Exposure Point Concentrations (EPCs) in the SLERA. The first tier used “worst case” exposure and toxicity assumptions, whereas the second tier used less conservative parameters such as setting the chemicals of potential ecological concern (COPEC) EPCs equal to 95% Upper Confidence Limits (UCLs). Confirm that this follows the “Final Process for Ecological Risk Assessment, June 22, 2006 proposal.
9. The RFI/CMS Report provided multiple statements about aquatic habitats and their receptors. However, all of the ecological receptors evaluated at SWMU 51 are terrestrial, not aquatic. Please review and update the text to eliminate all references to aquatic habitats or receptors in order to focus only on the receptors evaluated in this SLERA.

## **SPECIFIC COMMENTS**

10. **Section 2.5, Site Hydrogeology, Page 2-14:** The first paragraph notes that the depth to groundwater at the site fluctuated between 11 and 15 feet during the period of July 2002 and September 2003. The highest groundwater elevation provided in this paragraph is 1804.61 feet mean sea level (msl), recorded in well 51MW1 in July 2002. According to Figure 2-4, SWMU 51 Geologic Cross Section Line 1 – Line 1’, the bottom of the sludge material is recorded at approximately 1810 feet msl. The RFI/CMS Report does not present groundwater elevation data for years other than 2002 and 2006, so it is unclear whether the groundwater table may have ever contacted the sludge at SWMU 51. Furthermore, the groundwater elevation data for the contours depicted on Figure 2-12, SWMU 51 Groundwater Contour Map, have not been provided. To substantiate the contours depicted on Figure 2-12 and to provide further clarity regarding the historical elevation of groundwater in relation to the elevation of the sludge, please provide a table summarizing historical and current groundwater elevation data for the SWMU 51 wells and those wells used to develop the contours on Figure 2-12. Additionally, please discuss why groundwater levels fluctuated as significantly as they did between 2002 and 2003, discuss rainfall totals for these 2 years with respect to the average rainfall total (i.e., discuss whether this was an average, wet, or dry year), and indicate whether such fluctuations have been noted in more recent years.

11. **Section 2.6.3, RCRA Facility Investigation, Dames & Moore, 1992, Page 2-16:** The first paragraph mentions several wells that were sampled as part of the 1992 RFI, but several of these wells (such as wells 16-1, 16-3, MW9, etc.) are not shown on Figure 2-12. Since these wells are not shown, their relation to the site is unclear. Please revise the RFI/CMS Report to include a figure that shows the locations for all of those wells mentioned in Section 2.6.3, or for which analytical data have been provided.
12. **Section 2.6.4, Facility-Wide Background Study, IT Corporation 2001, Page 2-16:** This section describes the facility-wide background study that characterized naturally-occurring inorganic concentrations in background soils and established a baseline for inorganic compounds of concern at the site. It is recommended that this section describe the number and location of background samples collected during this study. This information would ensure that the background dataset used to calculate 95% Upper Tolerance Levels (UTLs) for the risk assessments was large enough to represent background conditions. In addition, contaminants that are present above screening concentrations (but below site-specific background concentrations) should be carried through the risk assessment. A comparison to background concentrations can be included in the risk characterization section.
13. **Section 3.1.1, Borings for Chemical Analysis, Page 3-2:** The second paragraph states that surface samples for volatile organic compound (VOC) analysis were collected from 0 to 1 feet below ground surface (bgs). This depth differs from that presented in the notes section of Table 3-1, 2004 RFI Environmental Samples and Analyses, which states that “VOCs were collected from a depth of 0.5-1.0 ft.” Please revise the RFI/CMS Report to address this discrepancy.
14. **Section 3.1.6, Modifications to the Sampling Plan, Page 3-4:** This section describes “qualitative borings” that were advanced to delineate the northern and southern horizontal extents of the trench boundary. Boring logs and/or other field documentation for these borings have not been provided. Please provide field documentation for these borings to substantiate their use in defining the extent of the trench boundary.
15. **Section 3.2, Eastern Horseshoe Area Groundwater Investigation, Shaw, 2006, and Section 3.3, 2007 Investigation Groundwater Sampling, Shaw, 2007, Pages 3-4 and 3-5:** Sample logs from these groundwater sampling events have not been provided in the RFI/CMS Report. Typically, data and observations recorded on these logs may provide information relative to groundwater conditions at the site not necessarily discussed in the RFI/CMS Report. Further, sample logs can show that low-flow sampling techniques were adequately followed. Please provide the groundwater sample logs for the 2006 and 2007 groundwater sampling events.

16. **Table 4-1, Analytes Detected in Clean Fill and/or Native Soil:** The laboratory qualifier designation for several inorganic analytes is shown as an asterisk (\*), but the legend for this table does not define the meaning of the asterisk. Please define the meaning of the asterisk in Table 4-1, and any other tables that utilize this symbol.
17. **Section 4.4.2.1, Eastern Horseshoe Area Groundwater Sampling, and Section 4.4.2.2, 2007 Investigation Groundwater Sampling, Page 4-39:** The last sentence for each of these sections states that dioxins/furans do not appear to be a concern in groundwater at the site, but the rationale for these statements has not been substantiated as risk associated with these contaminants had not been presented in the RFI/CMS Report at that point. Dioxin/furan congeners were detected in a site well (51MW1) and a downgradient well (48MW07), but screening criteria were not available for the congeners identified. Lack of screening criteria is not adequate justification for stating that dioxins/furans are not of concern. Please revise the RFI/CMS Report to reserve statements about the level of concern for dioxins/furans until after the risk assessment discussion is presented in the text.
18. **Section 4.4.2.4, Nature and Extent Conclusions, Soil, Page 4-42:** It is stated that the “screening level of exceedances of explosives detected in soil below the trench sludge material are attributed to drag down of the paste-like sludge while advancing the direct push macrocore through the sludge layer.” While this is a possibility, it is also possible that contaminants have migrated through the sludge layer over time. The RFI/CMS Report needs to acknowledge the possible migration of contaminants via means other than the direct push macrocore, or provide compelling data that documents the presented “drag-down” theory. Please revise the RFI/CMS Report to acknowledge potential vertical migration of the site contaminants beneath the sludge layer.
19. **Section 4.4.2.4, Nature and Extent Conclusions, Groundwater, Page 4-42:** It is stated that “concentrations of metals detected in downgradient wells are consistent with those detected in upgradient wells and do not appear to be a concern in groundwater at SWMU 51.” The nature and extent evaluation has not included any groundwater data from upgradient wells, so this statement appears unsupported. Only 2006 and 2007 data from site wells 51MW1 and 51MW2 and downgradient wells 48MW07 and 59MW01 have been provided. Please revise the nature and extent evaluation to include recent groundwater data from upgradient wells to support the statement above.
20. **Section 6.0, Table 6-1, SWMU 51 Samples:** It appears that the sample nomenclature included for the Deep Soil samples are incorrect. According to the data presented in Table 4-7, Analytes Detected in Soil Below Sludge Material and/or Deep Soil, the soil samples should all begin with “51SB” versus “515B.” Additionally, samples 525B4D and 525B5D, noted in Table 6-1, could not be found in Table 4-7. It appears that these samples may actually be 51SB4D and

51SB5D. Please revise the nomenclature of the deep soil samples included in Table 6-1 to accurately reflect the sample IDs presented earlier in the RFI/CMS Report.

21. **Section 6.1.1.1, Surface Soil and Total Soil, Page 6-3:** It is noted that surface soil includes those samples collected from 0 to 1 feet bgs and total soil includes those samples collected from 1 to 20 feet bgs. First, since the total soil includes both surface and subsurface soil, the depth for total soil should be described as 0 to 20 feet bgs. Additionally, it does not appear that all soil samples collected shallower than 20 feet bgs were included in the total soil grouping. Table 4-7 notes that sample 51SB5C was collected at a depth of 16 to 18 feet bgs, and sample 51SB6C was collected at a depth of 9 to 11 feet bgs but neither of these samples was included in the Total Soil grouping in Table 6-1. While it is noted that these samples were collected below the sludge layer, they were also collected at depths that may be accessible to a future receptor during construction or land development activities, as noted for the Total Soil grouping. Please revise the risk assessment to address how risk associated with these two samples (51SB5C and 51SB6C) will be adequately evaluated, if they are not included in the Total Soil grouping.
22. **Section 6.1.2, Identification of COPCs, Page 6-4:** The third paragraph states that “analytes detected a maximum concentration greater than the corresponding adjusted RBC or screening values identified above (or those for which no screening criteria exists) were selected as COPCs.” It is not clear what is meant by “screening values identified above” in this sentence. Detection limits for those constituents that were non-detect are compared to applicable screening criteria in Tables E1-3, E1-5, and E1-7, but the end-use of this evaluation is not clear. The text does not discuss this evaluation nor are those constituents for which screening criteria exceeded detection limits included as chemicals of potential concern (COPCs). Please revise the risk assessment to clarify how the evaluation of detection limits was used in this risk assessment and in particular, for selection of COPCs.
23. **Section 6.2.3, Calculation of EPCs, Page 6-8:** It is noted that the volatilization model outlined in the American Society for Testing and Materials (ASTM) Risk-Based Corrective Action Guidance was used to calculate exposure point concentrations for VOCs in air. The input parameters and calculations for this model are presented in Appendix E-1, Table E.1-28; however, the sources for some of the site-specific parameters have not been provided. For example, values are provided for depth to groundwater, thickness of capillary fringe, and the width of the source area parallel to wind, but the sources for these values are not indicated. Additionally, the spreadsheet in Appendix E-1 titled “E1-28 table” presents a different depth to groundwater (1265 cm) than the depth to groundwater presented in spreadsheet “E1-28” (457 cm). Please revise the risk assessment to document the sources for the site-specific information that was used

in the derivation of ambient air concentrations, and to address the discrepancy regarding the depth to groundwater values used in the calculations.

24. **Section 6.2.3, Calculation of EPCs, Page 6-8:** The depth to groundwater used in the derivation of indoor air concentrations with the J&E model (1003 cm) differs from that used in the derivation of ambient air concentrations with the ASTM Risk-Based Corrective Action Guidance (either 1265 cm or 457 cm, depending on the table). Please revise the risk assessment to address this discrepancy. Additionally, please provide sources for the site-specific information used in the J&E model.
25. **Section 6.2.4, Quantification of Exposures: Calculation of Daily Intakes, Page 6-8:** The intake calculation for the dermal absorption pathway requires a chemical-specific dermal absorption factor ( $ABS_d$ ). Table E1-25 of Appendix E includes a list of the dermal absorption factors, but it does not appear to include all COPCs that were evaluated in the risk characterization. For example, dermal absorption factors are not provided for 2-amino-4,6-dinitrotoluene and 4,6-dinitro-o-cresol, both of which were identified as COPCs for total soil (Table E1-9). Chemical intakes have been calculated for these two constituents, but without the dermal absorption factors used for these constituents, the intakes could not be replicated. Please revise the risk assessment to provide dermal absorption factors for 2-amino-4,6-dinitrotoluene and 4,6-dinitro-o-cresol.
26. **Appendix E-6, Tables E-6.2 through E-6.6:** These tables are supposed to summarize the risks and hazards associated with the cover soil. However, the last two columns in these tables, “Cover Soil Risk” and “Cover Soil HI” (hazard index), are both marked with notes that refer to the calculation of the deep soil Risk and HI. A description of how the cover soil risk and cover soil HI were calculated has not been provided. Please revise Tables E-6.2 through E-6.6 to clarify this discrepancy, and provide a description of how the cover soil risk and HI were calculated.
27. **Table 6-4, Summary of Risks and Hazards, SWMU 51 – Deep Soil:** This table summarizes risk and HI for the future maintenance worker, future industrial worker, and future excavation worker, but it does not include all of the receptors that were evaluated in Appendix E-6, Tables E-6.8 through E-6.12. These tables also include risk and HI calculations for the future lifetime resident and child resident, yet these results are not included in the Table 6-4 summary. In particular, the HI for the future child resident is 4.1. Please revise the HHRA to address this oversight.
28. **Section 6.6, HHRA Summary and Conclusions, Page 6-28:** The last sentence of this page states, “Because the deep soil is below 15 feet, no residential exposure to deep soil is anticipated.” As previously noted, sample 51SB6C was collected at a depth of 9 to 11 feet bgs, but was included as a deep soil sample for the risk calculations since it was collected below the sludge layer. Please revise

the conclusions to acknowledge that not all of the deep samples were collected below 15 feet. Exposures should be evaluated accordingly.

29. **Section 7.2.5, Selection of COPECs, 1st paragraph, Page 7-13:** The last sentence in this paragraph states, “For food chain exposure pathways, detected COPECs were selected unless they were not important bioaccumulative constituents.” This sentence was followed by a citation for the EPA 2001 document, Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. A review of this guidance document found no reference to removing chemicals from food chain modeling based on whether or not they were bioaccumulative compounds. More fundamentally, the chemicals assessed in the food chain modeling should be those identified as COPECs, irrespective of bioaccumulation concerns. Please revise the text and update the food chain modeling accordingly.
30. **Section 7.5.2, Bioaccumulation and Bioconcentration Factors, 2<sup>nd</sup> paragraph, Page 7-20:** This paragraph states that the soil-to-plant BAF/BCF (bioaccumulation factors/bioconcentration factors) were based on information from six different literature sources. However, there was no explanation on how a specific value was selected. For example, if more than one source had a value for a particular chemical, a set of criteria must have been used to select one value over the others. The 1997 EPA Ecological Risk Assessment Guidance for Superfund states that the most conservative (i.e., highest) bioaccumulation factor reported in the literature should be used in a SLERA. Please add a table that summarizes the values available from each source and highlight the values chosen for use in the risk assessment. Text also needs to be added to Section 7.5.2 explaining the selection hierarchy and decision points.
31. **Section 7.2.5, Selection of COPECs, Page 7-13:** This section needs to clearly state that the COPEC selection process being performed is a two track process. One track selects COPECs for food chain modeling and the other track selects COPECs for direct contact exposure. Please revise this section to more clearly explain the two methods used for COPEC selection.
32. **Section 7.2, Identification of COPECs and Concentration Statistics, Table 7-4 (Surface Soil Samples used in the SWMU 51 SLERA), Page 7-6:** Table 7-4 summarizes all of the soil samples used in the SLERA. Two duplicate samples (TMSB1A and TMSB8A) listed in Table 7-4 were not found in Table 4-1, Analytes Detected in Clean Fill and/or Native Soil. Also, Section 7.2 does not discuss how duplicate samples were handled during the COPECs selection process (e.g., averaged with the original sample). Please add these samples to Table 4-1 and include an explanation to Section 7.2 on how duplicate samples were handled.
33. **Section 7.4, Identification of Assessment and Measurement Endpoints, Page 7-17:** This section describes the assessment and measurement endpoints selected

for this SLERA. This section could be significantly improved by adding a table that clearly organizes the assessment endpoints and the associated measurement endpoints selected for each ecological receptor evaluated in the SLERA.

34. **Section 7.5.1, Intake, Page 7-20:** This section states that, “conservative Tier 1 exposures were based on maximum dietary intake, maximum incidental soil intake, minimum body weight, 100 percent site exposure, and the use of the maximum detected concentrations.” The 1997 EPA Ecological Risk Assessment Guidance states that for species that feed on more than one type of food, the screening-level assumption should be that the diet is composed entirely of whichever type of food is most contaminated. Please revise the food chain modeling for the American Robin and Red Fox in light of this guidance.
35. **Section 7.5.1, Intake, Equation, Page 7-20:** The dose equation shown on page 7-20 is missing the soil ingestion rate exposure parameter. Please correct this equation. It was noted that the exposure equations used in Tables F-5 through F-14 did incorporate the soil ingestion rate.
36. **Section 7.2.2, Descriptive Statistical Calculations, Page 7-6:** This section indicates that the 95% UCL of the mean was calculated for chemicals selected as COPECs. However, there was no discussion on how these values were calculated (i.e., Pro UCL 4.0 software or other means). Text needs to be added describing how the 95% UCL values were obtained. In addition, a new summary table should be provided that shows all of the calculated 95% UCL values and the statistical test used to derive each value. It is important to make sure the data sets have less than 70% non-detects and a minimum of eight detected values if a software program like Pro UCL 4.0 is used to calculate the 95% UCL. The 95% UCL value is considered unreliable if the data set does not meet both of these conditions.
37. **Section 7.7.2, Predictive Risk Estimation for Terrestrial Wildlife and Aquatic Wildlife, Page 7-23:** This section states that, “the criterion used to decide if HQ summation is appropriate and scientifically defensible includes those chemicals that have a similar mode of toxicity.” The summation of HQs was not based on chemicals with similar modes of toxicity, but in fact were simply the sum of all HQs calculated for a particular receptor. Please remove this statement.
38. **Tables F-5 through F-14, Chemicals of Potential EEQs and Hazard Indices:** All of these tables contain a column titled “Chemical-Specific Toxicity Value UF” and the values in this column are used to adjust the NOAEL and LOAEL values. A footnote is not provided describing the source for these values. There is also no discussion of these values in Section 7.6.2, Development of TRVs. Please add a footnote to these tables supplying the source and a detailed explanation of the “Chemical-Specific Toxicity Value UF” and its purpose to Section 7.6.2.
39. **Section 7.3.1, Terrestrial Receptors, 1<sup>st</sup> paragraph, Page 7-15:** This paragraph introduces the five representative wildlife receptor species for the site. There was a

note referring to terrestrial plants. However, plants are not discussed in detail until Section 7.7.1, Terrestrial Plant Impact Assessment. Please add text stating that terrestrial plants will be discussed in a later section of the SLERA.

40. **Table 7-8, Wildlife EEQ Hazard Summary for SWMU 51, Page 7-25:** This table summarizes the HIs calculated by Tier 1 and Tier 2 methods for each receptor. The column headings under Tier 1 and Tier 2 were labeled as “NOAEL-Based EEQ” and “LOAEL-Based EEQ”, however the values in these columns are the total EEQ or HI for each receptor. The column heading would be more accurate if “EEQ” was changed to either “total EEQ” or “Hazard Index.” Please make the change indicated.
41. **List of Acronyms and Abbreviations, Page viii:** The list of acronyms and abbreviations defines “EEQ” as “environmental effects quotient” but several tables such as Table 7-8, Wildlife EEQ Hazard Summary for SWMU 51, have a footnote that defines “EEQ” as “ecological effects quotient.” Please ensure that the acronym is consistent throughout the tables and text.
42. **Table 7.2, Species Inventory within RFAAP’s Grassland Community Type, Page 7-5:** Please remove fish from this table because it is not a species found in the grasslands.
43. **Pagination between page 7-6 and 7-13:** Section 7.2.2, Descriptive Statistical Calculations, begins on page 7-6 and continues onto the next page which is number 7-13. Please fix the pagination in this section.
44. **Section 9.2, Alternative Two – Institutional Controls (Land Use Controls, Groundwater Monitoring), Page 9-1:** The first paragraph indicates that the components of alternative two would include monitoring well installation. This activity does not appear to have been included in costs associated with this alternative, as shown on Table 9-1. Please revise the RFI/CMS Report to address this discrepancy.
45. **Section 9.2, Alternative Two – Institutional Controls (Land Use Controls, Groundwater Monitoring), Page 9-1:** The last paragraph on Page 9-1 indicates that the long-term sampling plan for SWMU 51 would include annual monitoring of groundwater collected from existing wells. However, later paragraphs describe bi-annual monitoring, and Table 9-1 includes cost estimates for semi-annual monitoring. Please revise the RFI/CMS Report to consistently report the proposed groundwater monitoring schedule, and assure that the cost estimate reflects the proposed schedule. Please also provide rationale for the proposed monitoring schedule.



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

MCHB-TS-REH

28 JAN 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, SWMU 51, Radford Army Ammunition Plant, Virginia, December 2007"

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 concur with the results of the well-written risk assessment and find that the recommended remedial alternative for this site will be 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

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January 17, 2008

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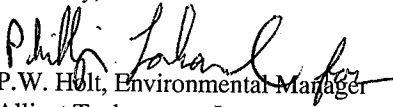
Subject: With Certification, Radford Army Ammunition Plant,  
SWMU 51 RCRA Facility Investigation/Corrective Measures Report, Draft Final Document January 2008  
EPA ID# VA1 210020730

Dear Mr. Geiger and Mr Cutler:

Enclosed is the certification for the subject document that was sent to you on January 16, 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,

  
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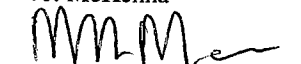
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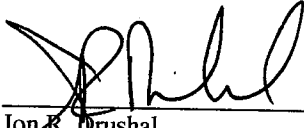
  
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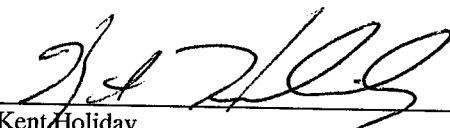
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*SWMU 51 RCRA Facility Investigation/Corrective Measures Report*  
*Draft Final Document January 2008*

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

Jim McKenna  
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## LIST OF ACRONYMS AND ABBREVIATIONS

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|                 |                              |                 |                             |
|-----------------|------------------------------|-----------------|-----------------------------|
| °C .....        | degrees Celsius              | EHSA .....      | Eastern Horseshoe Area      |
| µg/dl .....     | micrograms per deciliter     | EM .....        | Electromagnetic             |
| µg/kg .....     | micrograms per kilogram      | EPC .....       | Exposure Point              |
| µg/L .....      | micrograms per liter         |                 | Concentration               |
| 1,3,5-TNB ..... | 1,3,5-trinitrobenzene        | EPD .....       | Effective Prediction Domain |
| 1,3-DNB .....   | 1,3-dinitrobenzene           | EPIC .....      | Environmental Photographic  |
| 2,4,6-TNT ..... | 2,4,6-trinitrotoluene        |                 | Interpretation Center       |
| 2,4-DNT .....   | 2,4-dinitrotoluene           | ERAGS .....     | Ecological Risk Assessment  |
| 2,6-DNT .....   | 2,6-dinitrotoluene           |                 | Guidance for Superfund      |
| 2D-ERI .....    | 2-Dimensional Electrical-    | FA .....        | Fraction Absorbed Dose      |
|                 | Resistivity Imaging          | FOD .....       | Frequency of Detection      |
| ADAF .....      | Age-Dependent Adjustment     | ft .....        | feet                        |
|                 | Factor                       | g/dL .....      | grams per deciliter         |
| ALM .....       | Adult Lead Model             | GI .....        | Gastrointestinal            |
| ANL .....       | Argonne National Laboratory  | HEAST .....     | Health Effects Assessment   |
| ASTM .....      | American Society for Testing |                 | Summary Tables              |
|                 | and Materials                | HHRA .....      | Human Health Risk           |
| ATSDR .....     | Agency for Toxic Substances  |                 | Assessment                  |
|                 | Disease Registry             | HI .....        | Hazard Index                |
| AUF .....       | Area Use Factor              | HQ .....        | Hazard Quotient             |
| BAF .....       | Bioaccumulation Factor       | HSA .....       | Horseshoe Area              |
| BCF .....       | Bioconcentration Factor      | HWIR .....      | Hazardous Remediation       |
| bgs .....       | below ground surface         |                 | Waste Management            |
| BTAG .....      | Biological Technical         |                 | Requirements                |
|                 | Assistance Group             | HWMU .....      | Hazardous Waste             |
| CCME .....      | Canadian Council of          |                 | Management Unit             |
|                 | Ministers of the Environment | ICR .....       | Ignitability, Corrosivity,  |
| CDI .....       | Chronic Daily Intake         |                 | and/or Reactivity           |
| CMO .....       | Corrective Measures          | IEUBK .....     | Integrated Exposure Uptake  |
|                 | Objective                    |                 | Biokinetic                  |
| CMS .....       | Corrective Measures Study    | IRIS .....      | Integrated Risk Information |
| COI .....       | Contaminant of Interest      |                 | System                      |
| COPC .....      | Chemical of Potential        | LDR .....       | Land Disposal Restrictions  |
|                 | Concern                      | LOAEL .....     | Lowest Observable Adverse   |
| COPEC .....     | Chemical of Potential        |                 | Effect Level                |
|                 | Ecological Concern           | MCL .....       | Maximum Contaminant         |
| CSEM .....      | Conceptual Site Exposure     |                 | Level                       |
|                 | Model                        | MDC .....       | Maximum Detected            |
| CSF .....       | Cancer Slope Factor          |                 | Concentration               |
| CSM .....       | Conceptual Site Model        | MDL .....       | Method Detection Limit      |
| DQO .....       | Data Quality Objective       | mg/kg .....     | milligrams per kilogram     |
| ED .....        | Exposure Duration            | mg/kg-day ..... | mg chemical/kg body weight  |
| EEQ .....       | Ecological Effects Quotient  |                 | per day                     |

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|             |                                               |                |                                                   |
|-------------|-----------------------------------------------|----------------|---------------------------------------------------|
| mg/L .....  | milligrams per liter                          | TAT .....      | Turnaround Time                                   |
| mm Hg ..... | millimeters mercury                           | TCE .....      | Trichloroethene                                   |
| MMA .....   | Main Manufacturing Area                       | TCL .....      | Target Compound List                              |
| msl .....   | mean sea level                                | TCLP .....     | Toxicity Characteristic<br>Leachate Procedure     |
| MWP .....   | Master Work Plan                              | TE .....       | Toxicity Equivalent                               |
| NG .....    | Nitroglycerin                                 | TEF .....      | Toxicity Equivalence Factor                       |
| NOAEL ..... | No Observable Adverse<br>Effect Level         | TNT .....      | Trinitrotoluene                                   |
| NRU .....   | New River Unit                                | TOC .....      | Total Organic Content                             |
| ORNL .....  | Oak Ridge National<br>Laboratory              | TRV .....      | Toxicity Reference Value                          |
| PAH .....   | Polynuclear Aromatic<br>Hydrocarbon           | UCL .....      | Upper Confidence Limit                            |
| PCB .....   | Polychlorinated Biphenyl                      | USACE .....    | U.S. Army Corps of<br>Engineers                   |
| PCE .....   | Tetrachloroethene                             | USATHAMA ..... | U.S. Army Toxic and<br>Hazardous Materials Agency |
| PEF .....   | Particulate Emission Factor                   | USEPA .....    | U.S. Environmental<br>Protection Agency           |
| PETN .....  | Pentaerythritol tetranitrate                  | UTL .....      | Upper Tolerance Limit                             |
| PPRTV ..... | Provisional Peer Reviewed<br>Toxicity Value   | VDEQ .....     | Virginia Department of<br>Environmental Quality   |
| QA .....    | Quality Assurance                             | VOC .....      | Volatile Organic Compound                         |
| QC .....    | Quality Control                               | VRP .....      | Voluntary Remediation<br>Program                  |
| RAGS .....  | Risk Assessment Guidance<br>for Superfund     | WHO .....      | World Health Organization                         |
| RBC .....   | Risk-Based Concentration                      |                |                                                   |
| RCRA .....  | Resource Conservation and<br>Recovery Act     |                |                                                   |
| RDA .....   | Recommended Daily<br>Allowance                |                |                                                   |
| RFAAP ..... | Radford Army Ammunition<br>Plant              |                |                                                   |
| RfD .....   | Risk Reference Dose                           |                |                                                   |
| RFI .....   | RCRA Facility Investigation                   |                |                                                   |
| RG .....    | Remedial Goal                                 |                |                                                   |
| SCS .....   | Soil Conservation Service                     |                |                                                   |
| Shaw .....  | Shaw Environmental, Inc.                      |                |                                                   |
| SLERA ..... | Screening Level Ecological<br>Risk Assessment |                |                                                   |
| SQL .....   | Sample Quantitation Limit                     |                |                                                   |
| SRC .....   | Syracuse Research<br>Corporation              |                |                                                   |
| SSL .....   | Soil Screening Level                          |                |                                                   |
| SVOC .....  | Semivolatile Organic<br>Compound              |                |                                                   |
| SWMU .....  | Solid Waste Management<br>Unit                |                |                                                   |
| TAL .....   | Target Analyte List                           |                |                                                   |

## EXECUTIVE SUMMARY

Shaw Environmental, Inc. (Shaw) conducted a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Solid Waste Management Unit (SWMU) 51 (RAAP-001), the Trinitrotoluene (TNT) Waste Acid Neutralization Pit, during the months of March and April 2004. The investigation is required by the 2000 RCRA Corrective Action permit (USEPA, 2000a) for Radford Army Ammunition Plant and was performed in accordance with Master Work Plan (MWP) Addendum 017 (Shaw, 2004). MWP Addendum 017 was prepared to facilitate the investigation effort to comply with the requirements set forth in the 2000 RCRA Corrective Action permit and was approved by the U.S. Environmental Protection Agency (USEPA) Region III and the Virginia Department of Environmental Quality.

In addition to the MWP Addendum 017 field investigation (2004 RFI), six other investigations have been conducted to assess SWMU 51, including the 1987 RCRA Facility Assessment, the 1992 Installation Assessment, the 1992 RFI, a geophysical survey in 2002, a groundwater sampling effort of the Eastern Horseshoe Area in 2006, and a groundwater sampling effort as part of the 2007 Investigation of SWMUs 48/49/50/59. 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 contaminants identified in trench sludge material and grossly contaminated soil. The Contamination Assessment, Fate and Transport Analysis, risk assessments, and CMS are summarized below.

### ***Contamination Assessment***

**Soil.** The contamination assessment (*Section 4.0*) of SWMU 51 soil indicated that volatile organic compounds, non-explosive semivolatile organic compounds, pesticides, polychlorinated biphenyls, herbicides, and dioxins/furans are not a concern at the study area. With the exception of a single industrial exceedance of manganese in native soil outside the trench, there were no industrial screening level exceedances in soil samples collected from the clean fill overlying the trench or in soil below the trench sludge material; therefore, these two areas are not a concern at the site.

The main concern at the site is the trench sludge material and grossly contaminated soil immediately below the sludge material. The main parameters of concern are explosives and metals predominantly found in the trench sludge material.

**Groundwater.** The contamination assessment (*Section 4.0*) of SWMU 51 groundwater indicated that tetrachloroethene (PCE), aluminum, antimony, chromium, iron, and manganese were detected at concentrations exceeding groundwater screening levels in SWMU 51 downgradient wells. Explosives were not detected in any of the groundwater samples, indicating that explosives have not migrated downward from the trench sludge material at SWMU 51. PCE was only detected in one of four close downgradient wells at a concentration below the maximum contaminant level. Concentrations of metals detected in downgradient wells are consistent with those detected in upgradient wells and do not appear to be a concern in groundwater at SWMU 51.

### ***Contaminant Fate and Transport Analysis***

Contaminant fate and transport analysis (*Section 5.0*) indicates that the elevated levels of eight metals (antimony, cadmium, chromium, copper, iron, lead, manganese, and thallium), five polynuclear aromatic hydrocarbons [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene], and ten explosives [1,3,5-trinitrobenzene, 1,3-dinitrobenzene (1,3-DNB), 2,4,6-trinitrotoluene (2,4,6-TNT), 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), 2-amino-4,6-DNT, 2- and 4-nitrotoluene, RDX, and nitroglycerin (NG)] that were detected during the 2004 RFI activities are relatively immobile under site conditions and are primarily confined to the trench sludge material.

Explosives are the primary contaminants and chemicals of most concern in the trench sludge material. No explosives or explosives-related compounds were detected in the groundwater samples downgradient from SWMU 51. This provides strong evidence that there is very little migration downward from the sludge material. A second line of evidence to support the lack of migration is the decrease in concentration in explosives constituents between the sludge samples and samples collected from below the sludge material.

Based on the fate and transport analysis, it is concluded that contaminants present in the trench sludge material in SWMU 51 are not migrating beyond the soil immediately below the sludge layer and have not impacted groundwater.

### ***Human Health Risk Assessment (HHRA)***

An HHRA (*Section 6.0*) was conducted at SWMU 51 to identify potential risks at the site. The risks associated with eight exposure scenarios were calculated at the site: current maintenance workers, future maintenance workers, future industrial workers, future excavation workers, future adult residents (on-site and off-site), and future child residents (on-site and off-site). The potential cumulative risk for the current maintenance worker was less than the USEPA's target risk range. The potential cumulative risk for the future maintenance worker, future industrial worker, future excavation worker, future adult (lifetime) resident (on-site and off-site), and future child resident (on-site and off-site) were above USEPA's target risk range, primarily due to 2,4-DNT, 2,6-DNT, dioxins/furans, NG, 4-nitrotoluene, 2,4,6-TNT, PCE, and arsenic. Concentrations of arsenic, however, were found to within background levels for total soil. The potential cumulative hazard indices (HIs) for the current maintenance worker, future adult resident (off-site), and future child resident (off-site) were less than 1. The potential cumulative HIs for the future maintenance worker, future industrial worker, future excavation worker, future adult resident (on-site) and future child resident (on-site) were above 1, primarily due to 1,3-DNB, 2,4-DNT, 2,6-DNT, NG, 2- and 4-nitrotoluene, 2,4,6-TNT, aluminum, iron, manganese, and vanadium. Aluminum was only a chemical of concern for the excavation worker via the inhalation route. The margin-of-exposure evaluation indicated that the intake from iron was above the allowable range for the child resident. Concentrations of iron, manganese, and vanadium in total soil, however, were found to within background levels. Lead was also evaluated as a chemical of potential concern in total soil at SWMU 51 using the Adult Lead Model for the worker scenarios and the Integrated Exposure Uptake Biokinetic model for the resident scenarios. For the future maintenance worker and future industrial worker, concentrations of lead in total soil were below the health protective criterion for lead. For the future excavation worker, future adult resident (on-site) and future child resident (on-site), site concentrations of lead in total soil were above the health protective criterion for lead.

The soil samples at SWMU 51 included samples of the native cover material above the trench. In support of the CMS, analytical results from the cover soil samples were evaluated as a subset of the total soil data. Risks and hazards were calculated to determine whether the native cover material could be placed back into the trench after the sludge layer is removed.

For the future maintenance worker and excavation worker, potential cumulative cancer risks associated with the cover soil were below the target risk range. For the future industrial worker, adult (lifetime) resident, and child resident, cumulative cancer risks associated with the cover soil were within the target risk range.

The potential cumulative HIs for the future maintenance worker, industrial worker, and adult resident were below the target HI of 1. The cumulative HIs for the excavation worker and resident child were above 1. For the excavation worker, the elevated HI was primarily due to aluminum and manganese via inhalation. When recalculated by target organ, the HI for the central nervous system (CNS) also exceeded 1. No target organ was identified for aluminum via the route of inhalation; however, the HI exceeded 1. Aluminum and manganese have been determined to be within background concentrations for cover soil. The HI for the child resident was elevated due to manganese and vanadium. When recalculated by target organ, the HI for the CNS and the HI for the kidney slightly exceeded 1. Manganese and vanadium have been determined, however, to be within background concentrations for cover soil.

Soil samples were collected beneath the sludge layer at SWMU 51. Analyzed results for the deeper soil were also evaluated separately. Although no exposures to the deeper soil are expected, risks and hazards were calculated to determine whether the deep soil can remain in place.

For all receptors, potential cumulative cancer risks associated with deep soil were within the target risk range. The potential cumulative HIs for the maintenance worker and industrial worker were less than the target HI of 1. The HI for the excavation worker was above 1, due to aluminum and manganese via inhalation. When recalculated by target organ, the HI for the CNS exceeded 1. Aluminum and manganese have been determined to be within background concentrations in deep soil. With the exception of one sample, the deep soil is below 15 feet and no residential exposure to deep soil is anticipated.

### ***Screening Level Ecological Risk Assessment (SLERA)***

A SLERA (*Section 7.0*) was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at SWMU 51.

The Tier 2 no observable adverse effect level based food chain assessment results suggest potential adverse impacts to terrestrial wildlife for some chemicals (with chemical hazard driver in parenthesis following the wildlife species), such as the meadow vole (arsenic), short-tailed shrew (arsenic and TCDD), and American robin (zinc) via terrestrial invertebrate ingestion. However, more realistic lowest observable adverse effect level based food chain assessment results suggest there is no potential adverse impacts as no individual chemical had an ecological effects quotient greater than or equal to one.

The direct contact assessment results for soil invertebrates suggest that a reduction in wildlife food supply is not likely due to chemicals of potential ecological concern (COPECs) in surface soil, and the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 51.

Migration of COPECs in groundwater to surface water and sediment of the New River was determined unlikely due to the distance of this receptor area from the site and therefore was not deemed to be an ecological concern.

Based on the results of the SLERA conducted at SWMU 51, on the fact that no wildlife rare, threatened, or endangered species have been confirmed at the SWMU 51 study area, low level of calculated risk, and the very small size of the SWMU (0.31 acres), further action to address ecological concerns is not warranted for surface soil.

### ***Corrective Measures Study***

Because the RFI demonstrated that 1,3-DNB, 2,4-DNT, 2,6-DNT, NG, 2- and 4-nitrotoluene, 2,4,6-TNT, dioxins/furans, aluminum, and lead contamination is present in the sludge material at concentrations associated with unacceptable human health concerns, an evaluation of corrective measures to address the sludge and grossly contaminated soil at SWMU 51 was performed.

Three 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 Sludge and Grossly Contaminated Soil and Off-site Disposal.

These three alternatives were evaluated using the selection criteria: effectiveness, implementability, and cost. The corrective measures objective (CMO) for this RFI/CMS is to eliminate the potential threats to human health and the environment that exist from the sludge material and/or grossly contaminated soil under the sludge material, as well as eliminate the threat for a potential future release of contaminants from the sludge material to groundwater.

Alternative Three was selected as the final alternative for SWMU 51 because it is implementable and provides a greater level of protection to human health and the environment not provided by the other alternatives. Alternative Three is the sole alternative that facilitates clean closure. By achieving clean closure, Alternative Three exceeds the CMO for this RFI/CMS. The other two alternatives do not achieve such a goal. In addition, Alternative Three has a lower cost and meets CMOs, which Alternative Two does not. Alternative Three 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. The total estimated cost for this alternative is \$621,380.

This alternative includes the following:

- Delineation of sludge material.
- Excavation of the delineated sludge as well as any grossly contaminated soil present under the sludge.
- Transportation and off-site disposal of soil.
- Site restoration activities.

It should be noted that the Hazardous Remediation Waste Management Requirements (HWIR) pertaining to land disposal of contaminated media would pertain to this site. The sludge present in the SWMU 51 disposal pit is a wastewater treatment sludge from the manufacturing and processing of explosives, and therefore, meets the definition of a RCRA source-specific waste (K044 listed waste). However, this listing is based on a determination that these wastes are reactive. On 16 May 2001, the EPA issued the final HWIR rule that allows more wastes to take advantage of exclusions from hazardous waste regulation. With the new changes, all wastes listed solely for the characteristics of ignitability, corrosivity, and/or reactivity (ICR) are not considered hazardous wastes if they no longer exhibit any of these characteristics. The EPA states that when a waste has been listed solely for ICR characteristics, and that waste does not exhibit any hazardous characteristics at the point of generation, then that waste is not subject to Land Disposal Restrictions (LDR) standards. However, if the characteristic is removed after the point of generation, the waste is still subject to all applicable LDR requirements in 40 CFR 268. As the K044 listed wastes are listed solely for the characteristic of reactivity, these exclusions apply. Therefore, if sampling during the excavation determines that the waste is no longer reactive, the soil will not be considered to be a K044 waste and will be disposed as either a hazardous, non-listed waste or a non-hazardous waste based on the RCRA waste characteristics. As the soil does not contain greater than 10% explosives, it is not likely that the soil will be determined to be reactive so it is not likely to be classified as a K044 waste. The hazardous waste determination would therefore be based on the Toxicity Characteristic Leachate Procedure (TCLP) sample results. If the TCLP results indicate that the soil is a toxic waste (i.e., TCLP result greater than the 40 CFR 261.30(b) standards) it will be disposed per RCRA Subtitle C requirements. For cost-estimating purposes in this RFI/CMS, it was assumed that the sludge meets the definition of hazardous waste and will be disposed in a RCRA Subtitle C landfill.

Implementation of this alternative will eliminate contaminated soil 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.

## 1.0 INTRODUCTION

Shaw Environmental, Inc. (Shaw) was tasked by the U.S. Army Corps of Engineers (USACE), Baltimore District, to address data gaps at Solid Waste Management Unit (SWMU) 51 (RAAP-001), the Trinitrotoluene (TNT) Waste Acid Neutralization Pit, located in the Horseshoe Area (HSA) of Radford Army Ammunition Plant (RFAAP) (**Figure 1-1**), in accordance with Contract No. DACA31-02-F-0080 and follow on Contract No. W912QR-04-D-0027.

Previous investigations have been conducted as a collective effort at or adjacent to SWMU 51 (SWMUs 28, 51, and 52) and are discussed in the following section of this report. A data review, including the development of a conceptual site model (CSM) and a data gap analysis, was performed in Master Work Plan (MWP) Addendum 017 (Shaw, 2004). Review of the data indicated that there was no existing soil chemical data for SWMU 51, representing a data gap. Once the data needs were identified, sampling strategies were developed to complete characterization and delineation of the former disposal trench.

The objectives of the field investigation at SWMU 51 were designed to:

- Characterize the vertical and horizontal extent of the trench and underlying unconsolidated hydrogeologic units.
- Characterize the nature and extent of possible contamination on site and identify possible contaminant sources.
- Generate sufficient data to evaluate human health and ecological risk through comparison to U.S. Environmental Protection Agency (USEPA) Region III Risk-Based Concentrations (RBCs) (USEPA, 2007a), ecological screening criteria, and the background concentration values developed in the Facility-Wide Background Study (IT, 2001).
- Reach a final decision regarding what future action, if any, is needed.

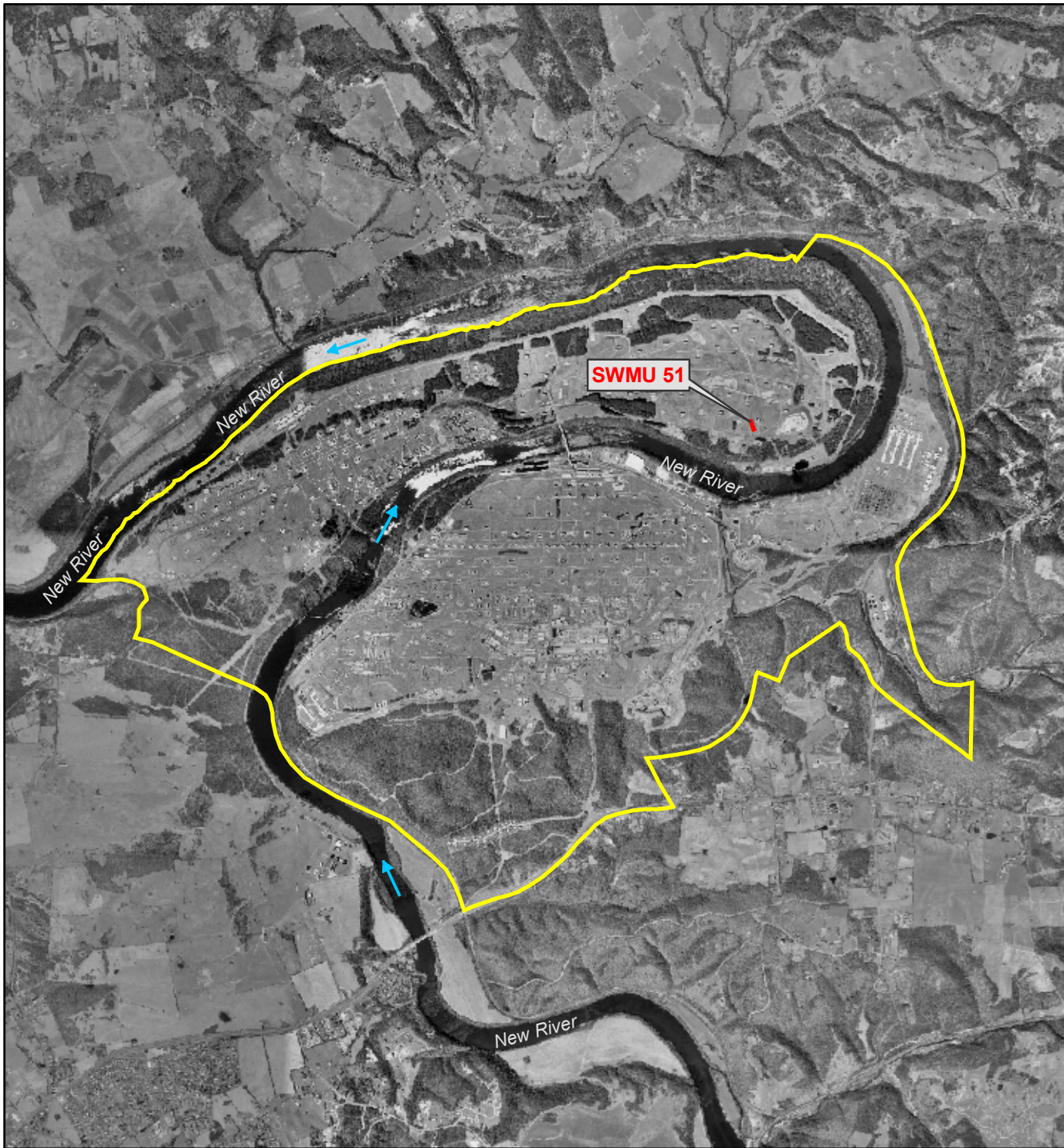
This data, in conjunction with the existing data, provided a sufficient data set for completion of a Nature and Extent of Contamination Assessment (*Section 4.0*), Fate and Transport Evaluation (*Section 5.0*), a Human Health Risk Assessment (HHRA) (*Section 6.0*), and a Screening Level Ecological Risk Assessment (SLERA) (*Section 7.0*) for the SWMU 51 study area.

Based on the results of the human health and ecological risk assessments, it was decided that evaluation of potential remedial actions to address lead, aluminum, explosives [1,3-dinitrobenzene (1,3-DNB), 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), nitroglycerin (NG), 2- and 4-nitrotoluene, and 2,4,6-trinitrotoluene (2,4,6-TNT)], and dioxins/furans [as TCDD toxicity equivalent (TE)] in soil was necessary. The purpose of the Corrective Measures Study (CMS) portion of this document was to develop and evaluate corrective measure alternatives and to recommend corrective measures to be implemented at SWMU 51. The CMS portion of this report presents corrective action objectives (*Section 8.0*), development of alternatives (*Section 9.0*), a detailed analysis of alternatives (*Section 10.0*), and a ranking (*Section 11.0*) and substantiation (*Section 12.0*) for the selection of the final remedy for SWMU 51.

Field activities were conducted in accordance with the MWP, Master Quality Assurance Plan, the Master Health and Safety Plan (URS, 2003), and MWP Addendum 017 (Shaw, 2004), as

approved by USEPA Region III and the Virginia Department of Environmental Quality (VDEQ). Modifications to MWP Addendum 017 proposed sampling activities are presented in *Section 3.1.6*.

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



## LEGEND

→ New River Flow Direction

Installation Boundary

SWMU 51 Boundary

### Notes:

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



Scale:  
0 1,750 3,500 7,000 Feet



U.S. Army Corps of Engineers



Shaw Environmental, Inc.

FIGURE 1-1  
SWMU 51 Location Map  
Radford, VA

## **2.0 SITE BACKGROUND**

### **2.1 Site Description**

SWMU 51 consists of one trench, approximately 140 feet (ft) long, 23 ft wide, and 14 ft deep (in the center of the trench), located immediately to the southeast of, and adjacent to, SWMU 30 (Closed Asbestos Waste Site) (**Figure 2-1**). SWMU 30 was reportedly used for asbestos disposal and is not part of this unit. SWMU 51 is located approximately 200 ft west of Hazardous Waste Management Unit (HWMU) 16 (Closed Hazardous Waste Landfill) and SWMU 52 (Closed Sanitary Landfill), and 200 ft southwest of SWMU 28 (Closed Sanitary Landfill). The trench has been filled to natural grade with soil and is covered by grass and weeds. A barbed-wire fence surrounds SWMU 51. Separate barbed-wire fencing surrounds the trench areas of SWMU 30.

As illustrated on **Figure 2-1**, the SWMU is situated on a plateau ranging from approximately 1,820 to 1,840 ft mean sea level (msl). The plateau is generally flat to slightly sloping and is surrounded by a horseshoe bend of the New River (approximately 1,700 ft msl).

### **2.2 Site History and Operations**

An unknown quantity of TNT neutralization sludge (estimated at 550-650 tons by geophysical investigation) from the treatment of red water, a waste product generated during the production of TNT, was disposed of in this unlined trench in the 1970s. The sludge contains 2,4,6-TNT, transformation products, and other associated explosives compounds. The source of the sludge was from the RFAAP Red Water Treatment Plant equalization/neutralization basin (listed as Unit 81a in USEPA, 1987).

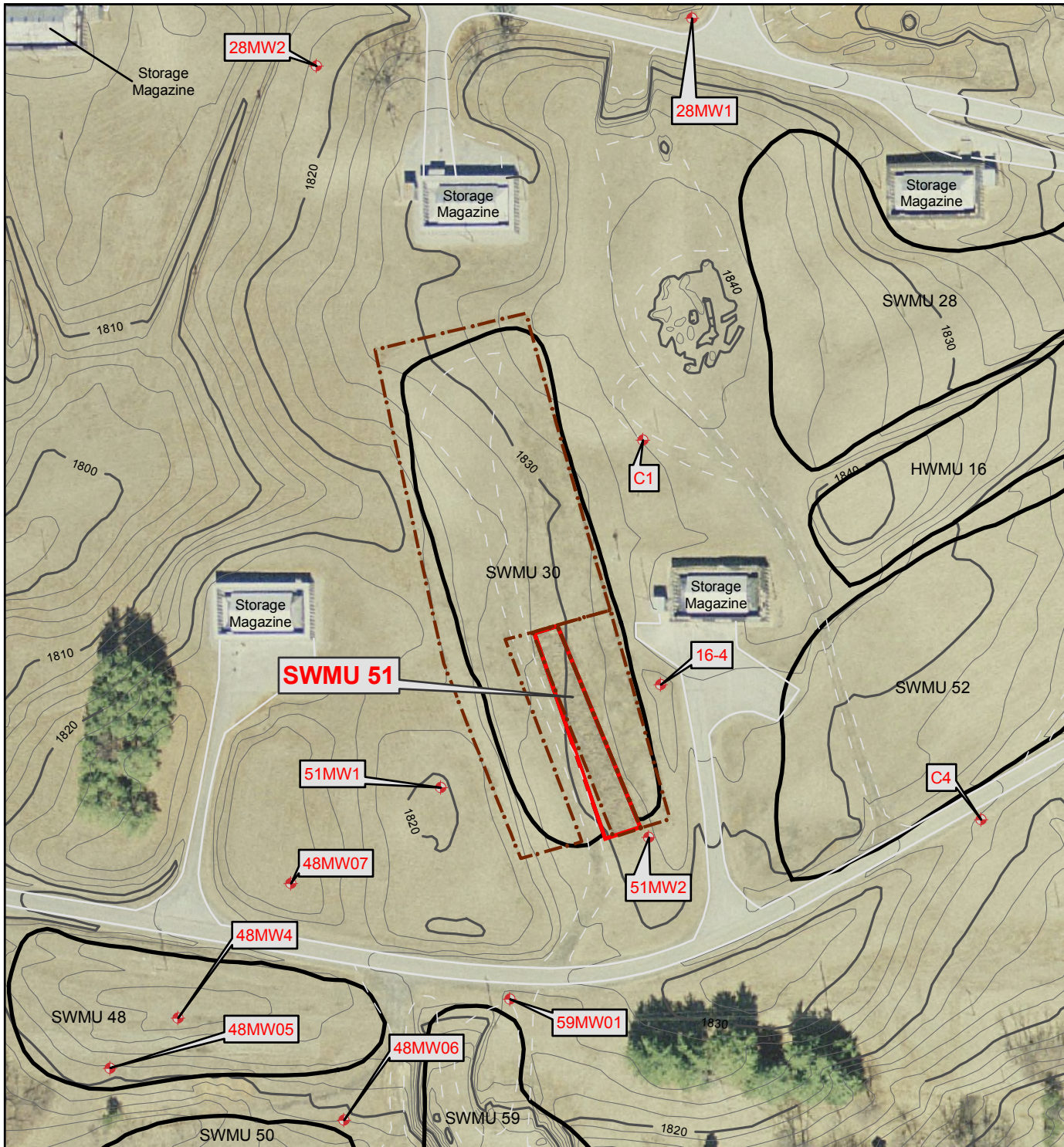
During the production of TNT, an alkaline, red-colored aqueous waste is generated (red water). This waste stream is composed of TNT purification filtrate, air pollution control scrubber effluent, washwater from cleaning of equipment and facilities, and washwater from product washdown operations. The sludge is the result of deliquification (settling/evaporation) of the red water. No red water was disposed in the trench.

In addition to sludge disposal, an estimated 10 tons of red water ash was reportedly disposed of in the trench from 1968 to 1972. During this period, red water was concentrated by evaporation and the sludge was burned in rotary kilns located in the TNT manufacturing area (USATHAMA, 1976). The ash from the red water sludge produced from these kilns (red water ash) was disposed in SWMUs 41 (Red Water Ash Landfill) and 51. Wastewater treatment sludges from the manufacturing and processing of explosives is identified as a USEPA hazardous waste (K044) solely for its reactivity (40 CFR 261.32).

There are no records after 1972 regarding activities at SWMU 51; however, aerial photographic analysis (USEPA, 1992) indicated that there was an open trench at the site in a 1975 photograph. A 1981 aerial photograph indicated that the trench had been filled and a revegetating ground scar was the major site feature visible (USEPA, 1992).

### **2.3 Site Soil**

The Soil Conservation Service (SCS) Map (SCS, 1985) for the SWMU 51 area shows that the site is underlain by the Braddock Loam (**Figure 2-2**). The Braddock Loam comprises about 21% of



## LEGEND

- Monitoring Well Location
- Dirt Road
- Paved Road
- 10 ft Contour Line
- Fence Line
- SWMU 51 Boundary
- Other SWMU/HWMU Boundary

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



Scale:  
0 75 150 300 Feet

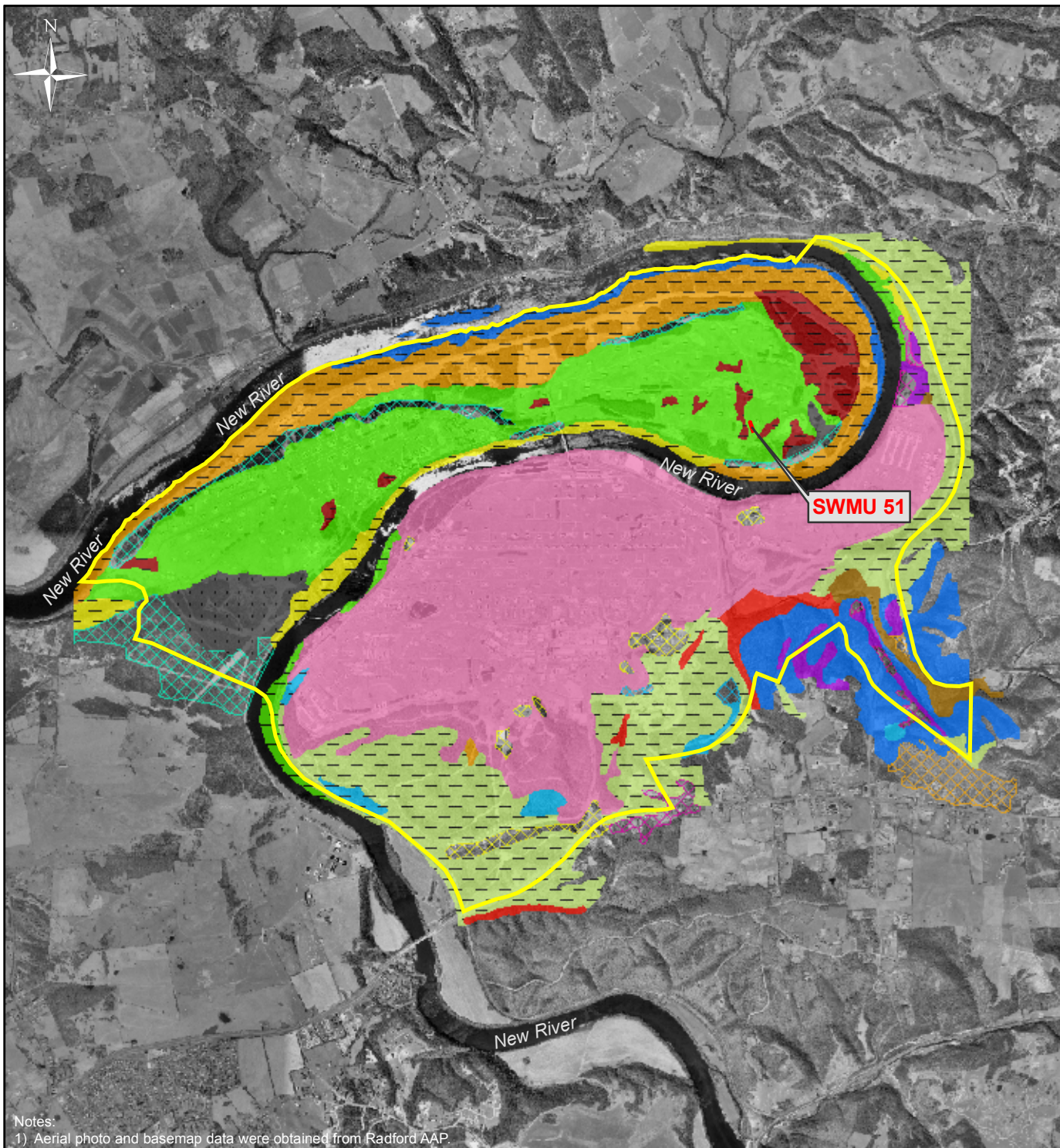


U.S. Army Corps of Engineers



Shaw Environmental, Inc.

FIGURE 2-1  
SWMU 51 Site Map  
Radford Army Ammunition Plant,  
Radford, VA



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

## LEGEND

SWMU 51 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 POPLIMTO

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



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FIGURE 2-2

SCS Soil Types at the  
Main Manufacturing Area  
Radford Army Ammunition Plant,  
Radford, VA

the HSA. This soil type is gently sloping (between 2% and 7%) and does not have a seasonal high water table within 6 ft of the surface.

Typically, the surface layer is dark yellowish-brown, and 7 inches thick. The subsoil, which is yellowish-red and red clay, extends to a depth of 60 inches or more. Depth to bedrock is more than 5 ft deep. Permeability of the Braddock Loam soil is moderate, natural fertility is low, and organic matter content is moderately low. This soil type is acidic or very strongly acidic.

## 2.4 Site Geology

RFAAP is located in the New River Valley, which crosses the Valley and Ridge Province approximately perpendicular to the regional strike of bedrock, and cross cuts Cambrian and Ordovician limestone or dolostone. Deep clay-rich residuum is prevalent in areas underlain by carbonate rocks. The valley is covered by river floodplain and terrace deposits; karst topography is dominant throughout the area.

Lithologic characterization of the subsurface at SWMU 51 was performed during the advancement of soil borings and monitoring well borings at the site. Geologic cross-sections were developed based on the logging descriptions recorded during the advancement of the soil borings (**Appendix B-1**). A plan view of the cross-sectional lines (Line 1-1', Line 2-2', Line 3-3', Line 4-4', Line 5-5', Line 6-6', Line 7-7', and Line 8-8') is presented on **Figure 2-3**. The geologic cross sections are presented on **Figures 2-4 through 2-11**.

Borings advanced at the site ranged from 20.3 ft (51SBC1 – refusal on river jack) to 46.3 ft (51SBC22) in depth. Borings at the site were advanced using a Bobcat-mounted direct push rig.

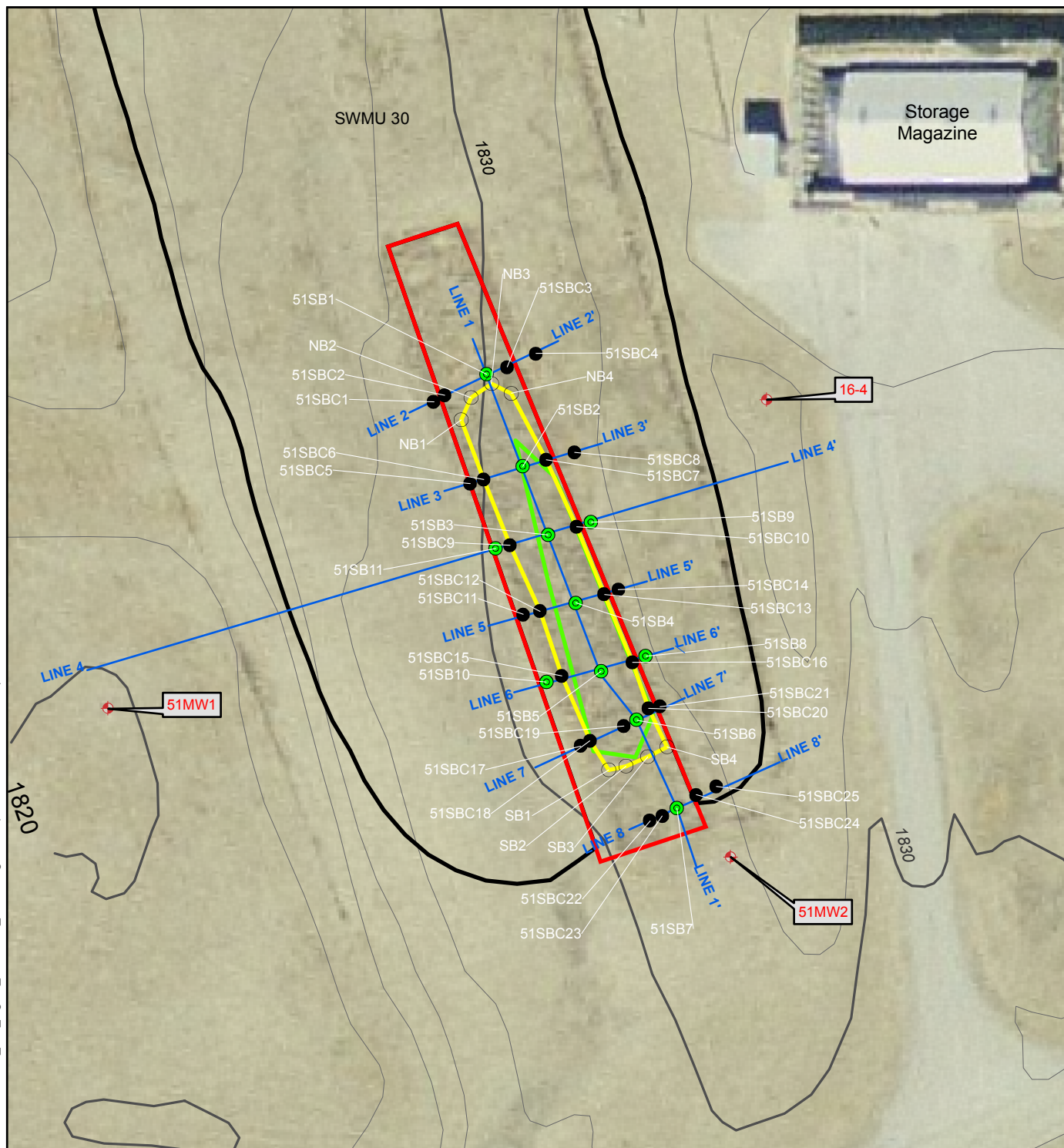
Depths to bedrock were inferred from refusal of the direct push rig and were directly measured at the monitoring well borings. Bedrock elevations ranged from approximately 1,775 ft msl to 1,785 ft msl, with the bedrock surface sloping to the southwest.

The bedrock under the site is the Cambrian-aged Elbrook Formation, which is a thickly bedded, blue-gray dolostone interspersed with blue-gray to white limestone. It is locally described in nearby well borings as interbedded green and maroon shale and yellowish-brown dolostone (51MW2 and 16-4) and greenish- to grayish-brown limestone and dolostone (C-1). The carbonate content of the bedrock near SWMU 51 appears to increase to the north, while shale dominates in the southern well borings.

Depth to competent bedrock at the site ranges from 45 to 55 ft. A saprolitic layer of yellow to olive clay and silt with interbedded red shale, formed from *in-situ* weathering of the carbonate bedrock, immediately overlies the competent bedrock. The saprolite is up to 25 ft in thickness.

The unconsolidated sediment immediately overlying the saprolite consists of interbedded alluvial deposits. Overbank deposits, consisting primarily of silt and clay with varying amounts of fine sand are interbedded with alluvial channel deposits of fine- to coarse-grained, yellowish-brown sand and layers of large cobbles (river jack). These Paleo-channel deposits are incised into the silt and clay deposits, and, in some cases, into the saprolite, so that in places the paleo-channel deposits rest directly on bedrock.

Within the boundaries of the trench, a sludge material, described in boring logs as paste-like, very soft black clay with some silt and fine sand, lines the bottom of the trench. This material was used as an indicator to define the limits of the trench. As illustrated on **Figures 2-4 through 2-11**, this layer forms an elongated bowl-shaped lens ranging in depth from approximately 0.5 ft



## LEGEND

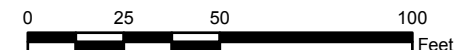
- Qualitative Soil Boring
- ◆ Monitoring Well
- Stratigraphic Characterization Soil Boring
- Chemical Sample Soil Boring
- 10 ft Contour Line
- ▭ Trench Boundary As Defined by Chemical and Stratigraphic Characterization Borings
- ▭ Area Of SWMU 51 Trench As Interpreted From 2D-ERI Profiling (ANL, 2003)
- ▭ SWMU 51 Boundary
- ▭ Other SWMU/HWMU Boundary

### Notes:

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



Scale:



U.S. Army Corps of Engineers

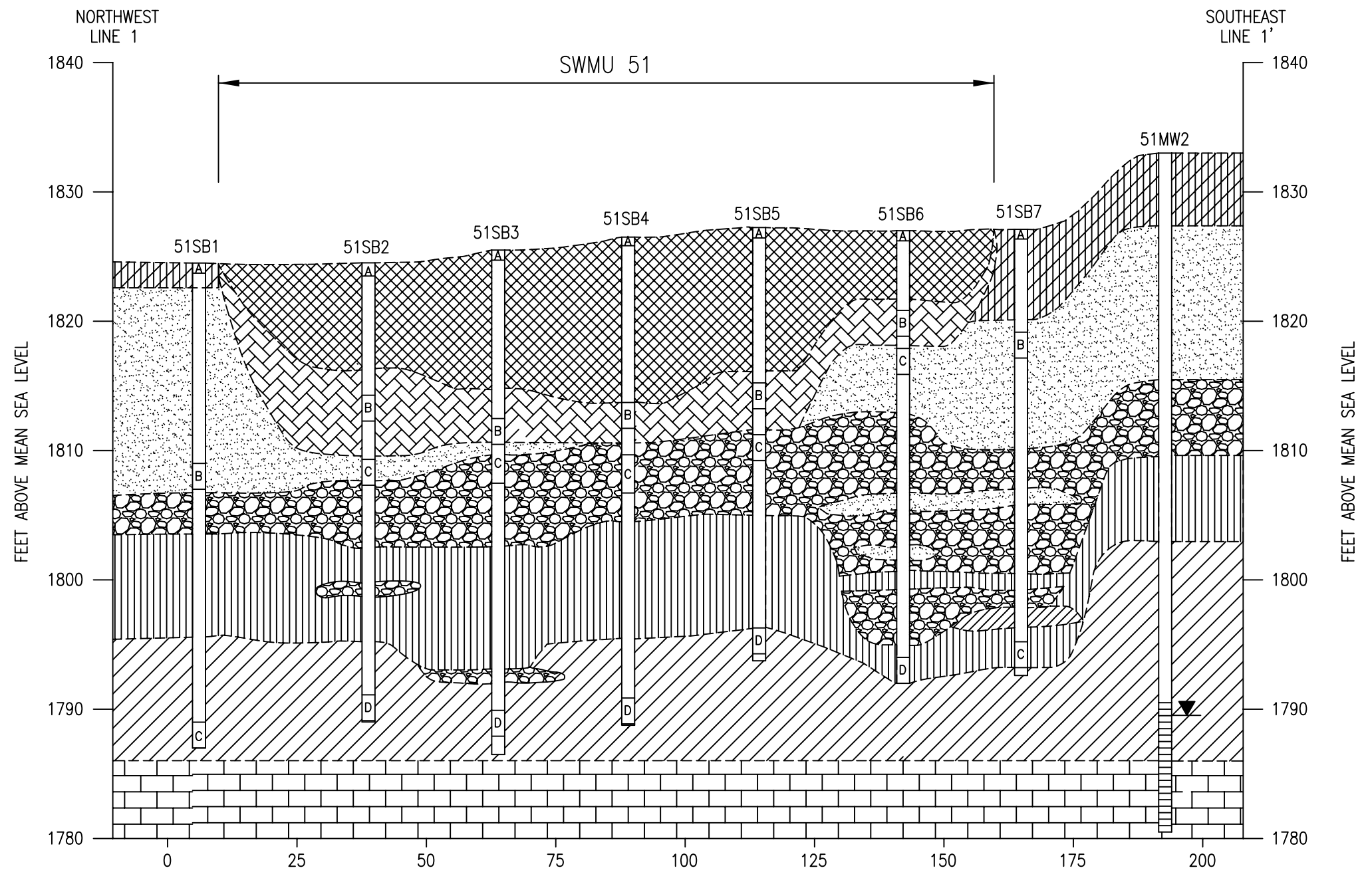


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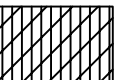
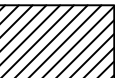
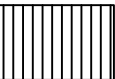
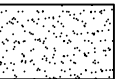
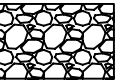
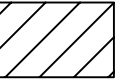
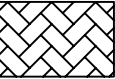
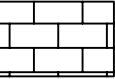
FIGURE 2-3

SWMU 51 Soil Boring Locations

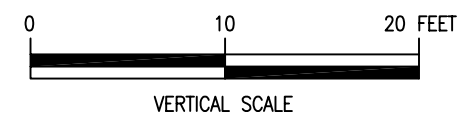
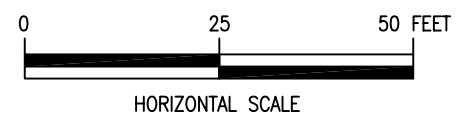
Radford Army Ammunition Plant,  
Radford, VA



# LEGEND

-  FILL
-  SILT/CLAY (ML/CL)
-  CLAY (CL)
-  SILT (ML)
-  SAND – SANDY CLAY, POORLY GRADED AND WELL GRADED SAND
-  GRAVEL – GRAVEL AND GRAVELLY SAND (RIVER JACK)
-  SAPROLITE – IN-SITU WEATHERED BEDROCK (CL/ML)
-  TRENCH SLUDGE MATERIAL
-  BEDROCK – SHALE, LIMESTONE, AND DOLOMITE
-  SAMPLE INTERVAL
-  WATER LEVEL (MEASURED APRIL 2006)
-  GEOLOGIC CONTACT
-  GEOLOGIC CONTACT (INFERRED)
-  SCREEN INTERVAL

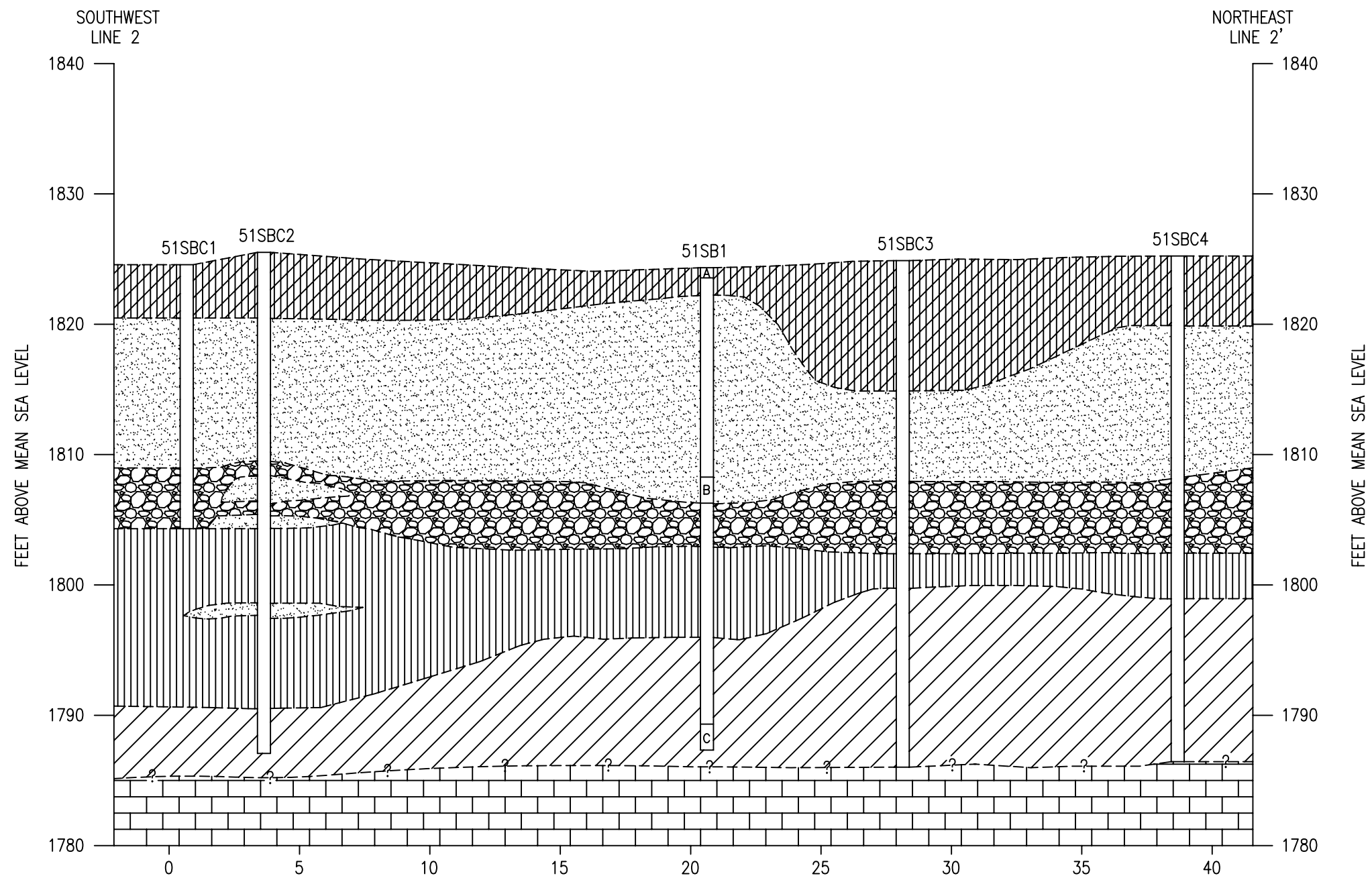
NOTE: 51MW2 LITHOLOGY FROM DAMES AND MOORE (1992).



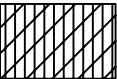
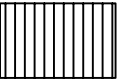
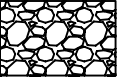
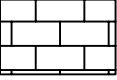
| RADFORD AAP       |                         |
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| CHECKED BY: MT    | SHAW DWG NO: Figure 2-4 |
| DATE: APRIL 2008  |                         |

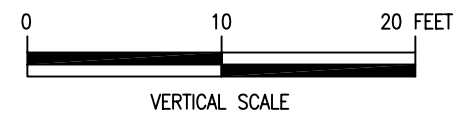
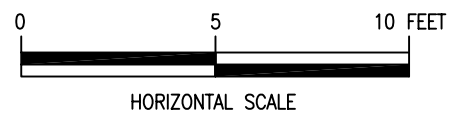
FIGURE 2-4

SWMU 51 GEOLOGIC CROSS SECTION (LINE 1- LINE 1')



# LEGEND

-  SILT/CLAY (ML/CL)
-  SILT (ML)
-  SAND – SANDY CLAY, POORLY GRADED AND WELL GRADED SAND
-  GRAVEL – GRAVEL AND GRAVELLY SAND (RIVER JACK)
-  SAPROLITE – IN-SITU WEATHERED BEDROCK (CL/ML)
-  BEDROCK – SHALE, LIMESTONE, AND DOLOMITE
-  GEOLOGIC CONTACT
-  GEOLOGIC CONTACT (INFERRED)
-  SAMPLE INTERVAL



**RADFORD AAP**

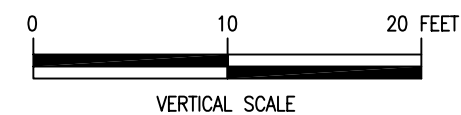
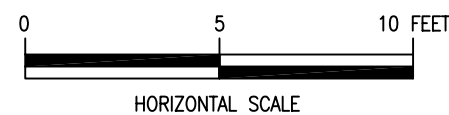
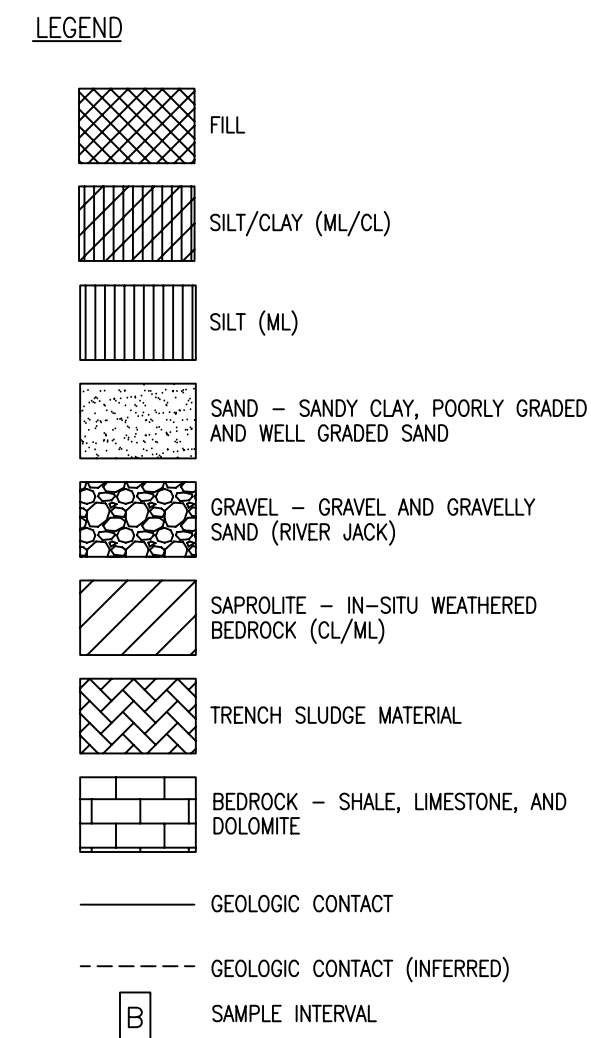
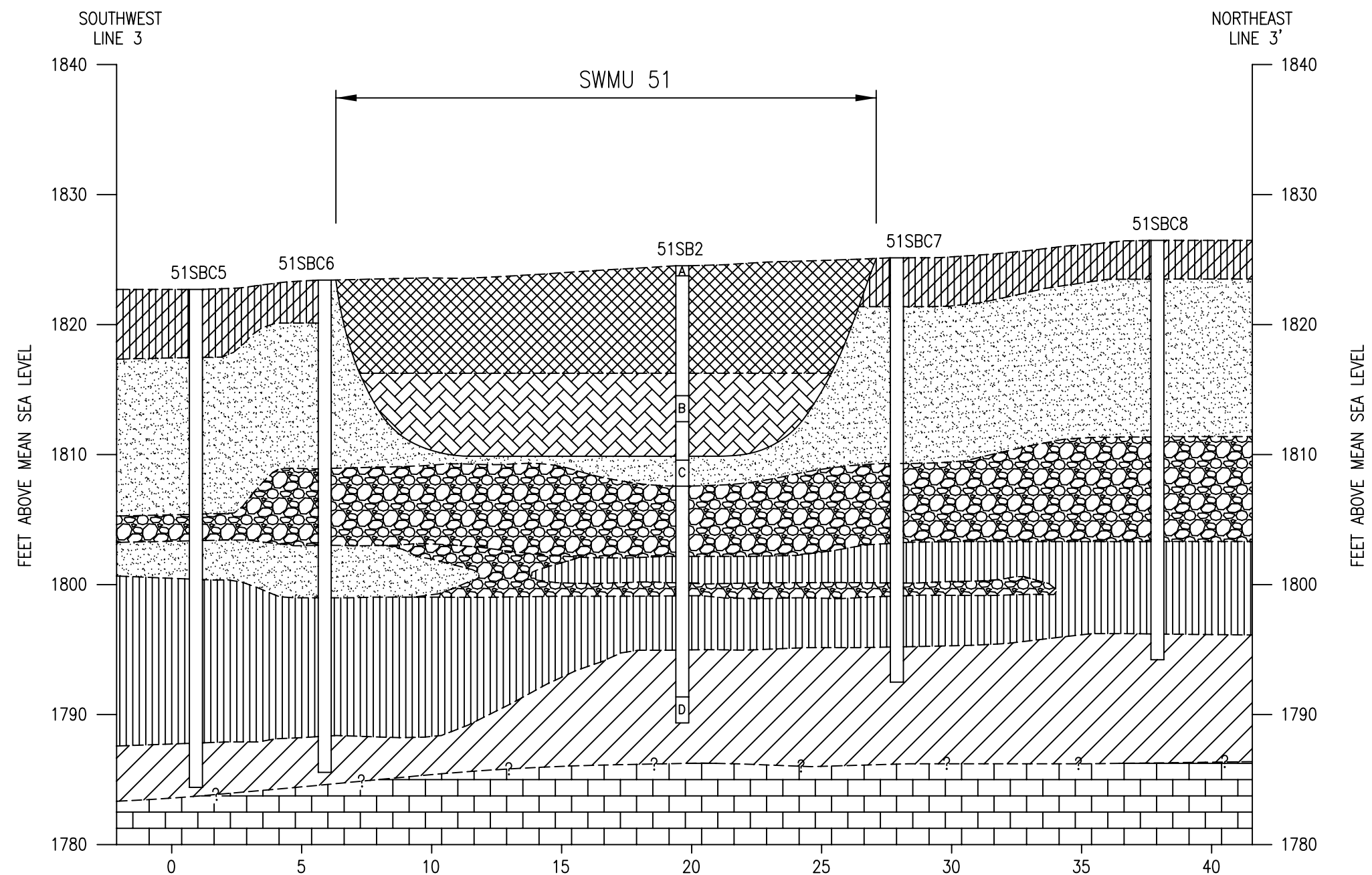
PREPARED BY: SHAW TASK NO: 83919705000000

CHECKED BY: MT SHAW DWG NO:

DATE: APRIL 2008 Figure 2-5

FIGURE 2-5

SWMU 51 GEOLOGIC  
CROSS SECTION  
(LINE 2 – LINE 2')

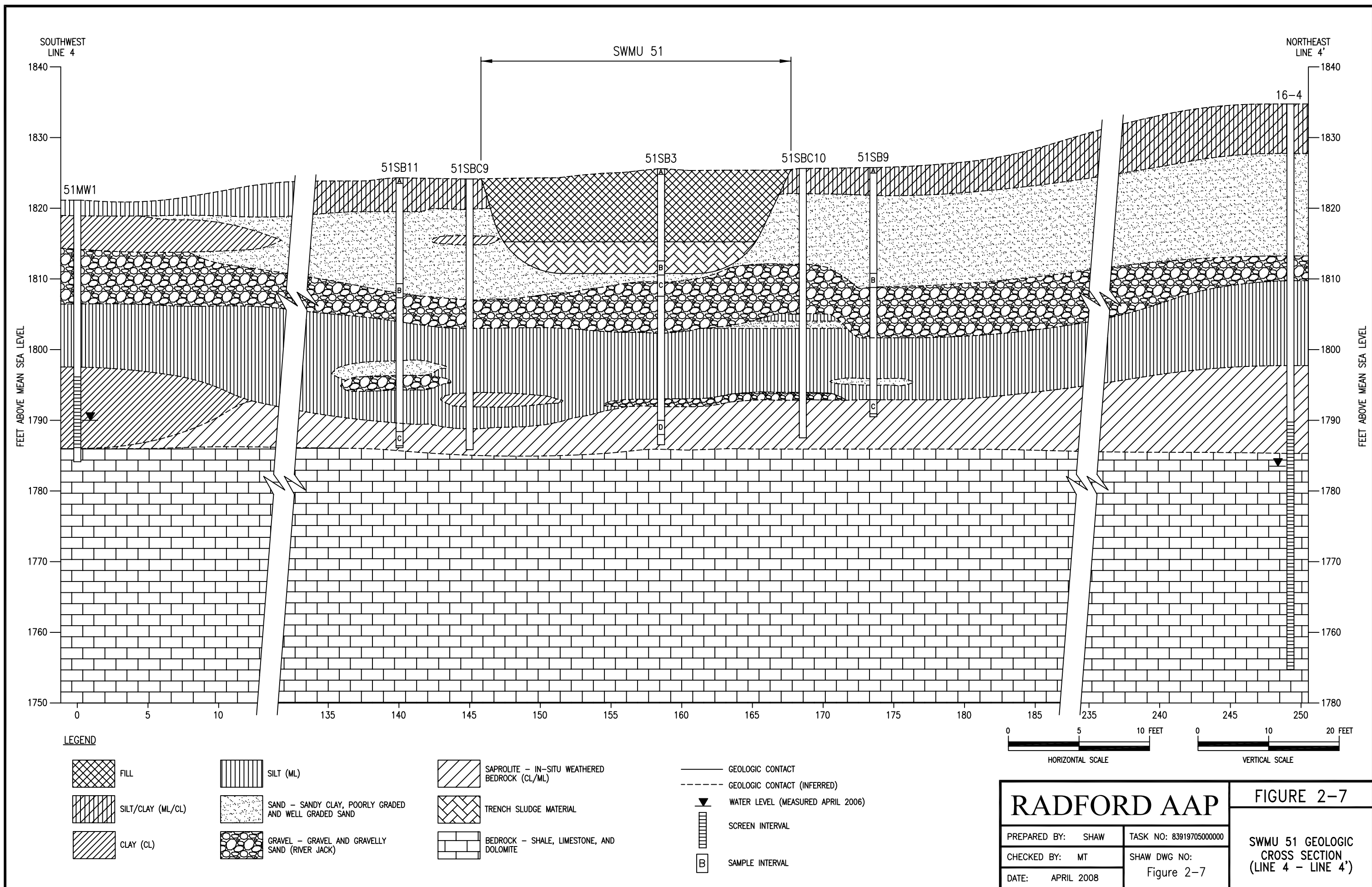


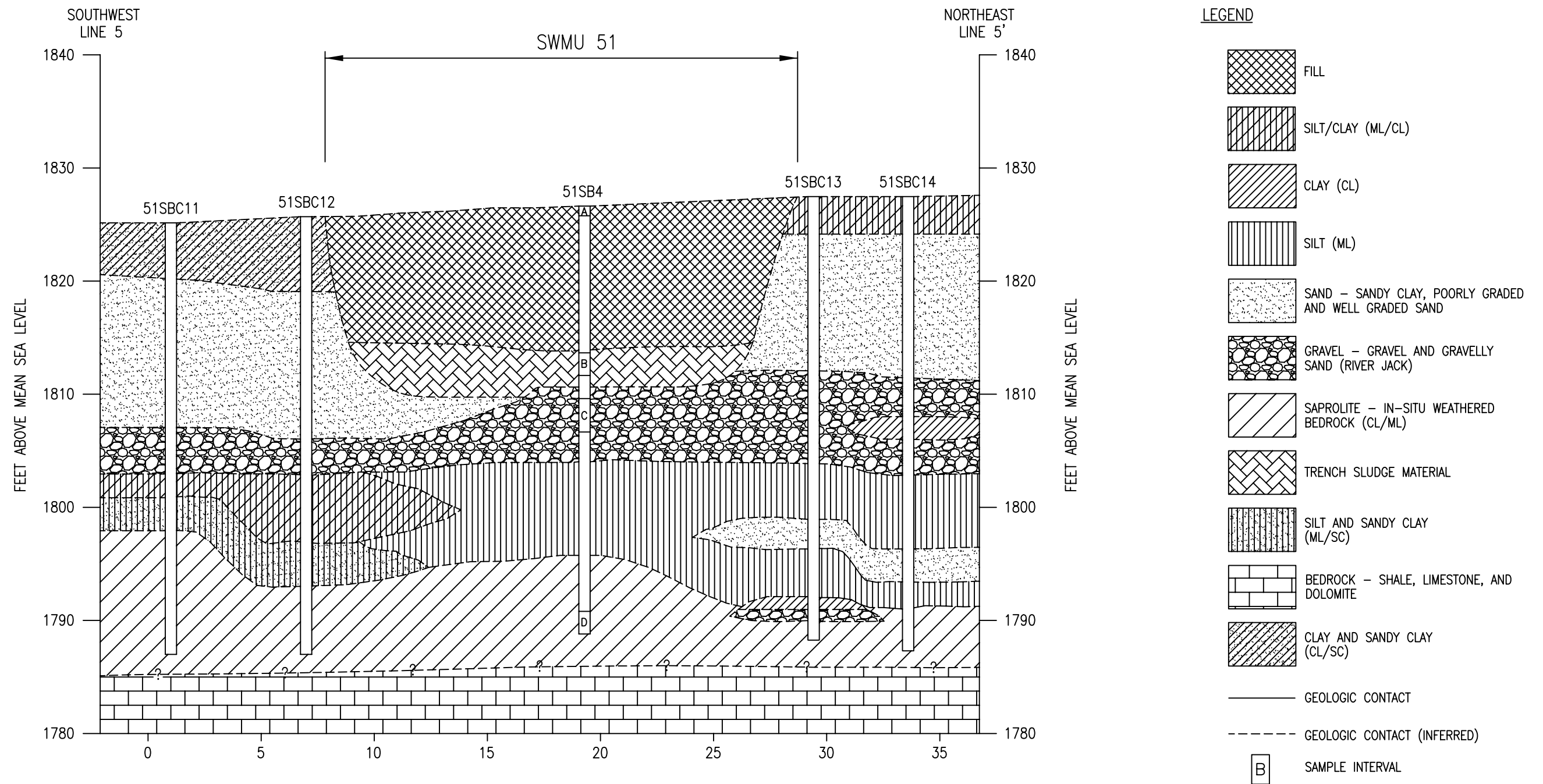
**RADFORD AAP**

|                   |                         |
|-------------------|-------------------------|
| PREPARED BY: SHAW | TASK NO: 83919705000000 |
| CHECKED BY: MT    | SHAW DWG NO:            |
| DATE: APRIL 2008  | Figure 2-6              |

FIGURE 2-6

SWMU 51 GEOLOGIC  
CROSS SECTION  
(LINE 3 – LINE 3')





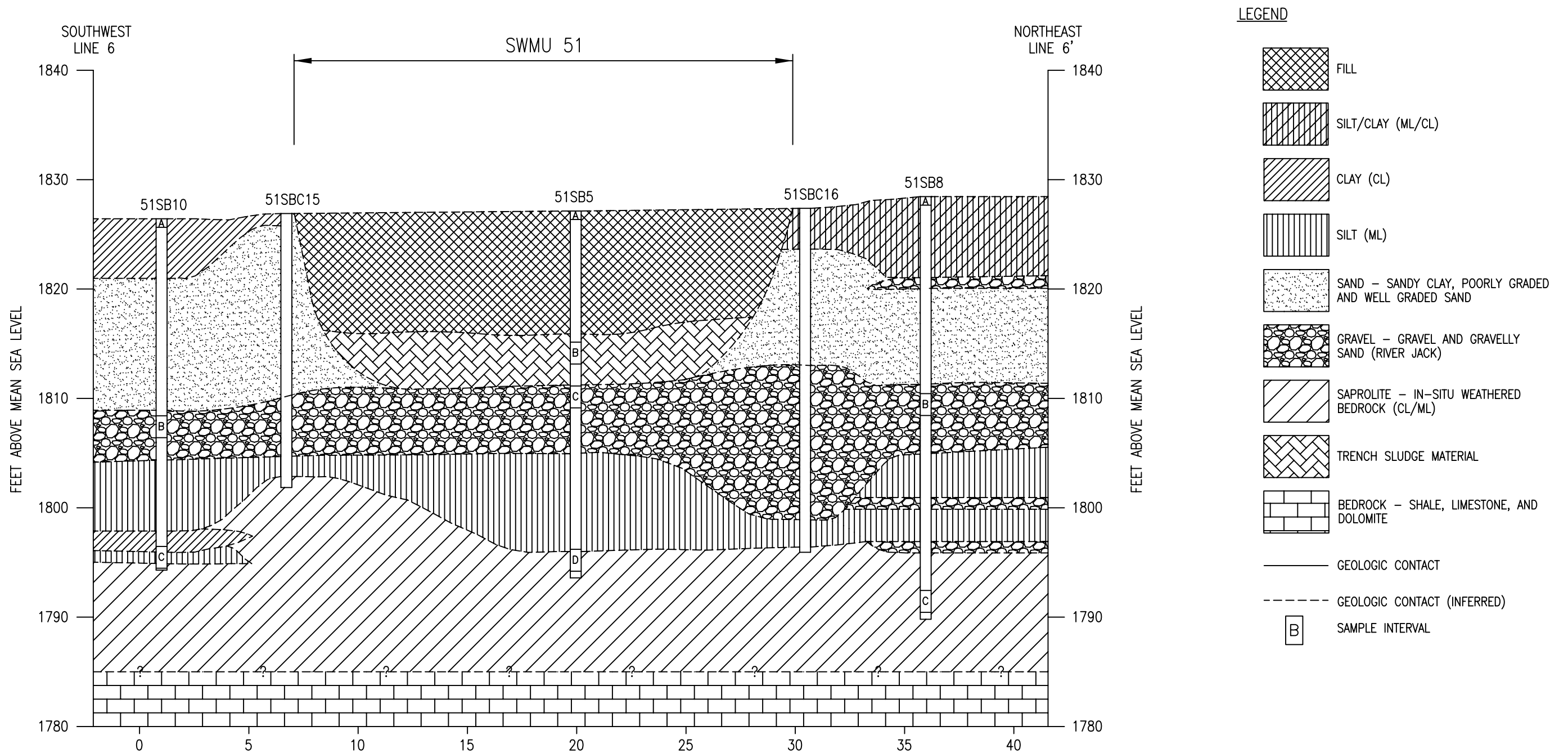
# RADFORD AAP

PREPARED BY: SHAW  
 CHECKED BY: MT  
 DATE: APRIL 2008

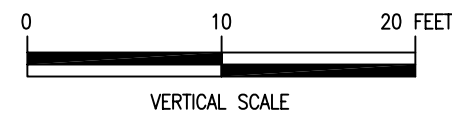
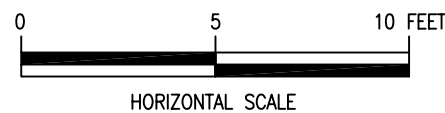
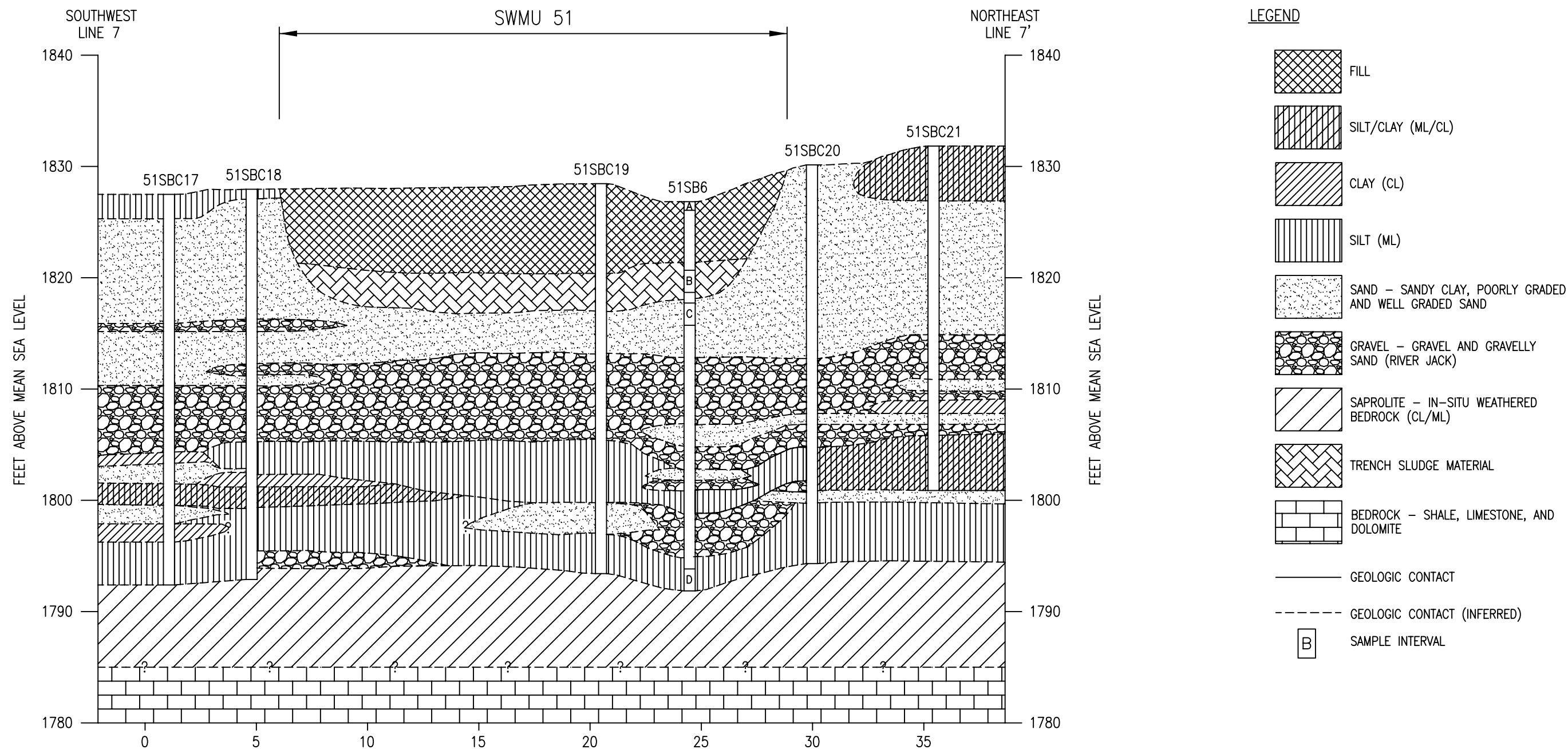
TASK NO: 83919705000000  
 SHAW DWG NO:  
 Figure 2-8

FIGURE 2-8

SWMU 51 GEOLOGIC  
 CROSS SECTION  
 (LINE 5 – LINE 5')



| RADFORD AAP       |                         | FIGURE 2-9                                        |
|-------------------|-------------------------|---------------------------------------------------|
| PREPARED BY: SHAW | TASK NO: 83919705000000 | SWMU 51 GEOLOGIC CROSS SECTION (LINE 6 – LINE 6') |
| CHECKED BY: MT    | SHAW DWG NO:            |                                                   |
| DATE: APRIL 2008  | Figure 2-9              |                                                   |



**RADFORD AAP**

PREPARED BY: SHAW

CHECKED BY: MT

DATE: APRIL 2008

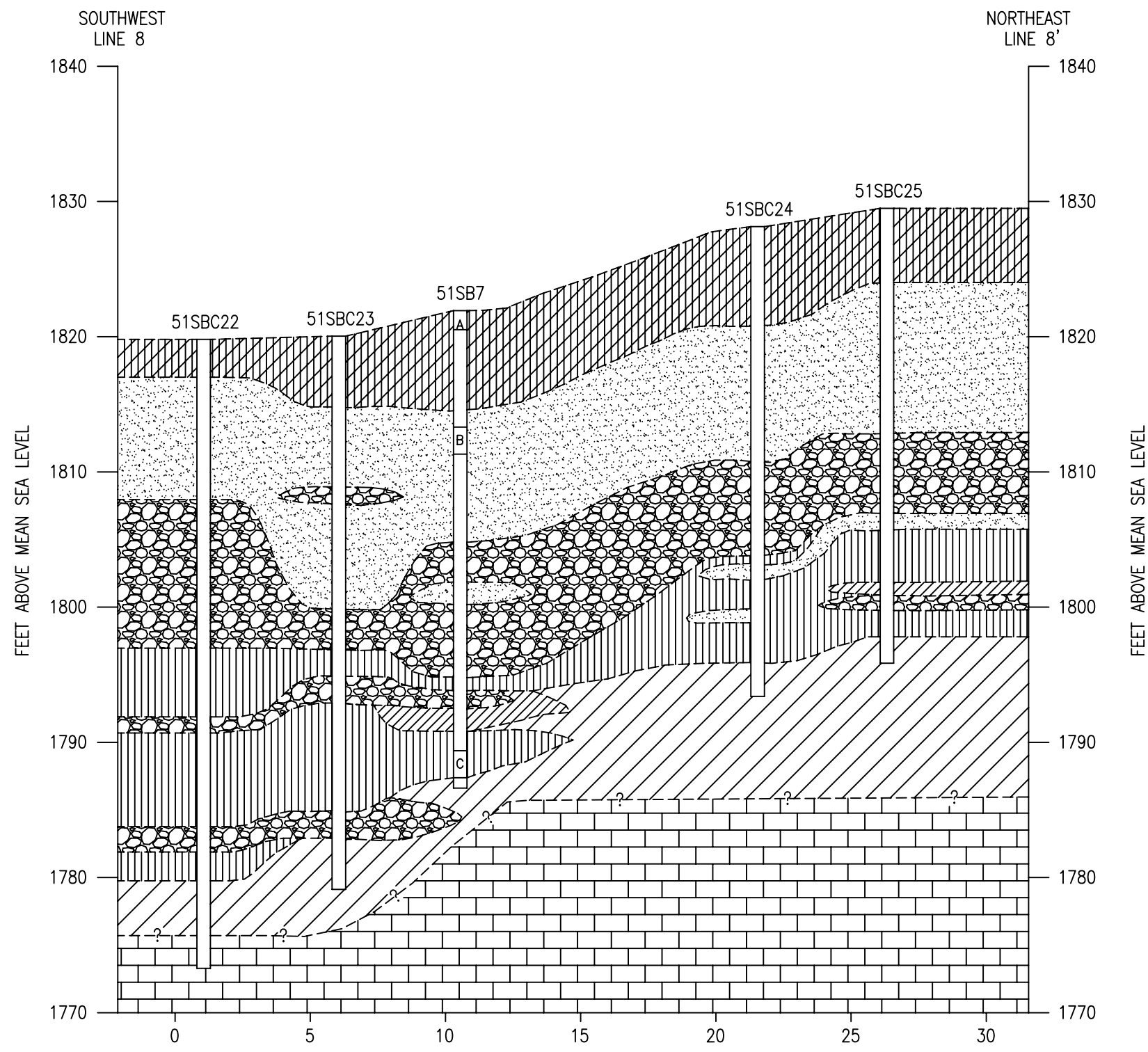
TASK NO: 83919705000000

SHAW DWG NO:

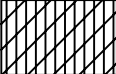
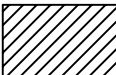
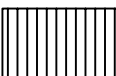
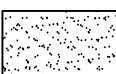
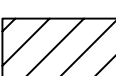
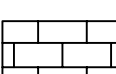
Figure 2-10

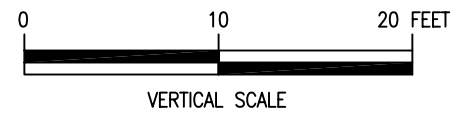
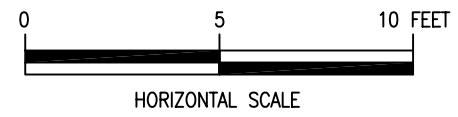
**FIGURE 2-10**

**SWMU 51 GEOLOGIC  
CROSS SECTION  
(LINE 7 – LINE 7')**



**LEGEND**

-  FILL
-  SILT/CLAY (ML/CL)
-  CLAY (CL)
-  SILT (ML)
-  SAND – SANDY CLAY, POORLY GRADED AND WELL GRADED SAND
-  GRAVEL – GRAVEL AND GRAVELLY SAND (RIVER JACK)
-  SAPROLITE – IN-SITU WEATHERED BEDROCK (CL/ML)
-  BEDROCK – SHALE, LIMESTONE, AND DOLOMITE
-  GEOLOGIC CONTACT
-  GEOLOGIC CONTACT (INFERRED)
-  SAMPLE INTERVAL



| RADFORD AAP       |                          | FIGURE 2-11                                       |
|-------------------|--------------------------|---------------------------------------------------|
| PREPARED BY: SHAW | TASK NO: 83919705000000  | SWMU 51 GEOLOGIC CROSS SECTION (LINE 8 – LINE 8') |
| CHECKED BY: MT    | SHAW DWG NO: Figure 2-11 |                                                   |
| DATE: APRIL 2008  |                          |                                                   |

below ground surface (bgs) along the northern and southern boundaries to approximately 14 ft bgs in the center. Thickness of the sludge averages approximately 3-4 ft in thickness and pinches out at the ends and sides of the trench. Fill material consisting of silt and clay, with varying amounts of fine sand, covers the sludge to return the land surface to its approximate natural grade.

A more detailed discussion of the geology and soil at RFAAP is presented in *Sections 3.4 through 3.7* of the MWP (URS, 2003) and in the Facility-Wide Background Study (IT, 2001).

## 2.5 Site Hydrogeology

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. SWMU 51 is located in the uplands within the center of the HSA and is primarily underlain by the bedrock aquifer, with locally saturated overburden. Monitoring well 51MW1 was installed in the unconsolidated sediments and well 51MW2 was installed in the interface between the unconsolidated sediments and bedrock.

Monthly groundwater elevation measurements were collected from the HSA, including the two wells at SWMU 51, between July 2002 and September 2003. Stabilized groundwater measurements ranged from 1782.39 ft msl (51MW2) in July 2002 to 1804.61 ft msl (51MW1). The depth to water fluctuated 15 ft in 51MW1 and 11 ft in 51MW2 during that timeframe. Extremely heavy rainfall in June and July 2003 account for these high water levels. A more detailed discussion of long term water level monitoring, rainfall, and water budgets for Radford AAP is provided in the *Current Conditions Report – Horseshoe Area* (Shaw, 2005).

Recent stabilized groundwater measurements from April 2006 indicated that groundwater was present in 51MW1 at 1,790.05 ft msl and at a depth of 1784.70 ft msl in 51MW2. **Table 2-1** presents the water level measurements from July 2002 through September 2003 and recent measurements from April 2006 and August 2007 for monitoring wells in the SWMU 51 vicinity.

Precipitation infiltrates in the high areas at the center of the HSA and recharges the bedrock aquifer. The groundwater flow in the vicinity of SWMU 51 is radial outward towards the New River to the south, east and north. Groundwater flows from the bedrock aquifer into the overburden aquifer in the floodplain adjacent to the New River and into the New River. Within the overall flow pattern at the Eastern Horseshoe Area (EHSA), groundwater flow at SWMU 51 is generally towards the south. **Figure 2-12** presents groundwater elevation contours within the vicinity of SWMU 51. Additional monthly groundwater flow maps for the time period between July 2002 and September 2003 are presented in the *Current Conditions Report – Horseshoe Area* (Shaw, 2005) in Appendix B. **Figure 2-12** is fairly typical of the general pattern in the area.

## 2.6 Previous Investigations

Five previous investigations have been conducted at this site. In 1987, under authority of the 1984 Hazardous and Solid Waste Amendments, USEPA conducted a RCRA Facility Assessment at the site to evaluate releases of hazardous waste or hazardous waste constituents and to implement corrective actions, as necessary. In 1992, Environmental Photographic Interpretation Center (EPIC) provided aerial photographic analysis of SWMU 51. Also in 1992, in accordance with the 1989 RCRA permit requirements, Dames & Moore performed RCRA Facility Investigation (RFI) sampling to evaluate potential contamination resulting from site activities. In 2001, a Facility-Wide Background Study was conducted at the Main Manufacturing Area

**Table 2-1**  
**Monthly Groundwater Elevations for Monitoring Wells in the SWMU 51 Vicinity**  
**Page 1 of 3**

| Well Number | Screened Media | Water Depth    | Groundwater | Water Depth    | Groundwater | Water Depth    | Groundwater | Water Depth    | Groundwater | Water Depth    | Groundwater |
|-------------|----------------|----------------|-------------|----------------|-------------|----------------|-------------|----------------|-------------|----------------|-------------|
|             |                | (from meas pt) | Elevation   | (from meas pt) | Elevation   | (from meas pt) | Elevation   | (from meas pt) | Elevation   | (from meas pt) | Elevation   |
|             |                | Jul-02         | Jul-02      | Sep-02         | Sep-02      | Oct-02         | Oct-02      | Nov-02         | Nov-02      | Dec-02         | Dec-02      |
| 16-4        | Bedrock        | 53.22          | 1782.13     | 52.98          | 1782.37     | 53.05          | 1782.30     | 53.21          | 1782.14     | 52.71          | 1782.64     |
| 28MW1       | Bedrock        | 29.81          | 1796.05     | 30.25          | 1795.61     | 30.40          | 1795.46     | 30.35          | 1795.51     | 28.91          | 1796.95     |
| 28MW2       | Bedrock        | 62.40          | 1757.86     | 62.61          | 1757.65     | 62.61          | 1757.65     | 62.65          | 1757.61     | 62.60          | 1757.66     |
| 48MW4       | Bedrock        | 79.95          | 1751.20     | 80.19          | 1750.96     | 80.30          | 1750.85     | 80.62          | 1750.53     | 80.11          | 1751.04     |
| 48MW06      | Bedrock        | na             | na          | na             | na          | na             | na          | na             | na          | na             | na          |
| 48MW07      | Bedrock        | na             | na          | na             | na          | na             | na          | na             | na          | na             | na          |
| 51MW1       | Unconsol*      | 32.00          | 1789.72     | 32.65          | 1789.07     | 32.97          | 1788.75     | 18.02          | 1803.70     | 20.80          | 1800.92     |
| 51MW2       | Interface      | 50.97          | 1782.39     | 49.81          | 1783.55     | 49.83          | 1783.53     | 49.91          | 1783.45     | 49.49          | 1783.87     |
| 59MW01      | Bedrock        | na             | na          | na             | na          | na             | na          | na             | na          | na             | na          |
| C1          | Bedrock        | 51.82          | 1788.32     | 50.82          | 1789.32     | 50.91          | 1789.23     | 51.09          | 1789.05     | 50.72          | 1789.42     |
| C4          | Bedrock        | 54.14          | 1770.43     | 54.25          | 1770.32     | 54.29          | 1770.28     | 53.89          | 1770.68     | 52.71          | 1771.86     |

\* The bottom of screen is at the top of rock.

na = not applicable

**Table 2-1**  
**Monthly Groundwater Elevations for Monitoring Wells in the SWMU 51 Vicinity**  
**Page 2 of 3**

| Well Number | Screened Media | Water Depth    | Groundwater | Water Depth    | Groundwater | Water Depth    | Groundwater | Groundwater | Water Depth    | Groundwater | Water Depth    |
|-------------|----------------|----------------|-------------|----------------|-------------|----------------|-------------|-------------|----------------|-------------|----------------|
|             |                | (from meas pt) | Elevation   | (from meas pt) | Elevation   | (from meas pt) | Elevation   | Elevation   | (from meas pt) | Elevation   | (from meas pt) |
|             |                | Jan-03         | Jan-03      | Feb-03         | Feb-03      | Mar-03         | Mar-03      | Apr-03      | May-03         | May-03      | Jun-03         |
| 16-4        | Bedrock        | 51.78          | 1783.57     | 50.74          | 1784.61     | 49.84          | 1785.51     | 1786.68     | 47.81          | 1787.54     | 48.15          |
| 28MW1       | Bedrock        | 28.00          | 1797.86     | 28.17          | 1797.69     | 27.47          | 1798.39     | 1798.69     | 26.64          | 1799.22     | 27.27          |
| 28MW2       | Bedrock        | 62.53          | 1757.73     | 62.44          | 1757.82     | 62.28          | 1757.98     | 1758.09     | 61.89          | 1758.37     | 61.69          |
| 48MW4       | Bedrock        | 79.56          | 1751.59     | 78.91          | 1752.24     | 77.87          | 1753.28     | 1753.69     | 77.11          | 1754.04     | 77.49          |
| 48MW06      | Bedrock        | na             | na          | na             | na          | na             | na          | na          | na             | na          | na             |
| 48MW07      | Bedrock        | na             | na          | na             | na          | na             | na          | na          | na             | na          | na             |
| 51MW1       | Unconsol*      | 27.05          | 1794.67     | 31.09          | 1790.63     | 21.44          | 1800.28     | 1794.15     | 29.31          | 1792.41     | 21.61          |
| 51MW2       | Interface      | 48.33          | 1785.03     | 46.87          | 1786.49     | 44.34          | 1789.02     | 1790.54     | 41.95          | 1791.41     | 42.40          |
| 59MW01      | Bedrock        | na             | na          | na             | na          | na             | na          | na          | na             | na          | na             |
| C1          | Bedrock        | 49.61          | 1790.53     | 48.53          | 1791.61     | 47.90          | 1792.24     | 1793.51     | 45.95          | 1794.19     | 46.40          |
| C4          | Bedrock        | 51.42          | 1773.15     | 52.71          | 1771.86     | 50.51          | 1774.06     | 1773.70     | 50.37          | 1774.20     | 48.53          |

\* The bottom of screen is at the top of rock.

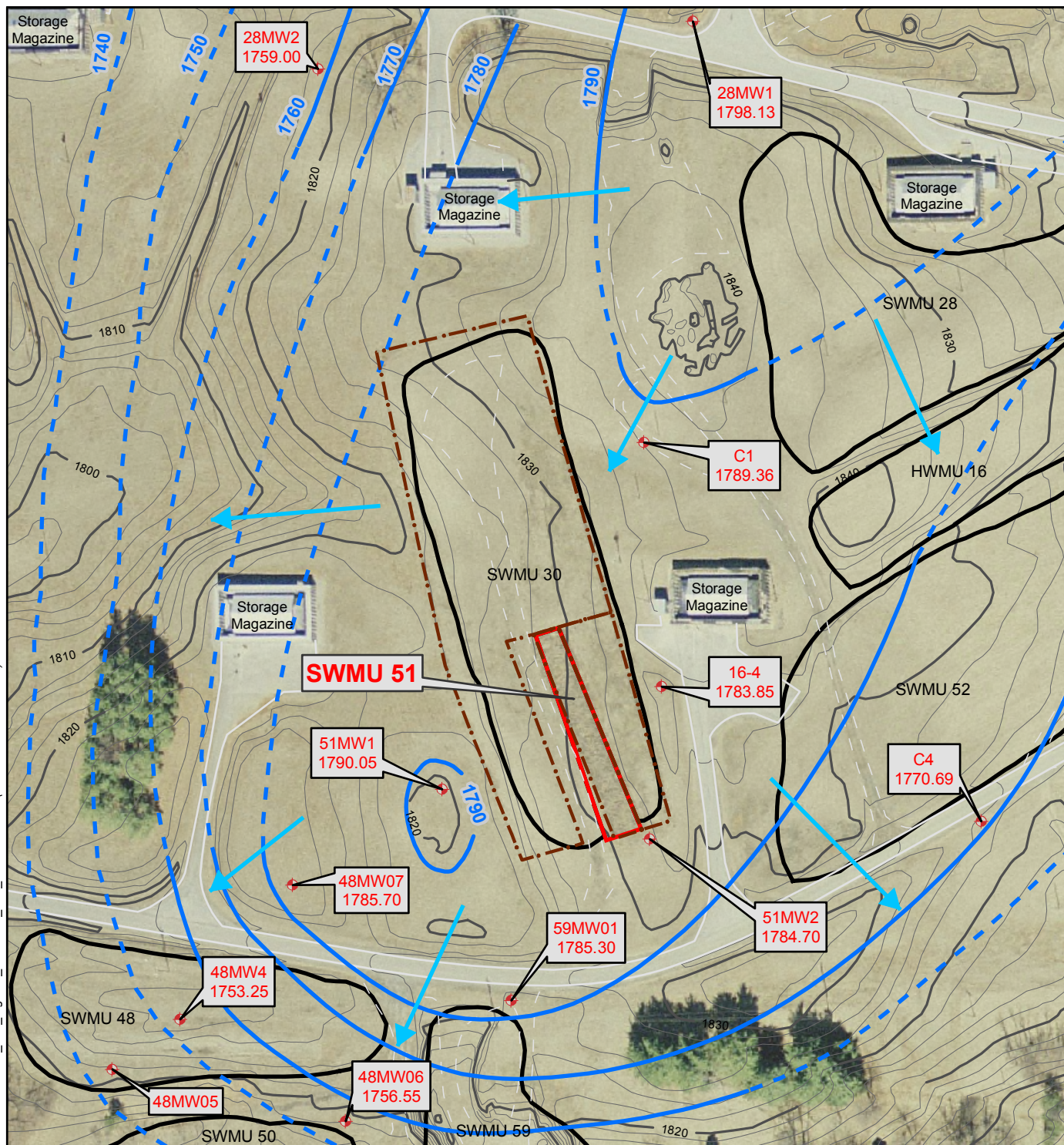
na = not applicable

**Table 2-1**  
**Monthly Groundwater Elevations for Monitoring Wells in the SWMU 51 Vicinity**  
**Page 3 of 3**

| Well Number | Screened Media | Groundwater | Water Depth    | Groundwater | Water Depth    | Groundwater | Water Depth    | Groundwater | Water Depth    | Groundwater | Water Depth    | Groundwater |
|-------------|----------------|-------------|----------------|-------------|----------------|-------------|----------------|-------------|----------------|-------------|----------------|-------------|
|             |                | Elevation   | (from meas pt) | Elevation   | (from meas pt) | Elevation   | (from meas pt) | Elevation   | (from meas pt) | Elevation   | (from meas pt) | Elevation   |
|             |                | Jun-03      | Jul-03         | Jul-03      | Aug-03         | Aug-03      | Sep-03         | Sep-03      | Apr-06         | Apr-06      | Aug-07         | Aug-07      |
| 16-4        | Bedrock        | 1787.20     | 45.87          | 1789.48     | 46.58          | 1788.77     | 47.48          | 1787.87     | 52.91          | 1783.85     | na             | na          |
| 28MW1       | Bedrock        | 1798.59     | 24.24          | 1801.62     | 26.66          | 1799.20     | 27.33          | 1798.53     | 29.05          | 1798.13     | na             | na          |
| 28MW2       | Bedrock        | 1758.57     | 51.92          | 1768.34     | 54.54          | 1765.72     | 58.58          | 1761.68     | 62.56          | 1759.00     | na             | na          |
| 48MW4       | Bedrock        | 1753.66     | 75.10          | 1756.05     | 76.86          | 1754.29     | 77.59          | 1753.56     | 80.41          | 1752.19     | 79.35          | 1753.25     |
| 48MW06      | Bedrock        | na          | na             | na          | na             | na          | na             | na          | na             | na          | 66.65          | 1756.55     |
| 48MW07      | Bedrock        | na          | na             | na          | na             | na          | na             | na          | na             | na          | 48.24          | 1785.70     |
| 51MW1       | Unconsol*      | 1800.11     | 17.11          | 1804.61     | 26.63          | 1795.09     | 30.95          | 1800.20     | 33.08          | 1790.05     | na             | na          |
| 51MW2       | Interface      | 1790.96     | 39.61          | 1793.75     | 40.88          | 1792.48     | 41.91          | 1789.24     | 50.07          | 1784.70     | na             | na          |
| 59MW01      | Bedrock        | na          | na             | na          | na             | na          | na             | na          | na             | na          | 45.90          | 1785.30     |
| C1          | Bedrock        | 1793.74     | 44.04          | 1796.10     | 45.00          | 1795.14     | 45.93          | 1794.21     | 50.78          | 1789.36     | na             | na          |
| C4          | Bedrock        | 1776.04     | 46.96          | 1777.61     | 48.85          | 1775.72     | 49.96          | 1774.61     | 53.88          | 1770.69     | na             | na          |

\* The bottom of screen is at the top of rock.

na = not applicable



## LEGEND

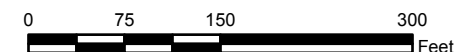
- Monitoring Well Location
- Dirt Road
- Paved Road
- 10 ft Contour Line
- Groundwater Contour
- Inferred Groundwater Contour
- Groundwater Flow Direction
- Fence Line
- SWMU 51 Boundary
- Other SWMU/HWMU Boundary

### Notes:

- 1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
- 2) Water levels for wells 48MW4, 48MW06, 48MW07, and 59MW01 were measured in Aug 2007. Water levels for the remainder of the wells were measured in April 2006.



Scale:



U.S. Army Corps of Engineers



Shaw® Shaw Environmental, Inc.

**FIGURE 2-12**  
**SWMU 51 Groundwater Contour Map**

Radford Army Ammunition Plant,  
Radford, VA

(MMA) and New River Unit (NRU) at RFAAP to characterize naturally-occurring background soil inorganic concentrations to establish a baseline for inorganic compounds of concern at RFAAP. In 2002, Argonne National Laboratory (ANL) performed a geophysical survey of SWMU 51 to delineate both the lateral and vertical extent of the former trench. These investigations are summarized below.

### **2.6.1 RCRA Facility Assessment, USEPA, 1987**

An assessment was conducted at the unit to evaluate potential hazardous waste or hazardous constituent releases and implement corrective actions, as necessary. The assessment consisted of a preliminary review and evaluation of available site information, personnel interviews, and a visual inspection of the site. Environmental samples were not collected at SWMU 51 as part of the inspection. The assessment concluded that low levels of dinitrotoluene (DNT) and halomethane groundwater detections in HWMU 16 monitoring wells were indicative of SWMU 51 disposal activities. However, site-specific chemical samples were required in accordance with the RFAAP 1989 RCRA permit.

### **2.6.2 Installation Assessment, USEPA, 1992**

The EPIC, through the USEPA and U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), provided aerial photographic analysis of 42 known SWMUs at RFAAP (USEPA, 1992). Aerial photographs from 1937 through 1986 were analyzed to identify features which may have represented potential groundwater or surface water contamination sources at RFAAP.

The aerial photographic analysis of SWMU 51 indicated that activity was first noted at the site in 1975, where a trench that appeared to be empty was visible in the photograph. By 1981, the trench had been filled and a revegetating ground scar was the sole feature that remained.

### **2.6.3 RCRA Facility Investigation, Dames & Moore, 1992**

Because of the proximate nature and similar disposal methods used at SWMUs 28, 51, and 52, the 1992 RFI combined these sites into one study area. Other similar disposal units (HWMU 16 and SWMU 30) were located within the RFI study area, but these sites were not included in the RFAAP 1989 RCRA permit and were not specifically targeted as areas of investigation for the RFI (Dames & Moore, 1992a). RFI field activities included the installation and sampling of four monitoring wells (28MW1, 28MW2, 51MW1, and 51MW2) and the sampling of nine existing monitoring wells in the EHSA. Three of the existing wells sampled in the vicinity of SWMU 51 included wells 16-4, C1, and C4. In addition, five representative soil samples were collected from the well borings for physical testing.

Groundwater samples were analyzed for metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), explosives, total organic content (TOC), total organic halides, and pH. As shown in **Table 2-2** and summarized in **Table 2-3**, groundwater results indicate that one VOC (methylene chloride), one SVOC [bis(2-ethylhexyl)phthalate], one explosive (1,3-DNB), and three metals (aluminum, arsenic, and manganese) were present at the time of the investigation above current groundwater screening levels in the combined study area. Concentrations in wells 51MW1 or 51MW2 did not exceed current groundwater screening levels.

Based on the investigation results, the RFI recommended a CMS for the SWMU 51 study area for the purpose of isolating the waste and preventing leachate generation.

**Table 2-2**  
**Analytes Detected in SWMUs 28, 51, and 52 Groundwater - 1992 RFI**  
**Page 1 of 3**

| Analyte                                | Sample ID<br>Sample Date<br>Sample Depth |        | 16-1 (RDWC*13)<br>2/4/92<br>59-59 |       |       | 16-1 (RDWC*33)<br>2/7/92<br>59-59 |       |       | 16-1 (RDWC*34)<br>2/5/92<br>59-59 |       |       | 16-3 (RDWC*14)<br>1/28/92<br>72-72 |       |       | 16-4 (RDWC*15)<br>1/23/92<br>65-65 |       |       | 16-4 (RDWC*90)<br>1/28/92<br>65-65 |       |       | 28MW1 (RDWC*6)<br>1/30/92<br>45-45 |       |       |
|----------------------------------------|------------------------------------------|--------|-----------------------------------|-------|-------|-----------------------------------|-------|-------|-----------------------------------|-------|-------|------------------------------------|-------|-------|------------------------------------|-------|-------|------------------------------------|-------|-------|------------------------------------|-------|-------|
|                                        | MCL                                      | tw-RBC | Result                            | Lab Q | Val Q | Result                            | Lab Q | Val Q | Result                            | Lab Q | Val Q | Result                             | Lab Q | Val Q | Result                             | Lab Q | Val Q | Result                             | Lab Q | Val Q | Result                             | Lab Q | Val Q |
| <b>VOCs (ug/L)</b>                     |                                          |        |                                   |       |       |                                   |       |       |                                   |       |       |                                    |       |       |                                    |       |       |                                    |       |       |                                    |       |       |
| 1,1,1-Trichloroethane                  | 200                                      | 170    | 0.5                               | U     |       | NT                                |       |       | NT                                |       |       | 0.5                                | U     |       | 0.5                                | U     |       | NT                                 |       |       | 1.5                                |       |       |
| 1,1-Dichloroethane                     | na                                       | 90     | 0.68                              | U     |       | NT                                |       |       | NT                                |       |       | 0.68                               | U     |       | 0.68                               | U     |       | NT                                 |       |       | 0.68                               | U     |       |
| Carbon disulfide                       | na                                       | 100    | 1.7                               |       |       | NT                                |       |       | NT                                |       |       | 0.67                               |       |       | 0.5                                | U     |       | NT                                 |       |       | 1.2                                |       |       |
| Methylene chloride                     | 5                                        | 4.1    | 2.3                               | U     |       | NT                                |       |       | NT                                |       |       | 2.3                                | U     |       | 2.3                                | U     |       | NT                                 |       |       | 2.3                                | U     |       |
| Toluene                                | 1000                                     | 75     | 0.5                               | U     |       | NT                                |       |       | NT                                |       |       | 0.51                               |       |       | 0.5                                | U     |       | NT                                 |       |       | 0.5                                | U     |       |
| Trichlorofluoromethane                 | na                                       | 130    | 1.4                               | U     |       | NT                                |       |       | NT                                |       |       | 1.4                                | U     |       | 6.5                                |       |       | NT                                 |       |       | 1.4                                | U     |       |
| <b>SVOCs (ug/L)</b>                    |                                          |        |                                   |       |       |                                   |       |       |                                   |       |       |                                    |       |       |                                    |       |       |                                    |       |       |                                    |       |       |
| bis(2-Ethylhexyl)phthalate             | 6                                        | 4.8    | NT                                |       |       | 4.8                               | U     |       | NT                                |       |       | 4.8                                | U     |       | 8.5                                |       |       | NT                                 |       |       | 4.8                                | U     |       |
| <b>Pesticides (ug/L)</b> None detected |                                          |        |                                   |       |       |                                   |       |       |                                   |       |       |                                    |       |       |                                    |       |       |                                    |       |       |                                    |       |       |
| <b>PCBs (ug/L)</b> None detected       |                                          |        |                                   |       |       |                                   |       |       |                                   |       |       |                                    |       |       |                                    |       |       |                                    |       |       |                                    |       |       |
| <b>Explosives (ug/L)</b>               |                                          |        |                                   |       |       |                                   |       |       |                                   |       |       |                                    |       |       |                                    |       |       |                                    |       |       |                                    |       |       |
| 1,3-Dinitrobenzene                     | na                                       | 0.36   | NT                                |       |       | NT                                |       |       | 0.611                             | U     |       | 0.799                              |       |       | 0.611                              | U     |       | NT                                 |       |       | 0.611                              | U     |       |
| 2,6-Dinitrotoluene                     | na                                       | 3.7    | NT                                |       |       | NT                                |       |       | 0.0738                            | U     |       | 0.0738                             | U     |       | 0.147                              |       |       | NT                                 |       |       | 0.0738                             | U     |       |
| <b>Metals (ug/L)</b>                   |                                          |        |                                   |       |       |                                   |       |       |                                   |       |       |                                    |       |       |                                    |       |       |                                    |       |       |                                    |       |       |
| Aluminum                               | 50                                       | na     | 140                               |       |       | NT                                |       |       | NT                                |       |       | 141                                | U     |       | 141                                | U     |       | NT                                 |       |       | 141                                | U     |       |
| Arsenic                                | 10                                       | 0.045  | 2.54                              | U     |       | NT                                |       |       | NT                                |       |       | 2.54                               | U     |       | 2.54                               | U     |       | NT                                 |       |       | 2.54                               | U     |       |
| Barium                                 | 2000                                     | 730    | 147                               |       |       | NT                                |       |       | NT                                |       |       | 380                                |       |       | 113                                |       |       | NT                                 |       |       | 78                                 |       |       |
| Calcium                                | na                                       | na     | 69400                             |       |       | NT                                |       |       | NT                                |       |       | 23100                              |       |       | 24700                              |       |       | NT                                 |       |       | 27600                              |       |       |
| Iron                                   | 300                                      | 1100   | 180                               |       |       | NT                                |       |       | NT                                |       |       | 38.8                               | U     |       | 38.8                               | U     |       | NT                                 |       |       | 83.9                               |       |       |
| Lead                                   | 15                                       | na     | 1.26                              | U     |       | NT                                |       |       | NT                                |       |       | 1.26                               | U     |       | 1.41                               |       |       | NT                                 |       |       | 1.26                               | U     |       |
| Magnesium                              | na                                       | na     | 29400                             |       |       | NT                                |       |       | NT                                |       |       | 22400                              |       |       | 18900                              |       |       | NT                                 |       |       | 22100                              |       |       |
| Manganese                              | 50                                       | 73     | 22.2                              |       |       | NT                                |       |       | NT                                |       |       | 3.95                               |       |       | 2.75                               | U     |       | NT                                 |       |       | 2.75                               | U     |       |
| Potassium                              | na                                       | na     | 4190                              |       |       | NT                                |       |       | NT                                |       |       | 3110                               |       |       | 1800                               |       |       | NT                                 |       |       | 1710                               |       |       |
| Sodium                                 | na                                       | na     | 4490                              |       |       | NT                                |       |       | NT                                |       |       | 922                                |       |       | 941                                |       |       | NT                                 |       |       | 1330                               |       |       |
| Zinc                                   | 5000                                     | 1100   | 26.4                              |       |       | NT                                |       |       | NT                                |       |       | 21.1                               | U     |       | 21.1                               | U     |       | NT                                 |       |       | 30.9                               |       |       |
| <b>Misc.</b>                           |                                          |        |                                   |       |       |                                   |       |       |                                   |       |       |                                    |       |       |                                    |       |       |                                    |       |       |                                    |       |       |
| Total Organic Carbon (ug/L)            | na                                       | na     | 36.7                              |       |       | NT                                |       |       | NT                                |       |       | 11.3                               |       |       | NT                                 |       |       | 2.41                               |       |       | 3.75                               |       |       |
| Total Organic Halides (ug/L)           | na                                       | na     | 180                               |       |       | NT                                |       |       | NT                                |       |       | 145                                |       |       | NT                                 |       |       | 150                                |       |       | 59.7                               |       |       |
| pH                                     | na                                       | na     | 7.32                              |       | J     | NT                                |       |       | NT                                |       |       | 7.92                               |       |       | NT                                 |       |       | 8.06                               |       |       | 7.29                               |       | J     |

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

**Table 2-2**  
**Analytes Detected in SWMUs 28, 51, and 52 Groundwater - 1992 RFI**  
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| Analyte                                | Sample ID<br>Sample Date<br>Sample Depth |        | 28MW2 (RDWC*7)<br>2/4/92<br>76-76 |       |       | 51MW1 (RDWC*10)<br>1/28/92<br>35-35 |       |       | 51MW2 (RDWC*11)<br>1/23/92<br>53-53 |       |       | 51MW2 (RDWC*89)<br>1/28/92<br>53-53 |       |       | C1 (RDWC*8)<br>1/30/92<br>63-63 |       |       | C4 (RDWC*18)<br>2/4/92<br>70-70 |       |       | CDH-2 (RDWC*20)<br>1/23/92<br>61-61 |       |       |
|----------------------------------------|------------------------------------------|--------|-----------------------------------|-------|-------|-------------------------------------|-------|-------|-------------------------------------|-------|-------|-------------------------------------|-------|-------|---------------------------------|-------|-------|---------------------------------|-------|-------|-------------------------------------|-------|-------|
|                                        | MCL                                      | tw-RBC | Result                            | Lab Q | Val Q | Result                              | Lab Q | Val Q | Result                              | Lab Q | Val Q | Result                              | Lab Q | Val Q | Result                          | Lab Q | Val Q | Result                          | Lab Q | Val Q | Result                              | Lab Q | Val Q |
| <b>VOCs (ug/L)</b>                     |                                          |        |                                   |       |       |                                     |       |       |                                     |       |       |                                     |       |       |                                 |       |       |                                 |       |       |                                     |       |       |
| 1,1,1-Trichloroethane                  | 200                                      | 170    | 0.5                               | U     |       | 0.5                                 | U     |       | 0.5                                 | U     |       | NT                                  |       |       | 5                               |       |       | 0.5                             | U     |       | 0.5                                 | U     |       |
| 1,1-Dichloroethane                     | na                                       | 90     | 0.68                              | U     |       | 0.68                                | U     |       | 0.68                                | U     |       | NT                                  |       |       | 0.68                            | U     |       | 0.68                            | U     |       | 0.68                                | U     |       |
| Carbon disulfide                       | na                                       | 100    | 18                                |       |       | 0.5                                 | U     |       | 0.5                                 | U     |       | NT                                  |       |       | 1.1                             |       |       | 19                              |       |       | 0.5                                 | U     |       |
| Methylene chloride                     | 5                                        | 4.1    | 2.3                               | U     |       | 2.3                                 | U     |       | 2.3                                 | U     |       | NT                                  |       |       | 2.3                             | U     |       | 2.3                             | U     |       | 2.3                                 | U     |       |
| Toluene                                | 1000                                     | 75     | 0.5                               | U     |       | 0.5                                 | U     |       | 0.5                                 | U     |       | NT                                  |       |       | 0.5                             | U     |       | 0.5                             | U     |       | 0.5                                 | U     |       |
| Trichlorofluoromethane                 | na                                       | 130    | 1.4                               | U     |       | 1.4                                 | U     |       | 2.5                                 |       |       | NT                                  |       |       | 9.6                             |       |       | 2.1                             |       |       | 1.4                                 | U     |       |
| <b>SVOCs (ug/L)</b>                    |                                          |        |                                   |       |       |                                     |       |       |                                     |       |       |                                     |       |       |                                 |       |       |                                 |       |       |                                     |       |       |
| bis(2-Ethylhexyl)phthalate             | 6                                        | 4.8    | 4.8                               | U     |       | 4.8                                 | U     |       | 4.8                                 | U     |       | NT                                  |       |       | 4.8                             | U     |       | 4.8                             | U     |       | 4.8                                 | U     |       |
| <b>Pesticides (ug/L)</b> None detected |                                          |        |                                   |       |       |                                     |       |       |                                     |       |       |                                     |       |       |                                 |       |       |                                 |       |       |                                     |       |       |
| <b>PCBs (ug/L)</b> None detected       |                                          |        |                                   |       |       |                                     |       |       |                                     |       |       |                                     |       |       |                                 |       |       |                                 |       |       |                                     |       |       |
| <b>Explosives (ug/L)</b>               |                                          |        |                                   |       |       |                                     |       |       |                                     |       |       |                                     |       |       |                                 |       |       |                                 |       |       |                                     |       |       |
| 1,3-Dinitrobenzene                     | na                                       | 0.36   | 0.611                             | U     |       | 0.611                               | U     |       | 0.611                               | U     |       | NT                                  |       |       | 0.611                           | U     |       | 0.611                           | U     |       | 0.611                               | U     |       |
| 2,6-Dinitrotoluene                     | na                                       | 3.7    | 0.0738                            | U     |       | 0.0738                              | U     |       | 0.126                               |       |       | NT                                  |       |       | 0.0738                          | U     |       | 0.0738                          | U     |       | 0.0738                              | U     |       |
| <b>Metals (ug/L)</b>                   |                                          |        |                                   |       |       |                                     |       |       |                                     |       |       |                                     |       |       |                                 |       |       |                                 |       |       |                                     |       |       |
| Aluminum                               | 50                                       | na     | 141                               | U     |       | 141                                 | U     |       | 141                                 | U     |       | NT                                  |       |       | 141                             | U     |       | 141                             | U     |       | 141                                 | U     |       |
| Arsenic                                | 10                                       | 0.045  | 2.54                              | U     |       | 2.54                                | U     |       | 2.54                                | U     |       | NT                                  |       |       | 2.54                            | U     |       | 6.4                             |       |       | 2.54                                | U     |       |
| Barium                                 | 2000                                     | 730    | 268                               |       |       | 9.72                                |       |       | 11.5                                |       |       | NT                                  |       |       | 42.7                            |       |       | 125                             |       |       | 108                                 |       |       |
| Calcium                                | na                                       | na     | 46800                             |       |       | 18800                               |       |       | 36400                               |       |       | NT                                  |       |       | 37200                           |       |       | 45100                           |       |       | 76600                               |       |       |
| Iron                                   | 300                                      | 1100   | 44.4                              |       |       | 41.4                                |       |       | 38.8                                | U     |       | NT                                  |       |       | 38.8                            | U     |       | 72.4                            |       |       | 38.8                                | U     |       |
| Lead                                   | 15                                       | na     | 1.26                              | U     |       | 1.26                                | U     |       | 1.52                                |       |       | NT                                  |       |       | 2.82                            |       |       | 1.26                            | U     |       | 1.26                                | U     |       |
| Magnesium                              | na                                       | na     | 23600                             |       |       | 4840                                |       |       | 10500                               |       |       | NT                                  |       |       | 15600                           |       |       | 21000                           |       |       | 27400                               |       |       |
| Manganese                              | 50                                       | 73     | 3.46                              |       |       | 3.58                                |       |       | 2.75                                | U     |       | NT                                  |       |       | 2.75                            | U     |       | 135                             |       |       | 2.75                                | U     |       |
| Potassium                              | na                                       | na     | 2670                              |       |       | 2840                                |       |       | 1290                                |       |       | NT                                  |       |       | 2580                            |       |       | 1190                            |       |       | 2430                                |       |       |
| Sodium                                 | na                                       | na     | 4400                              |       |       | 1340                                |       |       | 1560                                |       |       | NT                                  |       |       | 2540                            |       |       | 2420                            |       |       | 2800                                |       |       |
| Zinc                                   | 5000                                     | 1100   | 49.4                              |       |       | 21.1                                | U     |       | 21.1                                | U     |       | NT                                  |       |       | 21.1                            | U     |       | 21.1                            | U     |       | 21.1                                | U     |       |
| <b>Misc.</b>                           |                                          |        |                                   |       |       |                                     |       |       |                                     |       |       |                                     |       |       |                                 |       |       |                                 |       |       |                                     |       |       |
| Total Organic Carbon (ug/L)            | na                                       | na     | 4.06                              |       |       | 4.55                                |       |       | NT                                  |       |       | 3.83                                |       |       | 37.1                            |       |       | 7.33                            |       |       | NT                                  |       |       |
| Total Organic Halides (ug/L)           | na                                       | na     | 82.5                              |       |       | 158                                 |       |       | NT                                  |       |       | 174                                 |       |       | 97                              |       |       | 75.8                            |       |       | NT                                  |       |       |
| pH                                     | na                                       | na     | 8.13                              |       | J     | 8.63                                |       |       | NT                                  |       |       | 8.81                                |       |       | 7.34                            |       | J     | 7.53                            |       | J     | NT                                  |       |       |

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

**Table 2-2**  
**Analytes Detected in SWMUs 28, 51, and 52 Groundwater - 1992 RFI**  
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| Analyte                                | Sample ID<br>Sample Date<br>Sample Depth |        | CDH-2 (RDWC*91)<br>1/28/92<br>61-61 |       |       | MW9 (RDWC*4)<br>1/29/92<br>70-70 |       |       | WC1-A (RDWC*21)<br>1/24/92<br>85-85 |       |       | WC1-A (RDWC*92)<br>1/28/92<br>70-70 |       |       | WC2-A (RDWC*22)<br>1/29/92<br>69-69 |       |       |
|----------------------------------------|------------------------------------------|--------|-------------------------------------|-------|-------|----------------------------------|-------|-------|-------------------------------------|-------|-------|-------------------------------------|-------|-------|-------------------------------------|-------|-------|
|                                        | MCL                                      | tw-RBC | Result                              | Lab Q | Val Q | Result                           | Lab Q | Val Q | Result                              | Lab Q | Val Q | Result                              | Lab Q | Val Q | Result                              | Lab Q | Val Q |
| <b>VOCs (ug/L)</b>                     |                                          |        |                                     |       |       |                                  |       |       |                                     |       |       |                                     |       |       |                                     |       |       |
| 1,1,1-Trichloroethane                  | 200                                      | 170    | NT                                  |       |       | 4.3                              |       |       | 0.5                                 | U     |       | NT                                  |       |       | 0.5                                 | U     |       |
| 1,1-Dichloroethane                     | na                                       | 90     | NT                                  |       |       | 1.3                              |       |       | 0.68                                | U     |       | NT                                  |       |       | 0.68                                | U     |       |
| Carbon disulfide                       | na                                       | 100    | NT                                  |       |       | 0.5                              | U     |       | 1                                   |       |       | NT                                  |       |       | 0.5                                 | U     |       |
| Methylene chloride                     | 5                                        | 4.1    | NT                                  |       |       | 5.7                              |       |       | 2.3                                 | U     |       | NT                                  |       |       | 5.6                                 |       |       |
| Toluene                                | 1000                                     | 75     | NT                                  |       |       | 0.5                              | U     |       | 0.5                                 | U     |       | NT                                  |       |       | 0.5                                 | U     |       |
| Trichlorofluoromethane                 | na                                       | 130    | NT                                  |       |       | 1.8                              |       |       | 1.4                                 | U     |       | NT                                  |       |       | 1.4                                 | U     |       |
| <b>SVOCs (ug/L)</b>                    |                                          |        |                                     |       |       |                                  |       |       |                                     |       |       |                                     |       |       |                                     |       |       |
| bis(2-Ethylhexyl)phthalate             | 6                                        | 4.8    | NT                                  |       |       | 4.8                              | U     |       | 5.3                                 |       |       | NT                                  |       |       | 4.8                                 | U     |       |
| <b>Pesticides (ug/L)</b> None detected |                                          |        |                                     |       |       |                                  |       |       |                                     |       |       |                                     |       |       |                                     |       |       |
| <b>PCBs (ug/L)</b> None detected       |                                          |        |                                     |       |       |                                  |       |       |                                     |       |       |                                     |       |       |                                     |       |       |
| <b>Explosives (ug/L)</b>               |                                          |        |                                     |       |       |                                  |       |       |                                     |       |       |                                     |       |       |                                     |       |       |
| 1,3-Dinitrobenzene                     | na                                       | 0.36   | NT                                  |       |       | 0.611                            | U     |       | 0.611                               | U     |       | NT                                  |       |       | 0.611                               | U     |       |
| 2,6-Dinitrotoluene                     | na                                       | 3.7    | NT                                  |       |       | 0.0738                           | U     |       | 0.0738                              | U     |       | NT                                  |       |       | 0.0738                              | U     |       |
| <b>Metals (ug/L)</b>                   |                                          |        |                                     |       |       |                                  |       |       |                                     |       |       |                                     |       |       |                                     |       |       |
| Aluminum                               | 50                                       | na     | NT                                  |       |       | 141                              | U     |       | 141                                 | U     |       | NT                                  |       |       | 141                                 | U     |       |
| Arsenic                                | 10                                       | 0.045  | NT                                  |       |       | 2.54                             | U     |       | 2.54                                | U     |       | NT                                  |       |       | 2.54                                | U     |       |
| Barium                                 | 2000                                     | 730    | NT                                  |       |       | 165                              |       |       | 136                                 |       |       | NT                                  |       |       | 132                                 |       |       |
| Calcium                                | na                                       | na     | NT                                  |       |       | 61700                            |       |       | 76100                               |       |       | NT                                  |       |       | 23200                               |       |       |
| Iron                                   | 300                                      | 1100   | NT                                  |       |       | 38.8                             | U     |       | 38.8                                | U     |       | NT                                  |       |       | 38.8                                | U     |       |
| Lead                                   | 15                                       | na     | NT                                  |       |       | 1.26                             | U     |       | 5.64                                |       |       | NT                                  |       |       | 1.26                                | U     |       |
| Magnesium                              | na                                       | na     | NT                                  |       |       | 24200                            |       |       | 29800                               |       |       | NT                                  |       |       | 18500                               |       |       |
| Manganese                              | 50                                       | 73     | NT                                  |       |       | 3.66                             |       |       | 23.9                                |       |       | NT                                  |       |       | 18.8                                |       |       |
| Potassium                              | na                                       | na     | NT                                  |       |       | 6660                             |       |       | 7050                                |       |       | NT                                  |       |       | 3370                                |       |       |
| Sodium                                 | na                                       | na     | NT                                  |       |       | 7410                             |       |       | 7670                                |       |       | NT                                  |       |       | 4900                                |       |       |
| Zinc                                   | 5000                                     | 1100   | NT                                  |       |       | 21.1                             | U     |       | 21.1                                | U     |       | NT                                  |       |       | 21.1                                | U     |       |
| <b>Misc.</b>                           |                                          |        |                                     |       |       |                                  |       |       |                                     |       |       |                                     |       |       |                                     |       |       |
| Total Organic Carbon (ug/L)            | na                                       | na     | 5.25                                |       |       | 4.64                             |       |       | NT                                  |       |       | 11.4                                |       |       | 9.47                                |       |       |
| Total Organic Halides (ug/L)           | na                                       | na     | 212                                 |       |       | 177                              |       |       | NT                                  |       |       | 51.2                                |       |       | 118                                 |       |       |
| pH                                     | na                                       | na     | 6.99                                |       |       | 7.62                             |       | J     | NT                                  |       |       | 7.14                                |       |       | 7.99                                |       | J     |

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

**Table 2-2**  
**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.

**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 2-3**  
**Summary of Analytes Detected in SWMUs 28, 51, and 52 Wells - 1992 RFI**

| Analyte                                       | MCL  | tw-RBC | # of MCL Exceedances | # of tw-RBC Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|-----------------------------------------------|------|--------|----------------------|-------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| <b>VOCs (ug/L)</b>                            |      |        |                      |                         |                 |              |                       |                       |                     |
| 1,1,1-Trichloroethane                         | 200  | 170    | 0                    | 0                       | 3               | 13           | 1.5                   | 5                     | C1 (RDWC*8)         |
| 1,1-Dichloroethane                            | na   | 90     | na                   | 0                       | 1               | 13           | 1.3                   | 1.3                   | MW9 (RDWC*4)        |
| Carbon disulfide                              | na   | 100    | na                   | 0                       | 7               | 13           | 0.67                  | 19                    | C4 (RDWC*18)        |
| Methylene chloride                            | 5    | 4.1    | 2                    | 2                       | 2               | 13           | 5.6                   | 5.7                   | MW9 (RDWC*4)        |
| Toluene                                       | 1000 | 75     | 0                    | 0                       | 1               | 13           | 0.51                  | 0.51                  | 16-3 (RDWC*14)      |
| Trichlorofluoromethane                        | na   | 130    | na                   | 0                       | 5               | 13           | 1.8                   | 9.6                   | C1 (RDWC*8)         |
| <b>SVOCs (ug/L)</b>                           |      |        |                      |                         |                 |              |                       |                       |                     |
| bis(2-Ethylhexyl)phthalate                    | 6    | 4.8    | 1                    | 2                       | 2               | 13           | 5.3                   | 8.5                   | 16-4 (RDWC*15)      |
| <b>Pesticides (ug/L)</b> <i>None detected</i> |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>PCBs (ug/L)</b> <i>None detected</i>       |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>Explosives (ug/L)</b>                      |      |        |                      |                         |                 |              |                       |                       |                     |
| 1,3-Dinitrobenzene                            | na   | 0.36   | na                   | 1                       | 1               | 13           | 0.799                 | 0.799                 | 16-3 (RDWC*14)      |
| 2,6-Dinitrotoluene                            | na   | 3.7    | na                   | 0                       | 2               | 13           | 0.126                 | 0.147                 | 16-4 (RDWC*15)      |
| <b>Metals (ug/L)</b>                          |      |        |                      |                         |                 |              |                       |                       |                     |
| Aluminum                                      | 50   | na     | 1                    | na                      | 1               | 13           | 140                   | 140                   | 16-1 (RDWC*13)      |
| Arsenic                                       | 10   | 0.045  | 0                    | 1                       | 1               | 13           | 6.4                   | 6.4                   | C4 (RDWC*18)        |
| Barium                                        | 2000 | 730    | 0                    | 0                       | 13              | 13           | 9.72                  | 380                   | 16-3 (RDWC*14)      |
| Calcium                                       | na   | na     | na                   | na                      | 13              | 13           | 18800                 | 76600                 | CDH-2 (RDWC*20)     |
| Iron                                          | 300  | 1100   | 0                    | 0                       | 5               | 13           | 41.4                  | 180                   | 16-1 (RDWC*13)      |
| Lead                                          | 15   | na     | 0                    | na                      | 4               | 13           | 1.41                  | 5.64                  | WC1-A (RDWC*21)     |
| Magnesium                                     | na   | na     | na                   | na                      | 13              | 13           | 4840                  | 29800                 | WC1-A (RDWC*21)     |
| Manganese                                     | 50   | 73     | 1                    | 1                       | 8               | 13           | 3.46                  | 135                   | C4 (RDWC*18)        |
| Potassium                                     | na   | na     | na                   | na                      | 13              | 13           | 1190                  | 7050                  | WC1-A (RDWC*21)     |
| Sodium                                        | na   | na     | na                   | na                      | 13              | 13           | 922                   | 7670                  | WC1-A (RDWC*21)     |
| Zinc                                          | 5000 | 1100   | 0                    | 0                       | 3               | 13           | 26.4                  | 49.4                  | 28MW2 (RDWC*7)      |
| <b>Misc.</b>                                  |      |        |                      |                         |                 |              |                       |                       |                     |
| Total Organic Carbon (ug/L)                   | na   | na     | na                   | na                      | 13              | 13           | 2.41                  | 37.1                  | C1 (RDWC*8)         |
| Total Organic Halides (ug/L)                  | na   | na     | na                   | na                      | 13              | 13           | 51.2                  | 212                   | CDH-2 (RDWC*91)     |
| pH                                            | na   | na     | na                   | na                      | 13              | 13           | 6.99                  | 8.81                  | 51MW2 (RDWC*89)     |

#### 2.6.4 Facility-Wide Background Study, IT Corporation, 2001

A Facility-Wide Background Study was conducted at the MMA and NRU at RFAAP in 2001 (IT, 2001). Task objectives were to characterize naturally-occurring background soil inorganic concentrations to establish a baseline for inorganic compounds of concern at RFAAP. Data was statistically evaluated across soil types, soil horizons, and study areas to assess the potential for expanding the effective data into one set. Statistical tests demonstrated that the data was statistically similar across soil types and study areas, resulting in one set of background values for both surface and subsurface soil. Facility-wide point estimates for background soil data were calculated as 95% upper tolerance limits (UTLs) and are presented in **Table 2-4**. In general, UTLs were calculated as follows:

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

where:

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

**Table 2-4**  
**Facility-Wide Point Estimates for Background Soil**

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

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

Inorganic constituents detected at concentrations exceeding screening levels are compared to the background concentrations to assess whether these metals are present at concentrations greater than naturally-occurring levels. Inorganics detected at concentrations less than background levels are not considered site-related constituents in the Nature and Extent of Contamination Assessment (*Section 4.0*), but are carried through the risk assessment process (*Sections 6.0 and 7.0*).

### **2.6.5 Geophysical Survey, ANL, 2002**

During the time period of August through September 2002, ANL performed a geophysical survey of SWMU 51 to characterize both the lateral and vertical extent of the former TNT neutralization sludge disposal trench. Subsurface information obtained by the geophysical surveys was used to develop the CSM and focus the sampling activities that were proposed in MWP Addendum 017 (Shaw, 2004).

Surface geophysical surveys using 2-dimensional resistivity profiling, seismic refraction tomography, and EM-31/34 terrain-conductivity mapping were performed at SWMU 51. Additional seismic velocity measurements were collected in four monitoring wells adjacent to SWMU 51 to help guide the seismic interpretations, and downhole electrical logging was collected by USACE New England District personnel to help validate the resistivity models. The complete draft geophysical report and methods are presented in **Appendices B-2 and B-3**.

Geophysical surveys for SWMU 51 consisted of three seismic-refraction profiles, four 2-dimensional electrical-resistivity imaging (2D-ERI) profiles, and one electromagnetic (EM) grid (**Appendix B-2, Figure B-1**). Also shown on **Appendix B-2, Figure B-1** are the locations of the main boundary fence for SWMU 30, the interior fence outlining the TNT sludge disposal trench, and the areal coverage provided by the EM grid (approximately 33 ft major survey lines are shown). Two of the profiles (L-2 and L-3) were collected parallel to the long axis of the trench, and the other two profiles (L-1 and L-4) were collected perpendicular to the long axis.

Seismic refraction tomography mapped a low-velocity zone interpreted to be due to the capping or backfilled material, but did not map the base of the trench. Earth-layer models constructed for the profiles indicate an intra-overburden increase in velocity, which occurs near the base of the trenching, and may indicate a maximum boundary for trenching. No significant structural features were indicated for the bedrock, and top-of-bedrock was mapped as a relatively horizontal surface [approximately 1,780-1,782 ft msl or 39-53 ft bgs (observed at monitoring wells 51MW1 and 51MW2, respectively)].

The 2D-ERI profiling modeled a zone of low-resistivity (<80 ohm-m) underlying the SWMU 51 fenced area. The source for the low-resistivity was interpreted to be either the waste or waste byproducts (leachate or leached material). Depth-to-top of this low-resistivity zone ranged from 5-9 ft bgs, and averaged 6-7 ft bgs. Therefore, the data suggests that the waste material deposited in the SWMU 51 trench is at least 5 ft bgs.

The resistivity data indicated a range of 15-25 ft bgs for the base, though it is possible that a downward migration of leachate (or leached material) has increased thickness of the low-

resistivity zone, thus overstating the thickness of the waste. At best, the base of the low-resistivity zone can serve as an upper boundary for estimating the thickness of the waste material.

EM surveys using the EM-31 and EM-34 instruments mapped a zone of increased electrical-conductivity (decreased resistivity) within the southern two-thirds of the SWMU 51 fenced area. A 1-2 mS/m increase was measured by the EM-31, and suggests that the top of the anomalous region must be within the upper 10 ft (approximately 3 meters) of the subsurface. The EM-34 instrument yielded a greater EM response than the EM-31, indicating that the source of this electrically conductivity zone (low-resistivity) extends below 10 ft (approximately 3 meters in depth). The anomalous area mapped by the EM-34 was approximately two-thirds that indicated by the 2D-ERI profiles.

In summary, geophysical surveys were conducted at SWMU 51 in order to delineate the horizontal and vertical boundaries of the disposal trench. The geophysical data suggested that the SWMU 51 related trenching and disposal is contained within the current SWMU 51 fence, and restricted to the southern two-thirds of the fenced area (**Figure 2-3**).

Based on the results of the geophysical survey the volume of waste was estimated as follows:

- The maximum areal extent of the trench defined by the 2D-ERI data is approximately 2,300 square feet (115 ft x 20 ft). The minimum areal extent can be estimated from the EM-34 conductivity anomaly map, and is 1,800 square feet (90 ft x 20 ft).
- Depth to top of the low-resistivity (electrically conductive) zone ranges from 5-9 ft, and averages 6-7 ft. Depth to bottom ranges from 15-25 ft, with an average of approximately 18 ft. The range in thickness is 6-20 ft, and averages approximately 11 ft.
- Using the average thickness (indicated on the 2D-ERI sections) and the areal extent, a volume range of 19,800 (11 ft x 90 ft x 20 ft) to 25,300 (11 ft x 115 ft x 20 ft) cubic ft or 733 to 937 cubic yards was calculated.

### 3.0 FIELD INVESTIGATION PROGRAMS

Three sampling events were conducted by Shaw in support of the SWMU 51 investigation. These investigations consisted of an RFI soil investigation at SWMU 51 in 2004, a groundwater investigation of the EHSA in 2006, and groundwater sampling as part of an RFI at the SWMU 48/49/50/59 area in 2007. Details of these investigations are described in *Section 3.1* (SWMU 51 RFI Soil Investigation), *Section 3.2* (EHSA Groundwater Investigation), and *Section 3.3* (2007 Investigation Groundwater Sampling). Results from these investigations are presented in *Section 4.0*.

#### 3.1 SWMU 51 RFI Soil Investigation, Shaw, 2004

Forty-four borings were advanced as part of the 2004 field investigation for SWMU 51. Thirty-three of these were for stratigraphic characterization and waste delineation. Thirty-eight soil samples were collected from the remaining 11 borings for chemical and physical analysis during RFI sampling activities at SWMU 51 (**Table 3-1**). Sampling locations (**Figure 2-3**) were selected based on preliminary geophysical data, site visit observations, negotiations with regulators, and the CSM.

**Table 3-1**  
**2004 RFI Environmental Samples and Analyses**

| Media           | Sample ID | Sample Depth | Analytes                                                                                        |
|-----------------|-----------|--------------|-------------------------------------------------------------------------------------------------|
| Surface Soil    | 51SB1A    | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL inorganics                 |
|                 | 51SB2A    | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB3A    | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB4A    | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB5A    | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB6A    | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB7A    | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, explosives, TAL inorganics                                              |
|                 | 51SB8A    | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, explosives, TAL inorganics                                              |
|                 | 51SB9A    | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, explosives, TAL inorganics                                              |
|                 | 51SB10A   | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, explosives, TAL inorganics                                              |
|                 | 51SB11A   | 0-0.5 ft bgs | TCL VOCs*, SVOCs, PAHs, explosives, TAL inorganics                                              |
| Subsurface Soil | 51SB1B    | 15-17 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                                               |
|                 | 51SB1C    | 35-37 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                                               |
|                 | 51SB2B    | 10-12 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics, PCBs, dioxins/furans                         |
|                 | 51SB2C    | 15-17 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans                         |
|                 | 51SB2D    | 33-35 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans                         |

**Table 3-1 (Continued)**  
**2004 RFI Environmental Samples and Analyses**

| Media           | Sample ID | Sample Depth | Analytes                                                                |
|-----------------|-----------|--------------|-------------------------------------------------------------------------|
| Subsurface Soil | 51SB3B    | 13-15 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB3C    | 15-18 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB3D    | 36-38 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB4B    | 13-15 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB4C    | 17-20 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB4D    | 36-38 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB5B    | 12-14 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB5C    | 16-18 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB5D    | 31-33 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB6B    | 6-8 ft bgs   | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB6C    | 9-11 ft bgs  | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB6D    | 33-35 ft bgs | TCL VOCs, SVOCs, PAHs, PCBs, explosives, TAL inorganics, dioxins/furans |
|                 | 51SB7B    | 8-10 ft bgs  | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                       |
|                 | 51SB7C    | 32-34 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                       |
|                 | 51SB8B    | 18-20 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                       |
|                 | 51SB8C    | 36-38 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                       |
|                 | 51SB9B    | 15-17 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                       |
|                 | 51SB9C    | 33-35 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                       |
|                 | 51SB10B   | 18-20 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                       |
|                 | 51SB10C   | 30-32 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                       |
|                 | 51SB11B   | 15-17 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                       |
|                 | 51SB11C   | 36-38 ft bgs | TCL VOCs, SVOCs, PAHs, explosives, TAL inorganics                       |

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

\* VOCs were collected from a depth of 0.5-1.0 ft

### 3.1.1 Borings for Chemical Analysis

As presented in **Table 3-1**, 38 analytical samples were collected from 11 borings (51SB1 through 51SB11) along the long axis of the trench and outside the trench boundary (**Figure 2-3, Lines 1, 4, and 6**). Three samples were collected from each boring outside the trench limits as follows: a sample was collected at the surface (0-0.5 ft bgs; 0.5-1 ft bgs for VOCs); at a depth corresponding to slightly below the bottom of the waste; and, at the maximum depth of the boring (refusal on weathered bedrock).

Four samples were collected from each boring within the trench limits as follows: a surface soil sample (0-0.5 ft bgs; 0-1 ft bgs for VOCs); a sample from the trench sludge material; a sample from just below the sludge material; and, a sample at maximum depth of the boring (refusal on

weathered bedrock). The two intermediate depth samples in each boring targeted both the trench waste layer and the sand and cobble layer (illustrated on **Figure 2-4**). Depths to intermediate samples were adjusted during sample collection to account for possible diffusion from the trench area. These depths were identified when the trench limits were defined during the continuous logging of stratigraphic borings inside the trench.

### 3.1.2 Borings for Physical Analysis

In addition to samples submitted for chemical analysis, four soil samples from boring 51SB3 were analyzed for physical and geotechnical properties [Section 5.8 of the MWP; applicable American Society for Testing and Materials (ASTM)] [51SB3A (0-0.5 ft bgs), 51SB3B (13-15 ft bgs), 51SB3C (15-18 ft bgs), and 51SB3D (36-38 ft bgs)]. Boring 51SB3 was advanced through the north-central portion of the trench. Samples were collected from each of the major lithologies encountered [51SB3A (0-0.5 ft bgs) – clay; 51SB3B (13-15 ft bgs) – silt; 51SB3C (15-18 ft bgs) – sand; and 51SB3D (36-38 ft bgs) – gravel]. Samples were analyzed for the following parameters in accordance with the MWP Addendum 017 Quality Assurance Plan (Shaw, 2004):

- Grain size analysis.
- Atterberg limits.
- Soil moisture content.
- TOC.
- Soil bulk density.
- Measurement of hydraulic conductivity.
- Soil porosity.
- pH.

The preparation and analytical methodologies used by the geotechnical laboratory are presented in **Appendix A-1, Table A-1**. A summary of the geotechnical laboratory results is presented in **Table 5-1**. These analyses were intended to enhance the understanding of the physical nature of the soil to provide data necessary for constituent migration modeling. Discussions of how the physical and chemical properties affect the fate and persistence of contaminants in the impacted soil of the former disposal trench are presented in *Section 5.0 – Contaminant Fate and Transport*.

### 3.1.3 Borings for Stratigraphic Characterization

Characterization borings were advanced prior to the borings proposed for chemical sampling to ensure that chemical samples were collected from the proper depths and locations relative to the trench. The borings were advanced to bedrock and continuously logged and interpreted (refer to **Appendix B-1** for the lithologic boring logs). The location and number of borings for stratigraphic characterization were based on the results of the geophysical survey (*Section 2.6.5*). The borings, in conjunction with the chemical and geophysical data, were used to accurately define the area of the trench both vertically and horizontally.

As illustrated on **Figure 2-3**, 25 borings (51SBC1 through 51SBC25) were advanced around and through the trench to verify the results of the geophysical survey and for subsurface stratigraphic

characterization of the disposal trench and surrounding soil. Borings 51SBC1 through 51SBC25 were advanced on lines perpendicular to the long axis of the trench. The lines were spaced approximately 25 ft apart (**Figure 2-3, Lines 2 through 8**). Eight additional borings (NB1 through NB4 and SB1 through SB4) were advanced to define the northern and southern horizontal extents of the trench boundary.

### **3.1.4 Global Positioning System Activities**

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

### **3.1.5 Quality Assurance**

The accuracy and integrity of 2004 RFI data were ensured through the implementation of internal quality control (QC) measures in accordance with MWP Addendum 017 (Shaw, 2004), 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**.

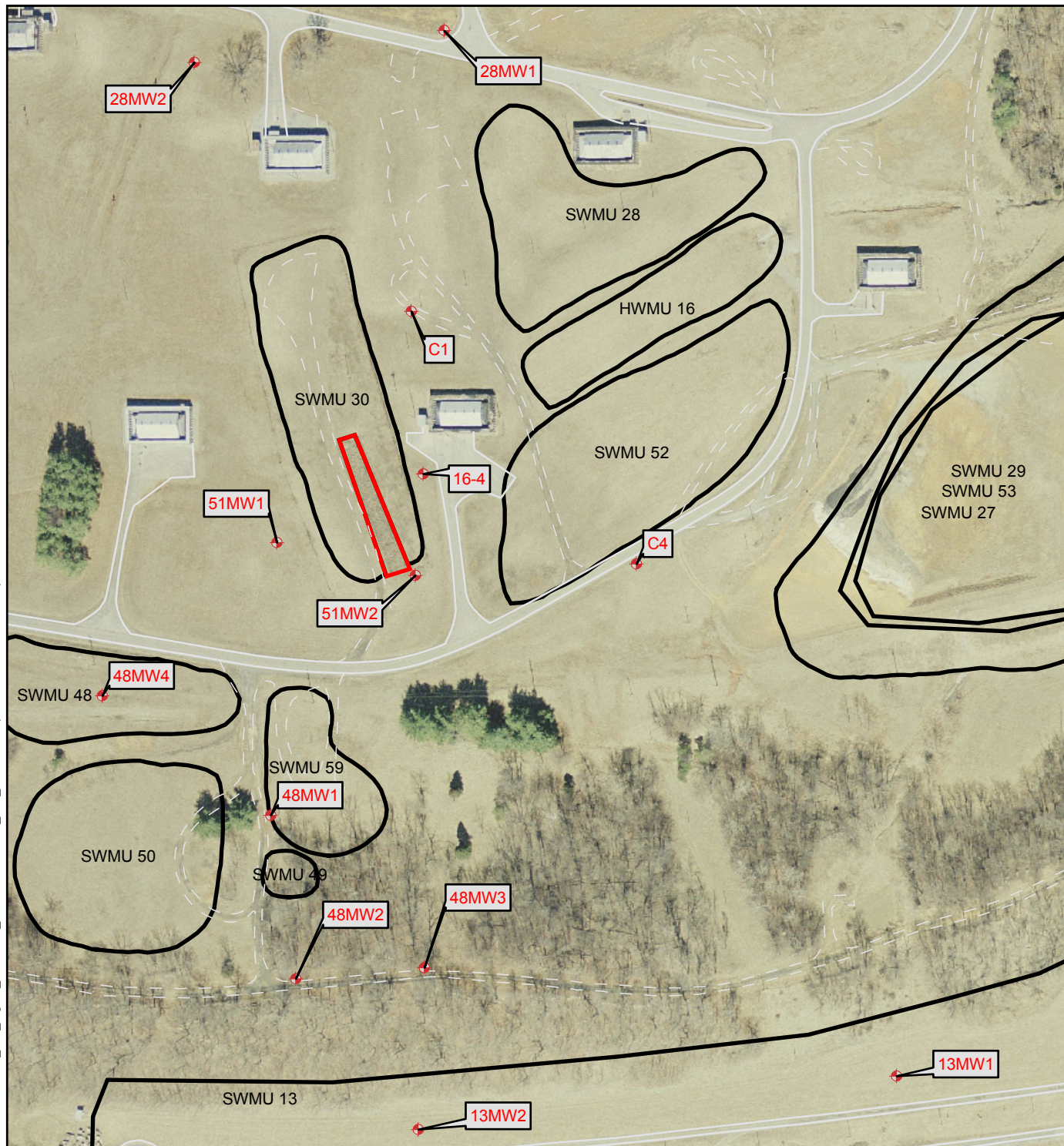
### **3.1.6 Modifications to the Sampling Plan**

In some cases, modifications to the Work Plan are necessary to adjust for field conditions as they occur during field sampling. One adjustment to MWP Addendum 017 (Shaw, 2004) was necessary during sampling activities at SWMU 51, as described below.

Additional borings were advanced at the site to accurately delineate the northern and southern horizontal extents of the trench boundary. These qualitative borings were offset horizontally in 6-inch increments and advanced vertically to a depth of 16 ft bgs until the northern and southern boundaries were accurately established. The locations of the qualitative borings (NB1 through NB4 and SB1 through SB4) that defined the northern and southern trench boundaries are illustrated on **Figure 2-3**.

## **3.2 Eastern Horseshoe Area Groundwater Investigation, Shaw, 2006**

In April 2006, a groundwater sampling event was conducted by Shaw in the EHSA of RFAAP to assess the current nature and extent of groundwater contamination and potential risk to human receptors and determine if any future investigation was warranted. The draft report was not submitted to the regulatory agencies. The combined study area included groundwater monitoring wells in HWMU 16 and SWMUs 13, 28, 48, 49, 50, 51, and 59. Groundwater samples were collected from EHSA wells 16-4, C1, C4, 13MW1, 13MW2, 28MW1, 28MW2, 48MW1, 48MW2, 48MW3, 48MW4, 51MW1, and 51MW2 using low-flow groundwater sampling techniques. The locations of these wells are illustrated on **Figure 3-1**. Monitoring



## LEGEND

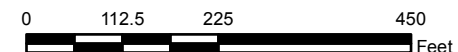
- Monitoring Well Location
- Dirt Road
- Paved Road
- SWMU 51 Boundary
- Other SWMU/HWMU Boundary

### Notes:

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



Scale:



U.S. Army Corps of Engineers



Shaw Environmental, Inc.

FIGURE 3-1

Eastern Horseshoe Area Groundwater  
Investigation Sample Locations

Radford Army Ammunition Plant,  
Radford, VA

well purge forms for wells used to assess SWMU 51 are presented in **Appendix B-4**. All samples were analyzed for target compound list (TCL) VOCs, TCL SVOCs, polynuclear aromatic hydrocarbons (PAHs), TCL pesticides/polychlorinated biphenyls (PCBs), explosives, target analyte list (TAL) metals, and dioxins/furans. Results from this groundwater investigation are presented in *Section 4.2*.

### **3.3 2007 Investigation Groundwater Sampling, Shaw, 2007**

In August 2007, an investigation was conducted by Shaw at nine sites within the MMA to collect additional data in order to complete RFIs for the nine sites. The investigation for the SWMU 48/49/50/59 sites, which are located southwest of SWMU 51, was combined due to the sites' proximity to each other, similar disposal histories, and similar constituents in groundwater. As part of the investigation, seven wells were installed at the four SWMUs. As illustrated on **Figure 2-12**, two of these newly installed wells (48MW07 and 59MW01) are located downgradient of SWMU 51 and can be used to further assess the impact of SWMU 51 soil contaminants on groundwater downgradient of the site. All samples were analyzed for TCL VOCs, TCL SVOCs, PAHs, TCL pest/PCBs, explosives, herbicides, TAL metals, dioxins/furans, and perchlorate. Results from this sampling event are presented in *Section 4.3*. Monitoring well purge forms for wells used to assess SWMU 51 are presented in **Appendix B-4**.

## 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 SWMU 51. 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 Screening.** Chemical results from soil samples are compared to adjusted USEPA Region III industrial and residential soil 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% UTLs are presented for comparison in **Tables 4-1 through 4-9** and on **Figure 4-1**. This comparison is 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.

**Groundwater Screening.** Groundwater sampling results are compared to the 2006 Edition of the Drinking Water Standards and Health Advisories [i.e., maximum contaminant levels (MCLs) and secondary MCLs] (USEPA, 2006a) and adjusted Tap Water RBCs (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. Results from the 2006 EHSA Groundwater Investigation and the 2007 Investigation Groundwater Sampling are presented for comparison in **Tables 4-10 through 4-13** and on **Figure 4-3**.

### 4.1 RCRA Facility Investigation, Shaw, 2004

Soil samples collected at SWMU 51 were separated into three categories based on depth and location of collection. The categories are clean fill and/or native soil, sludge material and/or grossly contaminated soil, and soil below sludge material and/or deep soil.

**Clean Fill and/or Native Soil.** Seventeen soil samples were collected from clean fill used to cover the trench and/or native soil outside the trench for chemical analysis. These samples included the following:

|                          |                          |                           |                           |
|--------------------------|--------------------------|---------------------------|---------------------------|
| 51SB1A<br>(0-0.5 ft bgs) | 51SB5A<br>(0-0.5 ft bgs) | 51SB8B<br>(18-20 ft bgs)  | 51SB11A<br>(0-0.5 ft bgs) |
| 51SB1B<br>(15-17 ft bgs) | 51SB6A<br>(0-0.5 ft bgs) | 51SB9A<br>(0-0.5 ft bgs)  | 51SB11B<br>(15-17 ft bgs) |
| 51SB2A<br>(0-0.5 ft bgs) | 51SB7A<br>(0-0.5 ft bgs) | 51SB9B<br>(15-17 ft bgs)  |                           |
| 51SB3A<br>(0-0.5 ft bgs) | 51SB7B<br>(8-10 ft bgs)  | 51SB10A<br>(0-0.5 ft bgs) |                           |
| 51SB4A<br>(0-0.5 ft bgs) | 51SB8A<br>(0-0.5 ft bgs) | 51SB10B<br>(18-20 ft bgs) |                           |

| Clean Fill and/or Native Soil |                        |
|-------------------------------|------------------------|
| Sample ID                     | Soil r-RBC Exceedances |
| 51SB1B                        | 1 explosive            |
| 51SB4A                        | 2 explosives           |
| 51SB7B                        | 1 metal                |
| 51SB8A                        | 1 PAH                  |
| Sample ID                     | Soil i-RBC Exceedances |
| 51SB7B                        | 1 metal                |

| Sludge Material and/or Grossly Contaminated Soil |                                                 |
|--------------------------------------------------|-------------------------------------------------|
| Sample ID                                        | Soil r-RBC Exceedances                          |
| 51SB2B                                           | 2 SVOCs, 7 explosives, 6 metals, 2 D/Fs         |
| 51SB2C                                           | 2 SVOCs, 6 explosives                           |
| 51SB3B                                           | 2 SVOCs, 7 explosives, 6 metals, 1 D/F          |
| 51SB3C                                           | 2 SVOCs, 6 explosives                           |
| 51SB4B                                           | 2 SVOCs, 5 explosives, 5 metals, 1 D/F          |
| 51SB4C                                           | 1 SVOC, 5 explosives                            |
| 51SB5B                                           | 2 SVOCs, 6 explosives, 6 metals, 1 D/F          |
| 51SB6B                                           | 4 PAHs, 2 SVOCs, 7 explosives, 7 metals, 2 D/Fs |
| Sample ID                                        | Soil i-RBC Exceedances                          |
| 51SB2B                                           | 2 SVOCs, 6 explosives, 4 metals                 |
| 51SB2C                                           | 2 SVOCs, 6 explosives                           |
| 51SB3B                                           | 2 SVOCs, 6 explosives, 3 metals                 |
| 51SB3C                                           | 2 SVOCs, 3 explosives                           |
| 51SB4B                                           | 2 SVOCs, 1 explosive, 3 metals                  |
| 51SB4C                                           | 1 explosive                                     |
| 51SB5B                                           | 2 SVOCs, 6 explosives, 3 metals                 |
| 51SB6B                                           | 1 PAH, 1 SVOC, 4 explosives, 3 metals, 1 D/F    |

| Soil Below Sludge Material and/or Deep Soil |                        |
|---------------------------------------------|------------------------|
| Sample ID                                   | Soil r-RBC Exceedances |
| 51SB3D                                      | 2 SVOCs, 4 explosives  |
| 51SB4D                                      | 1 explosive            |
| 51SB5C                                      | 2 SVOCs, 2 explosives  |
| 51SB5D                                      | 1 explosive            |
| 51SB6C                                      | 1 explosive            |
| 51SB6D                                      | 3 explosives           |
| 51SB8C                                      | 2 metals               |
| 51SB10C                                     | 2 explosives           |
| 51SB11C                                     | 3 explosives           |

**LEGEND**

 Monitoring Well

**Chemical Sample Soil Boring**

 < Residential RBC (October 2007)

**Soil Sample Exceedance Location**

 >= Residential RBC (October 2007)

 >= Industrial RBC (October 2007)

 10 ft Contour Line

 Trench Boundary As Defined By Chemical and Stratigraphic Characterization Borings

 SWMU 51 Boundary

 Other SWMU/HWMU Boundary

Notes:

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



Scale:

0

20

40

80

Feet

U.S. Army Corps of Engineers

Shaw Environmental, Inc.

FIGURE 4-1  
SWMU 51 Chemical Soil Boring  
Locations and Results  
Radford, VA

As shown in the above table, the majority of these samples were surface soil samples collected from 0-0.5 ft bgs (0.5-1.0 ft bgs for VOCs). Samples in this group collected from deeper intervals were located outside the trench boundaries. As indicated in **Table 3-1**, every sample was analyzed for TCL VOCs, SVOCs, PAHs, explosives [including NG and pentaerythritol tetranitrate (PETN)], and TAL inorganics. Six surface soil samples (51SB1A through 51SB6A) were collected and analyzed for TCL pesticides/PCBs and herbicides to characterize site surface soil for these parameters. Five of those samples (51SB2A through 51SB6A) were also analyzed for dioxins/furans because of the possibility that burned materials existed within site surface soil.

**Sludge Material and/or Grossly Contaminated Soil.** Eight samples (shown in the table below) were collected directly from the trench sludge material or from grossly contaminated soil immediately below the trench sludge material for chemical analysis.

|                          |                          |
|--------------------------|--------------------------|
| 51SB2B<br>(10-12 ft bgs) | 51SB4B<br>(13-15 ft bgs) |
| 51SB2C<br>(15-17 ft bgs) | 51SB4C<br>(17-20 ft bgs) |
| 51SB3B<br>(13-15 ft bgs) | 51SB5B<br>(12-14 ft bgs) |
| 51SB3C<br>(15-18 ft bgs) | 51SB6B<br>(6-8 ft bgs)   |

The trench sludge material consisted of a black, paste-like sludge material that was very evident when it was encountered. It was a very sticky substance that exhibited a sweet odor. Based on the disposal history that occurred at the site (*Section 2.2*), it is likely that the black, paste-like material encountered was TNT neutralization sludge from the treatment of red water, a waste product generated during the production of TNT. As illustrated on **Figure 2-4**, this layer ranged in depth from approximately 0.5 ft bgs along the northern and southern boundaries of the trench to approximately 14 ft bgs in the center of the trench. Thickness of the trench waste varied, but averages approximately 3-4 ft in thickness.

The majority of the samples from this grouping were collected from the trench sludge material and represent the area of highest contamination at the site. As shown in the above table, these samples were collected between 6 and 20 ft bgs from borings advanced within the trench boundary (**Figure 2-3**). As indicated in **Table 3-1**, these eight samples were analyzed for TCL VOCs, SVOCs, PAHs, explosives (including NG and PETN), TAL inorganics, PCBs, and dioxins/furans.

**Soil Below Sludge Material and/or Deep Soil.** Thirteen soil samples were collected from soil below the trench sludge material and/or deep soil at the site. These samples included the following:

|                          |                          |                           |
|--------------------------|--------------------------|---------------------------|
| 51SB1C<br>(35-37 ft bgs) | 51SB5D<br>(31-33 ft bgs) | 51SB9C<br>(33-35 ft bgs)  |
| 51SB2D<br>(33-35 ft bgs) | 51SB6C<br>(9-11 ft bgs)  | 51SB10C<br>(30-32 ft bgs) |
| 51SB3D<br>(36-38 ft bgs) | 51SB6D<br>(33-35 ft bgs) | 51SB11C<br>(36-38 ft bgs) |
| 51SB4D<br>(36-38 ft bgs) | 51SB7C<br>(32-34 ft bgs) |                           |
| 51SB5C<br>(16-18 ft bgs) | 51SB8C<br>(36-38 ft bgs) |                           |

As shown in the above table, the majority of these samples were subsurface soil samples collected between 30-38 ft bgs. Shallower samples from beneath the sludge layer were also included in this group. Consistent with chemical analysis of the surface soil samples, each of these samples was analyzed for TCL VOCs, SVOCs, PAHs, explosives (including NG and PETN), and TAL inorganics (**Table 3-1**). Samples collected from the five borings advanced inside the trench (51SB2 through 51SB6) were also analyzed for TCL PCBs and dioxins/furans.

#### **4.1.1 Analytical Results – RCRA Facility Investigation, Shaw, 2004**

**Clean Fill and/or Native Soil.** Seventeen soil samples were collected from clean fill and/or native soil at the site for chemical analysis. Detected constituents are presented in **Tables 4-1 and 4-2** (dioxins/furans) and summarized in **Table 4-3**. Exceedances of regulatory screening levels and background are presented on **Figure 4-1**. The vertical distribution of explosive compounds 2,4-DNT, 2,6-DNT, and 2,4,6,-TNT is illustrated on **Figure 4-2**.

**VOCs.** Five VOCs were detected in the soil samples. Concentrations were below residential screening levels.

**PAHs.** Thirteen PAHs were detected in these samples. One PAH [dibenz(a,h)anthracene] was found to exceed residential screening levels in 51SB8A, a surface soil sample collected just outside the trench boundary.

**SVOCs.** Five SVOCs were detected in clean fill and/or native soil samples. Concentrations were below residential screening levels.

**Pesticides.** Pesticides were not detected in these samples.

**PCBs.** PCBs were not detected in the soil samples.

**Explosives.** Eleven explosives were detected in clean fill and/or native soil samples. Three explosives (2,6-DNT, 2- and 4-nitrotoluene) were detected at concentrations exceeding residential screening levels in two samples (2,6-DNT in 51SB1B and 2- and 4-nitrotoluene both in 51SB4A).

**Herbicides.** Herbicides were not detected in clean fill and/or native soil samples.

**TAL Inorganics.** Twenty-two metals were detected in these samples. Manganese was the only metal detected at concentrations exceeding industrial screening levels. No other metals were detected above residential screening levels in the samples. Cyanide was detected in one sample at a concentration below residential screening levels.

**Dioxins/Furans.** Five dioxins/furan congeners were detected in the soil samples. Of these congeners that have an associated RBC, 2,3,7,8-TCDD was detected at a concentration below the residential screening level. Total HXCDD was also below its residential screening level.

**Sludge Material and/or Grossly Contaminated Soil.** Eight soil samples were collected from the trench sludge material and/or grossly contaminated soil at the site. Detected constituents are presented in **Tables 4-4 and 4-5** (dioxins/furans) and summarized in **Table 4-6**. Exceedances of regulatory screening levels and background are presented on **Figure 4-1**. The vertical distribution of explosive compounds 2,4-DNT, 2,6-DNT, and 2,4,6,-TNT is illustrated on **Figure 4-2**.

**VOCs.** Fourteen VOCs were detected in the soil samples. Concentrations were below residential screening levels.

**Table 4-1**  
**Analytes Detected in Clean Fill and/or Native Soil**  
**Page 1 of 3**

| Analyte                    | Sample ID    |          |            | 51SB1A |       |       |       |      | 51SB1B |       |       |       |      | 51SB2A |       |       |        |     | 51SB3A |       |       |        |      | 51SB4A |       |       |        |      | 51SB5A |       |       |        |      |       |     |
|----------------------------|--------------|----------|------------|--------|-------|-------|-------|------|--------|-------|-------|-------|------|--------|-------|-------|--------|-----|--------|-------|-------|--------|------|--------|-------|-------|--------|------|--------|-------|-------|--------|------|-------|-----|
|                            | Sample Date  |          |            | 4/7/04 |       |       |       |      | 4/7/04 |       |       |       |      | 4/6/04 |       |       |        |     | 4/5/04 |       |       |        |      | 4/1/04 |       |       |        |      | 4/1/04 |       |       |        |      |       |     |
|                            | Sample Depth |          |            | 0-0.5  |       |       |       |      | 15-17  |       |       |       |      | 0-0.5  |       |       |        |     | 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 | Result | Lab Q | Val Q | MDL    | MRL  | Result | Lab Q | Val Q | MDL    | MRL  | Result | Lab Q | Val Q | MDL    | MRL  |       |     |
| VOCs (ug/kg)               |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| 2-Butanone                 | 61000000     | 47000000 | na         | 9      | U     | R     | 2.1   | 9    | 12     | U     | R     | 2.9   | 12   | 9.8    | U     | R     | 2.3    | 9.8 | 10     | U     | R     | 2.4    | 10   | 10     | U     | R     | 2.4    | 10   | 10     | U     | R     | 2.4    | 10   |       |     |
| Acetone                    | 92000000     | 70000000 | na         | 17     | B     | B     | 2.5   | 9    | 14     | B     | B     | 3.4   | 12   | 110    | B     | B     | 2.7    | 9.8 | 40     | B     | B     | 2.8    | 10   | 61     | B     | B     | 2.9    | 10   | 110    | B     | B     | 2.8    | 10   |       |     |
| Methylene chloride         | 380000       | 85000    | na         | 1.1    | JB    | B     | 1     | 9    | 1.6    | JB    | B     | 1.4   | 12   | 3.2    | JB    | B     | 1.1    | 9.8 | 2.8    | JB    | B     | 1.1    | 10   | 10     | U     |       | 1.2    | 10   | 10     | U     |       | 1.2    | 10   |       |     |
| Styrene                    | 20000000     | 16000000 | na         | 4.5    | U     |       | 1.2   | 4.5  | 6.1    | U     | UL    | 1.6   | 6.1  | 4.9    | U     |       | 1.3    | 4.9 | 5      | U     |       | 1.3    | 5    | 5.2    | U     |       | 1.4    | 5.2  | 5.1    | U     |       | 1.3    | 5.1  |       |     |
| Toluene                    | 8200000      | 630000   | na         | 4.5    | U     |       | 1     | 4.5  | 6.1    | U     | UL    | 1.4   | 6.1  | 4.9    | U     |       | 1.1    | 4.9 | 5      | U     |       | 1.1    | 5    | 5.2    | U     |       | 1.2    | 5.2  | 5.1    | U     |       | 1.1    | 5.1  |       |     |
| PAHs (ug/kg)               |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| 2-Methylnaphthalene        | 410000       | 31000    | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 2.4    | 7.9  | 8.1    | U     |       | 2.4    | 8.1  |       |     |
| Benz(a)anthracene          | 3900         | 220      | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 1.2    | 7.9  | 8.1    | U     |       | 1.2    | 8.1  |       |     |
| Benzo(a)pyrene             | 390          | 22       | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 1.2    | 7.9  | 8.1    | U     |       | 1.2    | 8.1  |       |     |
| Benzo(b)fluoranthene       | 3900         | 220      | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 2      | 7.9  | 8.1    | U     |       | 2      | 8.1  |       |     |
| Benzo(g,h,i)perylene       | 3100000      | 230000   | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 4.7    | 7.9  | 8.1    | U     |       | 4.9    | 8.1  |       |     |
| Benzo(k)fluoranthene       | 39000        | 2200     | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 2      | 7.9  | 8.1    | U     |       | 2      | 8.1  |       |     |
| Chrysene                   | 390000       | 22000    | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 0.79   | 7.9  | 8.1    | U     |       | 0.81   | 8.1  |       |     |
| Dibenz(a,h)anthracene      | 390          | 22       | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 4      | 7.9  | 8.1    | U     |       | 4.1    | 8.1  |       |     |
| Fluoranthene               | 4100000      | 310000   | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 1.6    | 7.9  | 8.1    | U     |       | 1.6    | 8.1  |       |     |
| Indeno(1,2,3-cd)pyrene     | 3900         | 220      | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 1.2    | 7.9  | 8.1    | U     |       | 1.2    | 8.1  |       |     |
| Naphthalene                | 20000000     | 160000   | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 0.79   | 7.9  | 8.1    | U     |       | 0.81   | 8.1  |       |     |
| Phenanthrene               | 3100000      | 230000   | na         | 8.9    |       | J     | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 15     |       | J     | 7.9    | 7.9 | 16     |       | J     | 7.8    | 7.8  | 7.9    | U     |       | 0.79   | 7.9  | 11     |       |       | 0.81   | 8.1  |       |     |
| Pyrene                     | 3100000      | 230000   | na         | 7.7    | U     |       | 7.7   | 7.7  | 7.6    | U     |       | 7.6   | 7.6  | 7.9    | U     |       | 7.9    | 7.9 | 7.8    | U     |       | 7.8    | 7.8  | 7.9    | U     |       | 0.79   | 7.9  | 8.1    | U     |       | 0.81   | 8.1  |       |     |
| SVOCs (ug/kg)              |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| 2,4-Dinitrotoluene         | 200000       | 16000    | na         | 390    | U     |       | 60    | 390  | 380    | U     |       | 59    | 380  | 400    | U     |       | 62     | 400 | 380    | J     | B     | 61     | 390  | 400    | U     |       | 62     | 400  | 370    | J     | J     | 63     | 410  |       |     |
| 2,6-Dinitrotoluene         | 100000       | 7800     | na         | 390    | U     |       | 41    | 390  | 380    | U     |       | 41    | 380  | 400    | U     |       | 42     | 400 | 390    | U     |       | 42     | 390  | 400    | U     |       | 42     | 400  | 100    | J     | J     | 43     | 410  |       |     |
| Diethylphthalate           | 82000000     | 6300000  | na         | 390    | U     |       | 210   | 390  | 380    | U     |       | 210   | 380  | 400    | U     |       | 220    | 400 | 390    | U     |       | 220    | 390  | 400    | U     |       | 220    | 400  | 410    | U     |       | 230    | 410  |       |     |
| Di-n-butylphthalate        | 100000000    | 780000   | na         | 390    | U     |       | 49    | 390  | 380    | U     |       | 49    | 380  | 400    | U     |       | 51     | 400 | 390    | U     |       | 50     | 390  | 400    | U     |       | 51     | 400  | 410    | U     |       | 52     | 410  |       |     |
| N-nitrosodiphenylamine     | 580000       | 130000   | na         | 390    | U     |       | 37    | 390  | 380    | U     |       | 36    | 380  | 400    | U     |       | 38     | 400 | 390    | U     |       | 38     | 390  | 400    | U     |       | 38     | 400  | 410    | U     |       | 39     | 410  |       |     |
| Pesticides (ug/kg)         |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| None detected              |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| PCBs (mg/kg)               |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| None detected              |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| Explosives (mg/kg)         |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| 1,3,5-Trinitrobenzene      | 3100         | 230      | na         | 0.1    | U     | UL    | 0.025 | 0.1  | 0.07   | J     | L     | 0.025 | 0.1  | 0.1    | U     | UL    | 0.025  | 0.1 | 0.1    | U     |       | 0.025  | 0.1  | 0.1    | U     |       | 0.025  | 0.1  | 0.1    | U     |       | 0.025  | 0.1  |       |     |
| 1,3-Dinitrobenzene         | 10           | 0.78     | na         | 0.1    | U     |       | 0.01  | 0.1  | 0.1    | U     |       | 0.01  | 0.1  | 0.77   |       | J     | 0.01   | 0.1 | 0.1    | U     |       | 0.01   | 0.1  | 0.1    | U     |       | 0.01   | 0.1  | 0.18   |       | J     | 0.01   | 0.1  |       |     |
| 2,4,6-Trinitrotoluene      | 51           | 3.9      | na         | 0.1    | U     | UL    | 0.03  | 0.1  | 0.1    | U     | UL    | 0.03  | 0.1  | 0.06   | J     |       | 0.03   | 0.1 | 0.09   | J     | J     | 0.03   | 0.1  | 0.14   |       |       | 0.03   | 0.1  | 0.12   |       |       | 0.03   | 0.1  |       |     |
| 2,4-Dinitrotoluene         | 200          | 16       | na         | 0.1    | U     |       | 0.055 | 0.1  | 0.37   |       | J     | 0.055 | 0.1  | 0.66   |       |       | 0.055  | 0.1 | 0.8    |       |       | 0.055  | 0.1  | 2.5    |       |       | 0.055  | 0.1  | 0.68   |       |       | 0.055  | 0.1  |       |     |
| 2,6-Dinitrotoluene         | 100          | 7.8      | na         | 0.1    | U     |       | 0.1   | 0.1  | 7.9    |       |       | 0.1   | 0.1  | 0.29   |       | B     | 0.1    | 0.1 | 0.44   |       | B     | 0.1    | 0.1  | 1.7    |       | J     | 0.1    | 0.1  | 0.38   |       | J     | 0.1    | 0.1  |       |     |
| 2-amino-4,6-Dinitrotoluene | 200          | 16       | na         | 0.1    | U     |       | 0.036 | 0.1  | 0.1    | U     |       | 0.036 | 0.1  | 0.1    | U     |       | 0.036  | 0.1 | 0.1    | U     |       | 0.036  | 0.1  | 0.1    | U     |       | 0.036  | 0.1  | 0.1    | U     |       | 0.036  | 0.1  |       |     |
| 2-Nitrotoluene             | 1000         | 78       | na         | 0.2    | U     |       | 0.2   | 0.2  | 0.2    | U     |       | 0.2   | 0.2  | 3      |       |       | 0.2    | 0.2 | 38     |       |       | 0.2    | 0.2  |        |       | 110   |        |      | 0.8    | 1     | 24    |        | 0.2  | 0.2   |     |
| 3-Nitrotoluene             | na           | na       | na         | 0.2    | U     |       | 0.1   | 0.2  | 0.2    | U     |       | 0.1   | 0.2  | 0.34   |       | J     | 0.1    | 0.2 | 2.5    |       | J     | 0.1    | 0.2  |        |       | 9.2   |        | J    | 0.1    | 0.2   | 1.9   |        | J    | 0.1   | 0.2 |
| 4-Nitrotoluene             | 180          | 31       | na         | 0.2    | U     |       | 0.1   | 0.2  | 0.2    | U     |       | 0.1   | 0.2  | 1.4    |       | J     | 0.1    | 0.2 | 14     |       | J     | 0.1    | 0.2  |        |       | 62    |        |      | 0.4    | 1     | 13    |        |      | 0.1   | 0.2 |
| Nitrobenzene               | 51           | 3.9      | na         | 0.11   |       |       | 0.037 | 0.1  | 0.09   | J     | J     | 0.036 | 0.1  | 0.1    |       | J     | 0.038  | 0.1 | 0.1    | U     |       | 0.038  | 0.1  |        |       | 0.1   | U      |      | 0.038  | 0.1   | 0.1   | U      |      | 0.039 | 0.1 |
| RDX                        | 26           | 5.8      | na         | 0.2    | U     |       | 0.1   | 0.2  | 1.2    |       | J     | 0.1   | 0.2  | 0.2    | U     |       | 0.1    | 0.2 | 0.2    | U     |       | 0.1    | 0.2  | 0.2    | U     |       | 0.1    | 0.2  | 0.2    | U     |       | 0.1    | 0.2  |       |     |
| Herbicides (ug/kg)         |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| None detected              |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| Metals (mg/kg)             |              |          |            |        |       |       |       |      |        |       |       |       |      |        |       |       |        |     |        |       |       |        |      |        |       |       |        |      |        |       |       |        |      |       |     |
| Aluminum                   | 100000       | 7800     | 40041      | 22500  |       |       | 1.2   | 18.4 | 16700  |       |       | 1.2   | 18.2 | 24600  |       |       | 1.7    | 20  | 20800  |       |       | 1.7    | 19.8 | 28100  |       |       | 1.7    | 19.4 | 26800  |       |       | 1.6    | 19.3 |       |     |
| Antimony                   | 41           | 3.1      | na         | 0.3    | UN    |       | 0.3   | 1.8  | 0.3    | UN    | UL    | 0.3   | 1.8  | 0.68   | BN    | B     | 0.5    | 2   | 0.49   | UN    | UL    | 0.49   | 2    | 0.82   | BN    | B     | 0.49   | 1.9  | 0.55   | BN    | B     | 0.48   | 1.9  |       |     |
| Arsenic                    | 1.9          | 0.43     | 15.8       | 3.3    |       |       | 0.35  | 1.8  | 1.5    | B     | J     | 0.35  | 1.8  | 4.6    |       |       | 0.2    | 2   | 4      |       |       | 0.2    | 2    | 3.8    |       |       | 0.19   | 1.9  | 5.7    |       |       | 0.19   | 1.9  |       |     |
| Barium                     | 20000        | 1600     | 209        | 58.6   |       |       | 0.015 | 0.46 | 40.5   |       |       | 0.015 | 0.46 | 85.3   |       |       | 0.032  | 0.5 | 73     | N     | K     | 0.032  | 0.49 | 68.4   |       |       | 0.031  | 0.49 | 81.5   |       |       | 0.031  | 0.48 |       |     |
| Beryllium                  | 200          | 16       | 1.02       | 0.6    |       |       | 0.012 | 0.18 | 0.52   |       |       | 0.012 | 0.18 | 0.67   |       |       | 0.0057 | 0.2 | 0.57   |       |       | 0.0056 | 0.2  | 0.64   |       |       | 0.0055 | 0.19 | 0.71   |       |       | 0.0055 | 0.19 |       |     |
| Cadmium                    | 51           | 3.9      | 0.69       | 0.13   | B     | B     | 0.032 | 0.55 | 0.088  | B     | B     | 0.032 | 0.55 | 0.07   | B     | B     | 0.044  | 0.6 | 0.36   | B     | J     | 0.044  | 0.59 | 0.13   | B     | J     | 0.043  | 0.58 | 0.19   | B     | J     | 0.043  | 0.58 |       |     |
| Calcium                    | na           | na       | na         | 157    |       | B     | 7.1   | 91.8 | 34.6   | B     | B     | 7     | 91   | 295    |       | B     | 7.6    | 100 | 284    |       |       | 7.5    | 98.8 | 306    |       |       | 7.4    | 97.2 | 364    |       | B     | 7.3    | 96.7 |       |     |
| Chromium                   | 310          | 23       | 65.3       | 26     |       |       | 0.042 | 0.46 | 15.2   |       |       | 0.042 | 0.46 | 29     | *     |       | 0.12   | 0.5 | 27.4   | N     | K     | 0.12   | 0.49 | 28     |       |       | 0.12   | 0.49 | 34.6   |       |       | 0.12   | 0.48 |       |     |
| Cobalt                     | na           | na       | 72.3       | 7.7    |       |       | 0.08  | 0.46 | 7.1    |       |       | 0.079 | 0.46 | 9.1    |       |       | 0.08   | 0.5 | 8.4    |       |       | 0.079  | 0.49 | 10.2   |       |       | 0.078  | 0.49 | 7.2    |       |       | 0.077  | 0.48 |       |     |
| Copper                     | 4100         | 310      | 53.5       | 9.3    |       |       | 0.081 | 0.92 | 5.5    |       |       | 0.08  | 0.91 | 12.4   |       |       | 0.095  | 1   | 10.7   |       |       | 0.094  | 0.99 | 14.3   | E     |       | 0.092  | 0.97 | 17.4   | E     |       | 0.092  | 0.97 |       |     |
| Iron                       | 72000        | 5500     | 50962      | 25800  |       |       | 3     | 13.8 | 18300  |       |       | 3     | 13.7 | 28500  |       |       | 3.9    | 15  | 27800  |       |       | 3.9    | 14.8 | 30400  |       |       | 3.8    | 14.6 | 31600  |       |       | 3.8    | 14.5 |       |     |
| Lead                       | 800          | 400      | 26.8       | 11.7   |       |       | 0.12  | 0.92 | 7.4    |       |       | 0.12  | 0.91 | 17.3   |       |       | 0.21   | 1   | 15.7   |       |       | 0.21   | 0.99 | 13     | *     |       | 0.2    | 0.97 | 14.7   | *     |       | 0.2    | 0.97 |       |     |
| Magnesium                  | na           | na       | na         | 949    |       |       | 0.85  | 23   | 650    |       |       | 0.85  | 22.7 | 1020   | N     |       | 2.5    | 25  | 890    | N     | K     | 2.5    | 24.7 | 1280   | N     |       | 2.5    | 24.3 | 1930   | N     |       | 2.5    | 24.2 |       |     |
| Manganese                  | 2000         | 160      | 2543       | 260    |       |       | 0.015 | 0.46 | 316    |       |       | 0.015 | 0.46 | 664    |       |       | 0.025  | 0.5 | 627    |       |       | 0.025  | 0.49 | 381    | *     |       | 0      |      |        |       |       |        |      |       |     |

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



Table 4-1  
Analytes Detected in Clean Fill and/or Native Soil  
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| Analyte                    | Sample ID<br>Sample Date<br>Sample Depth |         |            | 51SB9B<br>4/5/04<br>15-17 |       |       |        |       | 51SB10A<br>4/1/04<br>0-0.5 |       |       |        |       | 51SB10B<br>4/1/04<br>18-20 |       |       |        |      | 51SB11A<br>4/5/04<br>0-0.5 |       |       |       |       | 51SB11B<br>4/5/04<br>15-17 |       |       |        |       |
|----------------------------|------------------------------------------|---------|------------|---------------------------|-------|-------|--------|-------|----------------------------|-------|-------|--------|-------|----------------------------|-------|-------|--------|------|----------------------------|-------|-------|-------|-------|----------------------------|-------|-------|--------|-------|
|                            | 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)                             |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| 2-Butanone                 | 61000000                                 | 4700000 | na         | 11                        | U     | R     | 2.5    | 11    | 9.2                        | U     | R     | 2.2    | 9.2   | 10                         | U     | R     | 2.4    | 10   | 10                         | U     | R     | 2.4   | 10    | 11                         | U     | R     | 2.5    | 11    |
| Acetone                    | 92000000                                 | 7000000 | na         | 5.3                       | JB    | B     | 2.9    | 11    | 30                         |       | B     | 2.5    | 9.2   | 13                         | B     | B     | 2.8    | 10   | 20                         |       | B     | 2.8   | 10    | 5.5                        | J     | B     | 2.9    | 11    |
| Methylene chloride         | 380000                                   | 85000   | na         | 4.3                       | JB    | B     | 1.2    | 11    | 9.2                        | U     |       | 1      | 9.2   | 2.6                        | JB    | B     | 1.1    | 10   | 2.4                        | JB    | B     | 1.1   | 10    | 3.2                        | JB    | B     | 1.2    | 11    |
| Styrene                    | 20000000                                 | 1600000 | na         | 5.3                       | U     |       | 1.4    | 5.3   | 4.6                        | U     |       | 1.2    | 4.6   | 5                          | U     | UJ    | 1.3    | 5    | 5.1                        | U     |       | 1.3   | 5.1   | 5.3                        | U     |       | 1.4    | 5.3   |
| Toluene                    | 8200000                                  | 630000  | na         | 5.3                       | U     |       | 1.2    | 5.3   | 4.6                        | U     |       | 1      | 4.6   | 1.4                        | J     | B     | 1.1    | 5    | 5.1                        | U     |       | 1.1   | 5.1   | 5.3                        | U     |       | 1.2    | 5.3   |
| PAHs (ug/kg)               |                                          |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| 2-Methylnaphthalene        | 410000                                   | 31000   | na         | 7.6                       | U     |       | 7.6    | 7.6   | 20                         |       |       | 2.4    | 7.9   | 7.6                        | U     |       | 2.3    | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Benz(a)anthracene          | 3900                                     | 220     | na         | 7.6                       | U     |       | 7.6    | 7.6   | 7.9                        | U     |       | 1.2    | 7.9   | 7.6                        | U     |       | 1.1    | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Benzo(a)pyrene             | 390                                      | 22      | na         | 7.6                       | U     |       | 7.6    | 7.6   | 7.9                        | U     |       | 1.2    | 7.9   | 7.6                        | U     |       | 1.1    | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Benzo(b)fluoranthene       | 3900                                     | 220     | na         | 7.6                       | U     |       | 7.6    | 7.6   | 7.9                        | U     |       | 2      | 7.9   | 7.6                        | U     |       | 1.9    | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Benzo(g,h,i)perylene       | 3100000                                  | 230000  | na         | 7.6                       | U     |       | 7.6    | 7.6   | 7.9                        | U     |       | 4.7    | 7.9   | 7.6                        | U     |       | 4.5    | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Benzo(k)fluoranthene       | 39000                                    | 2200    | na         | 7.6                       | U     |       | 7.6    | 7.6   | 7.9                        | U     |       | 2      | 7.9   | 7.6                        | U     |       | 1.9    | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Chrysene                   | 390000                                   | 22000   | na         | 7.6                       | U     |       | 7.6    | 7.6   | 7.9                        | U     |       | 0.79   | 7.9   | 7.6                        | U     |       | 0.76   | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Dibenz(a,h)anthracene      | 390                                      | 22      | na         | 7.6                       | U     |       | 7.6    | 7.6   | 7.9                        | U     |       | 3.9    | 7.9   | 7.6                        | U     |       | 3.8    | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Fluoranthene               | 4100000                                  | 310000  | na         | 7.6                       | U     |       | 7.6    | 7.6   | 14                         |       |       | 1.6    | 7.9   | 7.6                        | U     |       | 1.5    | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Indeno(1,2,3-cd)pyrene     | 3900                                     | 220     | na         | 7.6                       | U     |       | 7.6    | 7.6   | 7.9                        | U     |       | 1.2    | 7.9   | 7.6                        | U     |       | 1.1    | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Naphthalene                | 2000000                                  | 160000  | na         | 7.6                       | U     |       | 7.6    | 7.6   | 14                         |       | B     | 0.79   | 7.9   | 7.6                        | U     |       | 0.76   | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| Phenanthrene               | 3100000                                  | 230000  | na         | 13                        |       | J     | 7.6    | 7.6   | 30                         |       |       | 0.79   | 7.9   | 9.8                        |       |       | 0.76   | 7.6  | 20                         |       | J     | 7.7   | 7.7   | 15                         |       | J     | 7.8    | 7.8   |
| Pyrene                     | 3100000                                  | 230000  | na         | 7.6                       | U     |       | 7.6    | 7.6   | 11                         |       |       | 0.79   | 7.9   | 7.6                        | U     |       | 0.76   | 7.6  | 7.7                        | U     |       | 7.7   | 7.7   | 7.8                        | U     |       | 7.8    | 7.8   |
| SVOCs (ug/kg)              |                                          |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| 2,4-Dinitrotoluene         | 200000                                   | 16000   | na         | 160                       | J     | B     | 59     | 380   | 1200                       |       |       | 61     | 390   | 380                        | U     |       | 59     | 380  | 130                        | J     | B     | 60    | 390   | 1400                       |       | B     | 61     | 390   |
| 2,6-Dinitrotoluene         | 100000                                   | 7800    | na         | 44                        | J     | B     | 41     | 380   | 270                        | J     | J     | 42     | 390   | 380                        | U     |       | 40     | 380  | 390                        | U     |       | 41    | 390   | 340                        | J     | B     | 42     | 390   |
| Diethylphthalate           | 82000000                                 | 6300000 | na         | 380                       | U     |       | 210    | 380   | 390                        | U     |       | 220    | 390   | 380                        | U     |       | 210    | 380  | 390                        | U     |       | 210   | 390   | 390                        | U     |       | 220    | 390   |
| Di-n-butylphthalate        | 10000000                                 | 780000  | na         | 380                       | U     |       | 49     | 380   | 130                        | J     | B     | 50     | 390   | 81                         | J     | B     | 48     | 380  | 390                        | U     |       | 49    | 390   | 390                        | U     |       | 50     | 390   |
| N-nitrosodiphenylamine     | 580000                                   | 130000  | na         | 380                       | U     |       | 36     | 380   | 390                        | U     |       | 38     | 390   | 380                        | U     |       | 36     | 380  | 390                        | U     |       | 37    | 390   | 390                        | U     |       | 38     | 390   |
| Pesticides (ug/kg)         |                                          |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| None detected              |                                          |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| PCBs (mg/kg)               |                                          |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| None detected              |                                          |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| Explosives (mg/kg)         |                                          |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| 1,3,5-Trinitrobenzene      | 3100                                     | 230     | na         | 0.09                      | J     | J     | 0.025  | 0.1   | 0.1                        | U     |       | 0.025  | 0.1   | 0.1                        | U     |       | 0.025  | 0.1  | 0.1                        | U     |       | 0.025 | 0.1   | 0.1                        | U     |       | 0.025  | 0.1   |
| 1,3-Dinitrobenzene         | 10                                       | 0.78    | na         | 0.25                      |       | J     | 0.01   | 0.1   | 0.08                       | J     | J     | 0.01   | 0.1   | 0.1                        | U     |       | 0.01   | 0.1  | 0.1                        | U     |       | 0.01  | 0.1   | 0.1                        | U     |       | 0.01   | 0.1   |
| 2,4,6-Trinitrotoluene      | 51                                       | 3.9     | na         | 0.27                      |       | L     | 0.03   | 0.1   | 0.24                       |       |       | 0.03   | 0.1   | 0.39                       |       |       | 0.03   | 0.1  | 0.23                       |       |       | 0.03  | 0.1   | 0.76                       |       |       | 0.03   | 0.1   |
| 2,4-Dinitrotoluene         | 200                                      | 16      | na         | 0.38                      |       | J     | 0.055  | 0.1   | 0.93                       |       |       | 0.055  | 0.1   | 1.3                        |       |       | 0.055  | 0.1  | 0.77                       |       |       | 0.055 | 0.1   | 1.7                        |       |       | 0.055  | 0.1   |
| 2,6-Dinitrotoluene         | 100                                      | 7.8     | na         | 0.22                      |       | B     | 0.1    | 0.1   | 0.53                       |       | J     | 0.1    | 0.1   | 0.75                       |       | J     | 0.1    | 0.1  | 0.47                       |       | B     | 0.1   | 0.1   | 1.1                        |       | B     | 0.1    | 0.1   |
| 2-amino-4,6-Dinitrotoluene | 200                                      | 16      | na         | 0.1                       | U     |       | 0.036  | 0.1   | 0.1                        | U     |       | 0.036  | 0.1   | 0.1                        | U     |       | 0.036  | 0.1  | 0.1                        | U     |       | 0.036 | 0.1   | 0.1                        | U     |       | 0.036  | 0.1   |
| 2-Nitrotoluene             | 1000                                     | 78      | na         | 1.9                       |       | J     | 0.2    | 0.2   | 21                         |       |       | 0.2    | 0.2   | 36                         |       |       | 0.2    | 0.2  | 12                         |       |       | 0.2   | 0.2   | 43                         |       |       | 0.2    | 0.2   |
| 3-Nitrotoluene             | na                                       | na      | na         | 0.27                      |       | J     | 0.1    | 0.2   | 1.7                        |       | J     | 0.1    | 0.2   | 2.9                        |       | J     | 0.1    | 0.2  | 1.2                        |       | J     | 0.1   | 0.2   | 4.3                        |       | J     | 0.1    | 0.2   |
| 4-Nitrotoluene             | 180                                      | 31      | na         | 1.4                       |       | J     | 0.1    | 0.2   | 11                         |       | J     | 0.1    | 0.2   | 18                         |       | J     | 0.1    | 0.2  | 7.7                        |       | J     | 0.1   | 0.2   | 27                         |       | J     | 0.1    | 0.2   |
| Nitrobenzene               | 51                                       | 3.9     | na         | 0.17                      |       |       | 0.036  | 0.1   | 0.1                        | U     |       | 0.038  | 0.1   | 0.1                        | U     |       | 0.036  | 0.1  | 0.1                        | U     |       | 0.037 | 0.1   | 0.1                        |       |       | 0.038  | 0.1   |
| RDX                        | 26                                       | 5.8     | na         | 0.2                       | U     |       | 0.1    | 0.2   | 0.2                        | U     |       | 0.1    | 0.2   | 0.2                        | U     |       | 0.1    | 0.2  | 0.2                        | U     |       | 0.1   | 0.2   | 0.2                        | U     |       | 0.1    | 0.2   |
| Herbicides (ug/kg)         |                                          |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| None detected              |                                          |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| Metals (mg/kg)             |                                          |         |            |                           |       |       |        |       |                            |       |       |        |       |                            |       |       |        |      |                            |       |       |       |       |                            |       |       |        |       |
| Aluminum                   | 100000                                   | 7800    | 40041      | 14900                     |       |       | 1.6    | 18.8  | 10600                      |       |       | 1.6    | 18.5  | 13500                      |       |       | 1.5    | 17.7 | 10900                      |       |       | 1.5   | 17.7  | 17100                      |       |       | 1.5    | 18    |
| Antimony                   | 41                                       | 3.1     | na         | 0.76                      | BN    | B     | 0.47   | 1.9   | 0.6                        | BN    | B     | 0.46   | 1.9   | 0.67                       | BN    | B     | 0.44   | 1.8  | 0.44                       | UN    |       | 0.44  | 1.8   | 0.45                       | UN    |       | 0.45   | 1.8   |
| Arsenic                    | 1.9                                      | 0.43    | 15.8       | 1.4                       | B     | B     | 0.19   | 1.9   | 3.1                        |       |       | 0.19   | 1.9   | 1.7                        | B     | J     | 0.18   | 1.8  | 2.8                        |       |       | 0.18  | 1.8   | 1.1                        | B     | B     | 0.18   | 1.8   |
| Barium                     | 20000                                    | 1600    | 209        | 35                        |       |       | 0.03   | 0.47  | 92.2                       |       |       | 0.03   | 0.46  | 40.4                       |       |       | 0.028  | 0.44 | 93.7                       | N     |       | 0.028 | 0.44  | 48.2                       | N     |       | 0.029  | 0.45  |
| Beryllium                  | 200                                      | 16      | 1.02       | 0.42                      |       |       | 0.0054 | 0.19  | 0.56                       |       |       | 0.0053 | 0.19  | 0.45                       |       |       | 0.0051 | 0.18 | 0.51                       |       |       | 0.005 | 0.18  | 0.5                        |       |       | 0.0051 | 0.18  |
| Cadmium                    | 51                                       | 3.9     | 0.69       | 0.062                     | B     | B     | 0.041  | 0.57  | 0.12                       | B     | B     | 0.041  | 0.55  | 0.039                      | U     |       | 0.039  | 0.53 | 0.11                       | B     | B     | 0.039 | 0.53  | 0.17                       | B     | J     | 0.04   | 0.54  |
| Calcium                    | na                                       | na      | na         | 24.8                      | B     | B     | 7.1    | 94.1  | 297                        |       |       | 7      | 92.3  | 88.4                       | B     | B     | 6.7    | 88.7 | 228                        |       |       | 6.7   | 88.3  | 29.5                       | B     | B     | 6.8    | 90.2  |
| Chromium                   | 310                                      | 23      | 65.3       | 13.3                      | *     |       | 0.11   | 0.47  | 17.2                       |       |       | 0.11   | 0.46  | 19.7                       |       |       | 0.11   | 0.44 | 18.2                       | N     |       | 0.11  | 0.44  | 13.3                       | N     |       | 0.11   | 0.45  |
| Cobalt                     | na                                       | na      | 72.3       | 10.4                      |       |       | 0.075  | 0.47  | 3.9                        |       |       | 0.074  | 0.46  | 14.9                       |       |       | 0.071  | 0.44 | 3.3                        |       |       | 0.071 | 0.44  | 8.7                        |       |       | 0.072  | 0.45  |
| Copper                     | 4100                                     | 310     | 53.5       | 5.1                       |       |       | 0.089  | 0.94  | 4.7                        | E     |       | 0.088  | 0.92  | 4.6                        | E     |       | 0.084  | 0.89 | 5.2                        |       |       | 0.084 | 0.88  | 6.9                        |       |       | 0.086  | 0.9   |
| Iron                       | 72000                                    | 5500    | 50962      | 16100                     |       |       | 3.7    | 14.1  | 11500                      |       |       | 3.6    | 13.8  | 15100                      |       |       | 3.5    | 13.3 | 14200                      |       |       | 3.5   | 13.2  | 22100                      |       |       | 3.6    | 13.5  |
| Lead                       | 800                                      | 400     | 26.8       | 6.3                       |       |       | 0.2    | 0.94  | 14.1                       | *     |       | 0.19   | 0.92  | 4.2                        | *     |       | 0.19   | 0.89 | 13.3                       |       |       | 0.19  | 0.88  | 7.9                        |       |       | 0.19   | 0.9   |
| Magnesium                  | na                                       | na      | na         | 715                       | N     |       | 2.4    | 23.5  | 483                        | N     |       | 2.3    | 23.1  | 930                        | N     |       | 2.3    | 22.2 | 485                        | N     |       | 2.2   | 22.1  | 1160                       | N     |       | 2.3    | 22.6  |
| Manganese                  | 2000                                     | 160     | 2543       | 312                       |       |       | 0.024  | 0.47  | 385                        | *     |       | 0.023  | 0.46  | 370                        | *     |       | 0.022  | 0.44 | 289                        |       |       | 0.022 | 0.44  | 275                        |       |       | 0.023  | 0.45  |
| Mercury                    | 31                                       | 2.3     | 0.13       | 0.015                     | U     |       | 0.015  | 0.031 | 0.024                      | B     | J     | 0.016  | 0.032 | 0.015                      | U     |       | 0.015  | 0.03 | 0.016                      | U     |       | 0.016 | 0.032 | 0.015                      | U     |       | 0.015  | 0.031 |
| Nickel                     | 2000                                     | 160     | 62.8       | 5.8                       |       |       | 0.13   | 0.94  | 4.6                        |       |       | 0.13   | 0.92  | 6.4                        |       |       | 0.12   | 0.89 | 4.4                        |       |       | 0.12  | 0.88  | 7.8                        |       |       | 0.13   | 0.9   |
| Potassium                  | na                                       | na      | na         | 736                       | N     |       | 3.9    | 23.5  | 367                        | N     |       | 3.9    | 23.1  | 747                        | N     |       | 3.7    | 22.2 | 360                        | N     |       | 3.7   |       |                            |       |       |        |       |

**Table 4-1  
Legend**

|           |          |                                                                       |
|-----------|----------|-----------------------------------------------------------------------|
| 12        | J        | Shading and black font indicate an industrial RBC exceedance.         |
| 12        | J        | Bold outline indicates a residential RBC exceedance.                  |
| <b>12</b> | <b>J</b> | 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**

\* = Laboratory duplicate not within control limits

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 4-2**  
**Dioxins/Furans Detected in Clean Fill and/or Native Soil**  
**Page 1 of 2**

| Analyte                       | Sample ID<br>Sample Date<br>Sample Depth |       |            | 51SB2A<br>4/6/04<br>0-0.5 |       |       |      |      | 51SB3A<br>4/5/04<br>0-0.5 |       |       |       |      | 51SB4A<br>4/1/04<br>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  |
| <b>Dioxins/Furans (ng/kg)</b> |                                          |       |            |                           |       |       |      |      |                           |       |       |       |      |                           |       |       |       |      |
| 2,3,7,8-TCDD                  | 19                                       | 4.3   | na         | 0.24                      | A     |       | 0.24 | 0.19 | 0.2                       | U     |       | 0.11  | 0.2  | 0.2                       | U     |       | 0.16  | 0.2  |
| 1,2,3,4,6,7,8-HPCDD           | na                                       | na    | na         | 33                        |       |       | 0.76 | 0.94 | 30                        |       |       | 0.35  | 0.99 | 20                        |       |       | 0.27  | 0.99 |
| OCDD                          | na                                       | na    | na         | 3200                      |       |       | 0.59 | 1.9  | 4900                      |       |       | 0.11  | 2    | 1900                      |       |       | 0.15  | 2    |
| 1,2,3,4,6,7,8-HPCDF           | na                                       | na    | na         | 0.94                      | U     |       | 0.28 | 0.94 | 1.2                       | J     | J     | 0.082 | 0.99 | 0.99                      | U     |       | 0.17  | 0.99 |
| OCDF                          | na                                       | na    | na         | 1.9                       | U     |       | 0.45 | 1.9  | 2.1                       | J     | J     | 0.096 | 2    | 2                         | U     |       | 0.11  | 2    |
| TOTAL TCDD                    | na                                       | na    | na         | 0.19                      | U     |       | 0.24 | 0.19 | 0.2                       | U     |       | 0.11  | 0.2  | 0.2                       | U     |       | 0.16  | 0.2  |
| TOTAL PECDD                   | na                                       | na    | na         | 0.94                      | U     |       | 0.16 | 0.94 | 0.99                      | U     |       | 0.11  | 0.99 | 0.99                      | U     |       | 0.082 | 0.99 |
| TOTAL HXCDD                   | 460                                      | 100   | na         | 2.8                       | J     | J     | 0.25 | 0.94 | 3.5                       | J     | J     | 0.096 | 0.99 | 2.6                       | J     | J     | 0.12  | 0.99 |
| TOTAL HPCDD                   | na                                       | na    | na         | 66                        |       |       | 0.76 | 0.94 | 59                        |       |       | 0.35  | 0.99 | 42                        |       |       | 0.27  | 0.99 |
| TOTAL TCDF                    | na                                       | na    | na         | 0.19                      | U     |       | 0.15 | 0.19 | 0.2                       | U     |       | 0.07  | 0.2  | 0.2                       | U     |       | 0.086 | 0.2  |
| TOTAL HPCDF                   | na                                       | na    | na         | 0.94                      | U     |       | 0.32 | 0.94 | 1.2                       | J     | J     | 0.075 | 0.99 | 0.99                      | U     |       | 0.24  | 0.99 |

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

**Table 4-2**  
**Dioxins/Furans Detected in Clean Fill and/or Native Soil**  
**Page 2 of 2**

| Analyte                       | Sample ID<br>Sample Date<br>Sample Depth |       |            | 51SB5A<br>4/1/04<br>0-0.5 |       |       |       |      | 51SB6A<br>3/30/04<br>0-0.5 |       |       |       |      |
|-------------------------------|------------------------------------------|-------|------------|---------------------------|-------|-------|-------|------|----------------------------|-------|-------|-------|------|
|                               | i-RBC                                    | r-RBC | Background | Result                    | Lab Q | Val Q | MDL   | MRL  | Result                     | Lab Q | Val Q | MDL   | MRL  |
| <b>Dioxins/Furans (ng/kg)</b> |                                          |       |            |                           |       |       |       |      |                            |       |       |       |      |
| 2,3,7,8-TCDD                  | 19                                       | 4.3   | na         | 0.2                       | U     |       | 0.075 | 0.2  | 0.19                       | U     |       | 0.082 | 0.19 |
| 1,2,3,4,6,7,8-HPCDD           | na                                       | na    | na         | 38                        |       |       | 0.25  | 0.99 | 30                         |       |       | 0.33  | 0.97 |
| OCDD                          | na                                       | na    | na         | 5900                      |       |       | 0.16  | 2    | 4400                       |       |       | 0.11  | 1.9  |
| 1,2,3,4,6,7,8-HPCDF           | na                                       | na    | na         | 0.99                      | U     |       | 0.063 | 0.99 | 0.97                       | U     |       | 0.079 | 0.97 |
| OCDF                          | na                                       | na    | na         | 2                         | U     |       | 0.12  | 2    | 2.3                        | J     | J     | 0.11  | 1.9  |
| TOTAL TCDD                    | na                                       | na    | na         | 2.5                       |       |       | 0.075 | 0.2  | 0.26                       | J     | J     | 0.082 | 0.19 |
| TOTAL PECDD                   | na                                       | na    | na         | 2.6                       | J     | J     | 0.093 | 0.99 | 0.97                       | U     |       | 0.07  | 0.97 |
| TOTAL HXCDD                   | 460                                      | 100   | na         | 6.5                       |       |       | 0.089 | 0.99 | 3.1                        | J     | J     | 0.093 | 0.97 |
| TOTAL HPCDD                   | na                                       | na    | na         | 71                        |       |       | 0.25  | 0.99 | 59                         |       |       | 0.33  | 0.97 |
| TOTAL TCDF                    | na                                       | na    | na         | 0.2                       | U     |       | 0.054 | 0.2  | 0.22                       | J     | J     | 0.061 | 0.19 |
| TOTAL HPCDF                   | na                                       | na    | na         | 0.99                      | U     |       | 0.069 | 0.99 | 0.97                       | U     |       | 0.085 | 0.97 |

\*\*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.                  |
| <b>12</b> | <b>J</b> | 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).

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

NA = not applicable.

NT = analyte not tested.

**Lab Q = Lab Data Qualifiers**

\* = Laboratory duplicate not within control limits

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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

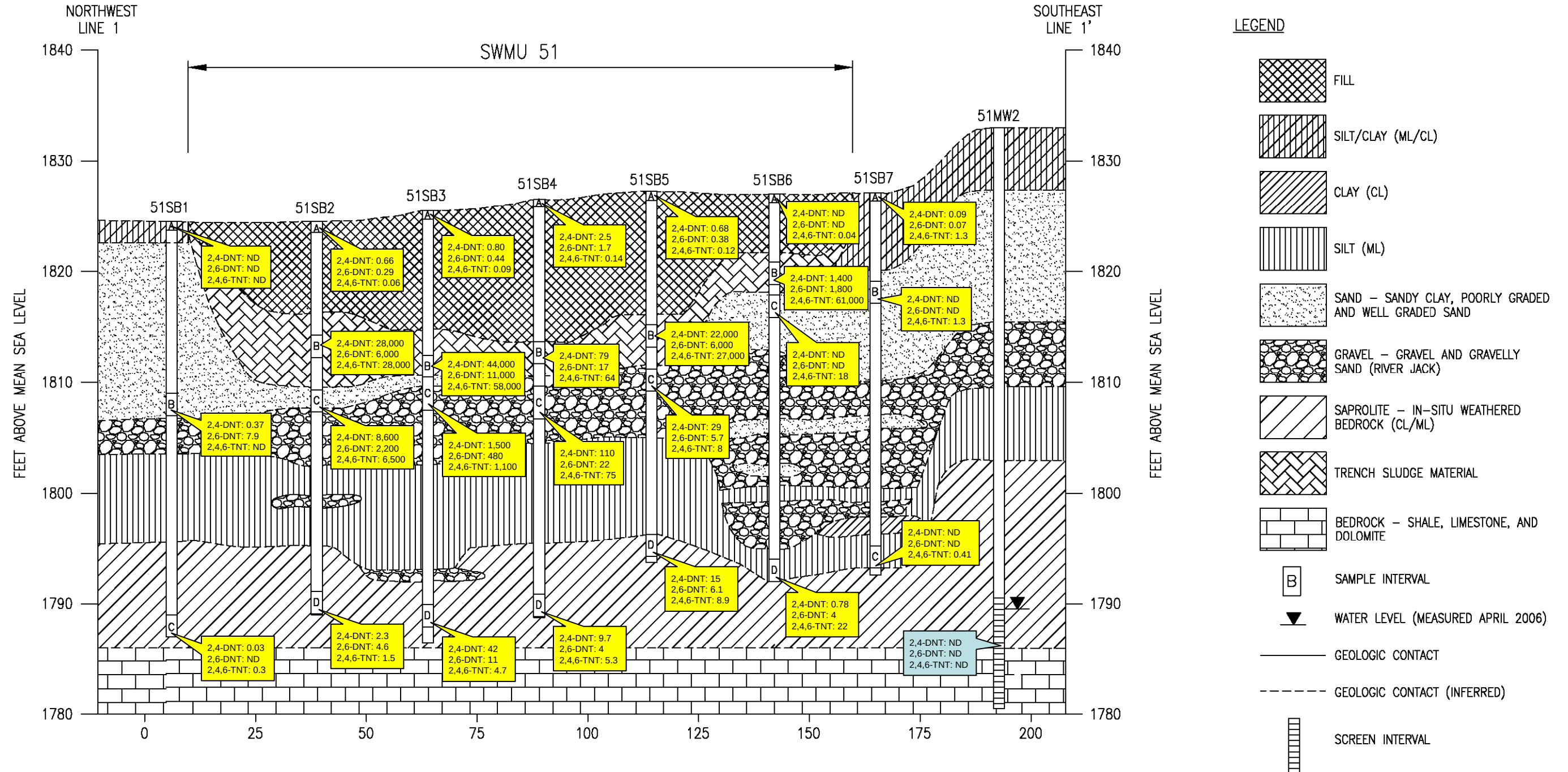
UJ = estimated concentration non-detect

UL = estimated concentration non-detect bias low



Table 4-3  
Summary of Analytes Detected in Clean Fill and/or Native Soil  
Page 2 of 2

| 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 |
|-------------------------------|--------|-------|------------|------------------------|------------------------|-----------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| <b>Metals (mg/kg)</b>         |        |       |            |                        |                        |                             |                 |              |                       |                       |                     |
| Aluminum                      | 100000 | 7800  | 40041      | 0                      | 0                      | 0                           | 17              | 17           | 10600                 | 28100                 | 51SB4A              |
| Antimony                      | 41     | 3.1   | na         | 0                      | 0                      | na                          | 10              | 17           | 0.55                  | 0.88                  | 51SB8B              |
| Arsenic                       | 1.9    | 0.43  | 15.8       | 0                      | 0                      | 0                           | 17              | 17           | 1.1                   | 5.7                   | 51SB5A              |
| Barium                        | 20000  | 1600  | 209        | 0                      | 0                      | 0                           | 17              | 17           | 33.6                  | 120                   | 51SB9A              |
| Beryllium                     | 200    | 16    | 1.02       | 0                      | 0                      | 0                           | 17              | 17           | 0.41                  | 0.8                   | 51SB9A              |
| Cadmium                       | 51     | 3.9   | 0.69       | 0                      | 0                      | 0                           | 11              | 17           | 0.062                 | 0.36                  | 51SB3A              |
| Calcium                       | na     | na    | na         | na                     | na                     | na                          | 17              | 17           | 24.8                  | 483                   | 51SB7A              |
| Chromium                      | 310    | 23    | 65.3       | 0                      | 0                      | 0                           | 17              | 17           | 13.3                  | 34.6                  | 51SB5A              |
| Cobalt                        | na     | na    | 72.3       | na                     | na                     | 1                           | 17              | 17           | 3.3                   | 179                   | 51SB7B              |
| Copper                        | 4100   | 310   | 53.5       | 0                      | 0                      | 0                           | 17              | 17           | 4.6                   | 17.4                  | 51SB5A              |
| Iron                          | 72000  | 5500  | 50962      | 0                      | 0                      | 0                           | 17              | 17           | 11500                 | 33100                 | 51SB7B              |
| Lead                          | 800    | 400   | 26.8       | 0                      | 0                      | 2                           | 17              | 17           | 4.2                   | 66.7                  | 51SB7B              |
| Magnesium                     | na     | na    | na         | na                     | na                     | na                          | 17              | 17           | 483                   | 1930                  | 51SB5A              |
| Manganese                     | 2000   | 160   | 2543       | 1                      | 1                      | 1                           | 17              | 17           | 251                   | 3590                  | 51SB7B              |
| Mercury                       | 31     | 2.3   | 0.13       | 0                      | 0                      | 1                           | 12              | 17           | 0.023                 | 0.14                  | 51SB7A              |
| Nickel                        | 2000   | 160   | 62.8       | 0                      | 0                      | 0                           | 17              | 17           | 4.4                   | 13.2                  | 51SB5A              |
| Potassium                     | na     | na    | na         | na                     | na                     | na                          | 17              | 17           | 360                   | 1610                  | 51SB5A              |
| Selenium                      | 510    | 39    | na         | 0                      | 0                      | na                          | 8               | 17           | 0.17                  | 0.59                  | 51SB1A              |
| Sodium                        | na     | na    | na         | na                     | na                     | na                          | 17              | 17           | 61.9                  | 163                   | 51SB10B             |
| Thallium                      | 7.2    | 0.55  | 2.11       | 0                      | 0                      | 0                           | 7               | 17           | 0.63                  | 1.4                   | 51SB5A              |
| Vanadium                      | 102    | 7.8   | 108        | 0                      | 0                      | 0                           | 17              | 17           | 21.2                  | 66.1                  | 51SB7B              |
| Zinc                          | 31000  | 2300  | 202        | 0                      | 0                      | 0                           | 17              | 17           | 19.5                  | 41.9                  | 51SB7B              |
| <b>Misc. (mg/kg)</b>          |        |       |            |                        |                        |                             |                 |              |                       |                       |                     |
| Cyanide                       | 2000   | 160   | na         | 0                      | 0                      | na                          | 1               | 17           | 0.21                  | 0.21                  | 51SB11B             |
| <b>Dioxins/Furans (ng/kg)</b> |        |       |            |                        |                        |                             |                 |              |                       |                       |                     |
| 2,3,7,8-TCDD                  | 19     | 4.3   | na         | 0                      | 0                      | na                          | 1               | 5            | 0.24                  | 0.24                  | 51SB2A              |
| 1,2,3,4,6,7,8-HPCDD           | na     | na    | na         | na                     | na                     | na                          | 5               | 5            | 20                    | 38                    | 51SB5A              |
| OCDD                          | na     | na    | na         | na                     | na                     | na                          | 5               | 5            | 1900                  | 5900                  | 51SB5A              |
| 1,2,3,4,6,7,8-HPCDF           | na     | na    | na         | na                     | na                     | na                          | 1               | 5            | 1.2                   | 1.2                   | 51SB3A              |
| OCDF                          | na     | na    | na         | na                     | na                     | na                          | 2               | 5            | 2.1                   | 2.3                   | 51SB6A              |
| TOTAL TCDD                    | na     | na    | na         | na                     | na                     | na                          | 2               | 5            | 0.26                  | 2.5                   | 51SB5A              |
| TOTAL PECDD                   | na     | na    | na         | na                     | na                     | na                          | 1               | 5            | 2.6                   | 2.6                   | 51SB5A              |
| TOTAL HXCDD                   | 460    | 100   | na         | 0                      | 0                      | na                          | 5               | 5            | 2.6                   | 6.5                   | 51SB5A              |
| TOTAL HPCDD                   | na     | na    | na         | na                     | na                     | na                          | 5               | 5            | 42                    | 71                    | 51SB5A              |
| TOTAL TCDF                    | na     | na    | na         | na                     | na                     | na                          | 1               | 5            | 0.22                  | 0.22                  | 51SB6A              |
| TOTAL HXCDF                   | na     | na    | na         | na                     | na                     | na                          | 0               | 5            | na                    | na                    | na                  |
| TOTAL HPCDF                   | na     | na    | na         | na                     | na                     | na                          | 1               | 5            | 1.2                   | 1.2                   | 51SB3A              |



# RADFORD AAP

PREPARED BY: SHAW  
 CHECKED BY: MT  
 DATE: APRIL 2008

TASK NO: 83919705000000  
 SHAW DWG NO:  
 Figure 4-2

## FIGURE 4-2

SWMU 51  
 EXPLOSIVE  
 CONCENTRATIONS IN SOIL  
 AND GROUNDWATER

Table 4-4  
Analytes Detected in Sludge Material and/or Grossly Contaminated Soil

| Analyte                    | Sample ID<br>Sample Date<br>Sample Depth |          |            | 51SB2B<br>4/6/04<br>10-12 |       |       |       |        | 51SB2C<br>4/6/04<br>15-17 |       |       |        |        | 51SB3B<br>4/5/04<br>13-15 |       |       |        |         | 51SB3C<br>4/5/04<br>15-18 |       |       |        |        | 51SB4B<br>4/1/04<br>13-15 |       |       |        |         | 51SB4C<br>4/1/04<br>17-20 |       |       |      |      | 51SB5B<br>4/1/04<br>12-14 |       |        |         |        | 51SB6B<br>3/30/04<br>6-8 |      |       |      |       |     |     |     |
|----------------------------|------------------------------------------|----------|------------|---------------------------|-------|-------|-------|--------|---------------------------|-------|-------|--------|--------|---------------------------|-------|-------|--------|---------|---------------------------|-------|-------|--------|--------|---------------------------|-------|-------|--------|---------|---------------------------|-------|-------|------|------|---------------------------|-------|--------|---------|--------|--------------------------|------|-------|------|-------|-----|-----|-----|
|                            | f-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    |                          |      |       |      |       |     |     |     |
| VOCs (ug/kg)               |                                          |          |            |                           |       |       |       |        |                           |       |       |        |        |                           |       |       |        |         |                           |       |       |        |        |                           |       |       |        |         |                           |       |       |      |      |                           |       |        |         |        |                          |      |       |      |       |     |     |     |
| 1,1,1-Trichloroethane      | 200000000                                | 16000000 | na         | 22                        | U     | UJ    | 3.9   | 22     | 7.3                       | U     | UJ    | 1.3    | 7.3    | 49                        |       |       | 3.4    | 19      | 1.7                       | J     | J     | 0.91   | 5      | 33                        |       |       | 2.9    | 16      | 4.6                       | U     |       | 0.85 | 4.6  | 41                        |       |        | 3.9     | 21     | 29                       |      | U     |      | 5.3   | 29  |     |     |
| 2-Butanone                 | 61000000                                 | 4700000  | na         | 43                        | U     | R     | 10    | 43     | 15                        | U     | R     | 3.5    | 15     | 37                        | U     |       | 8.8    | 37      | 8.3                       | J     | B     | 2.4    | 9.9    | 4000                      | U     | R     | 950    | 4000    | 9.3                       | U     | R     | 2.2  | 9.3  | 3800                      | U     | R      | 900     | 3800   | 58                       | U    | R     | 14   | 58    |     |     |     |
| 2-Hexanone                 | 4100000                                  | 310000   | na         | 43                        | U     | UJ    | 6.3   | 43     | 6.2                       | J     | J     | 2.1    | 15     | 37                        | U     |       | 5.4    | 37      | 8                         | J     | J     | 1.5    | 9.9    | 21                        | J     | J     | 4.6    | 32      | 9.3                       | U     |       | 1.4  | 9.3  | 18                        | J     | J      | 6.2     | 43     | 58                       | U    | UJ    | 8.4  | 58    |     |     |     |
| 4-Methyl-2-pentanone       | 8200000                                  | 630000   | na         | 43                        | U     | UJ    | 5.9   | 43     | 15                        |       | J     | 2      | 15     | 160                       |       |       | 5.1    | 37      | 25                        |       | J     | 1.4    | 9.9    | 100                       |       | J     | 4.3    | 32      | 6.9                       | J     | J     | 1.3  | 9.3  | 61                        |       | J      | 5.8     | 43     | 58                       | U    | UL    | 7.9  | 58    |     |     |     |
| Acetone                    | 92000000                                 | 7000000  | na         | 62                        | B     | B     | 12    | 43     | 23                        | B     | B     | 4      | 15     | 93                        |       | B     | 10     | 37      | 25                        |       | B     | 2.7    | 9.9    | 98                        |       | B     | 8.7    | 32      | 60                        | B     | B     | 2.6  | 9.3  | 67                        |       | B      | 12      | 43     | 58                       | U    | UL    | 16   | 58    |     |     |     |
| Benzene                    | 52000                                    | 12000    | na         | 6.6                       | J     | B     | 4.8   | 22     | 7.3                       | U     | UJ    | 1.6    | 7.3    | 190                       |       |       | 4.2    | 19      | 2.7                       | J     | B     | 1.1    | 5      | 130                       |       |       | 3.6    | 16      | 4.6                       | U     |       | 1    | 4.6  | 180                       |       |        | 4.8     | 21     | 29                       | U    |       | 6.5  | 29    |     |     |     |
| Chloroform                 | 1000000                                  | 78000    | na         | 22                        | U     | UJ    | 4.4   | 22     | 7.3                       | U     | UJ    | 1.5    | 7.3    | 6.9                       | J     | J     | 3.8    | 19      | 5                         | U     | UJ    | 1      | 5      | 16                        | U     |       | 3.2    | 16      | 4.6                       | U     |       | 0.95 | 4.6  | 21                        | U     |        | 4.4     | 21     | 29                       | U    |       | 5.9  | 29    |     |     |     |
| Ethylbenzene               | 10000000                                 | 780000   | na         | 22                        | U     | UJ    | 5.5   | 22     | 7.3                       | U     | UJ    | 1.9    | 7.3    | 46                        |       |       | 4.7    | 19      | 5                         | U     | UJ    | 1.3    | 5      | 31                        |       |       | 4      | 16      | 4.6                       | U     |       | 1.2  | 4.6  | 24                        |       |        | 5.4     | 21     | 29                       | U    |       | 7.3  | 29    |     |     |     |
| m- & p-Xylene              | 20000000                                 | 1600000  | na         | 22                        | U     | UJ    | 10    | 22     | 5.5                       | J     | B     | 3.5    | 7.3    | 140                       |       |       | 9      | 19      | 18                        |       | J     | 2.4    | 5      | 110                       |       |       | 7.6    | 16      | 4.6                       | U     |       | 2.2  | 4.6  | 70                        |       |        | 10      | 21     | 29                       | U    |       | 14   | 29    |     |     |     |
| Methylene chloride         | 380000                                   | 85000    | na         | 14                        | JB    | B     | 4.9   | 43     | 4.9                       | JB    | B     | 1.7    | 15     | 16                        | JB    | B     | 4.2    | 37      | 2.9                       | JB    | B     | 1.1    | 9.9    | 8.8                       | JB    | B     | 3.6    | 32      | 9.3                       | U     |       | 1.1  | 9.3  | 8.5                       | JB    | B      | 4.8     | 43     | 58                       | U    |       | 6.5  | 58    |     |     |     |
| o-Xylene                   | 20000000                                 | 1600000  | na         | 22                        | U     | UJ    | 2.6   | 22     | 2.7                       | J     | B     | 0.88   | 7.3    | 39                        |       |       | 2.2    | 19      | 8.2                       |       | J     | 0.6    | 5      | 32                        |       |       | 1.9    | 16      | 4.6                       | U     |       | 0.56 | 4.6  | 20                        | J     | J      | 2.6     | 21     | 29                       | U    |       | 3.5  | 29    |     |     |     |
| Tetrachloroethene          | 5300                                     | 1200     | na         | 22                        | U     | UJ    | 5.7   | 22     | 7.3                       | U     | UJ    | 2      | 7.3    | 15                        | J     | J     | 5      | 19      | 5                         | U     | UJ    | 1.3    | 5      | 12                        | J     | J     | 4.2    | 16      | 4.6                       | U     |       | 1.2  | 4.6  | 9.3                       | J     | J      | 5.7     | 21     | 29                       | U    |       | 7.7  | 29    |     |     |     |
| Toluene                    | 8200000                                  | 630000   | na         | 210                       |       | J     | 4.8   | 22     | 28                        |       | J     | 1.6    | 7.3    | 51000                     |       |       | 380    | 1700    | 85                        |       | J     | 1.1    | 5      | 20000                     |       |       | 450    | 2000    | 3                         | J     | B     | 1    | 4.6  | 2900                      |       | B      | 420     | 1900   | 29                       | U    |       | 6.4  | 29    |     |     |     |
| Trichloroethene            | 7200                                     | 1600     | na         | 5.5                       | J     | J     | 4.7   | 22     | 1.7                       | J     | J     | 1.6    | 7.3    | 32                        |       |       | 4.1    | 19      | 1.9                       | J     | J     | 1.1    | 5      | 19                        |       | B     | 3.5    | 16      | 4.6                       | U     |       | 1    | 4.6  | 25                        |       |        | 4.7     | 21     | 29                       | U    |       | 6.4  | 29    |     |     |     |
| PAHs (ug/kg)               |                                          |          |            |                           |       |       |       |        |                           |       |       |        |        |                           |       |       |        |         |                           |       |       |        |        |                           |       |       |        |         |                           |       |       |      |      |                           |       |        |         |        |                          |      |       |      |       |     |     |     |
| Benzo(a)anthracene         | 3900                                     | 220      | na         | NT                        |       |       |       |        | NT                        |       |       |        |        | NT                        |       |       |        |         | NT                        |       |       |        |        |                           |       |       | 1500   | U       |                           | 220   | 1500  | 7.7  | U    |                           | 1.2   | 7.7    | 1800    | U      |                          | 270  | 1800  | 900  |       | 330 | 330 |     |
| Benzo(a)pyrene             | 390                                      | 22       | na         | NT                        |       |       |       |        | NT                        |       |       |        |        | NT                        |       |       |        |         | NT                        |       |       |        |        |                           |       |       | 1500   | U       |                           | 220   | 1500  | 7.7  | U    |                           | 1.2   | 7.7    | 1800    | U      |                          | 270  | 1800  | 950  |       | 330 | 330 |     |
| Benzo(b)fluoranthene       | 3900                                     | 220      | na         | NT                        |       |       |       |        | NT                        |       |       |        |        | NT                        |       |       |        |         | NT                        |       |       |        |        |                           |       |       | 1500   | U       |                           | 370   | 1500  | 7.7  | U    |                           | 1.9   | 7.7    | 1800    | U      |                          | 460  | 1800  | 1600 |       | 330 | 330 |     |
| Benzo(g,h,i)perylene       | 3100000                                  | 230000   | na         | NT                        |       |       |       |        | NT                        |       |       |        |        | NT                        |       |       |        |         | NT                        |       |       |        |        |                           |       |       | 1500   | U       |                           | 890   | 1500  | 7.7  | U    |                           | 4.6   | 7.7    | 1800    | U      |                          | 1100 | 1800  | 590  |       | 330 | 330 |     |
| Benzo(k)fluoranthene       | 39000                                    | 2200     | na         | NT                        |       |       |       |        | NT                        |       |       |        |        | NT                        |       |       |        |         | NT                        |       |       |        |        |                           |       |       | 1500   | U       |                           | 370   | 1500  | 7.7  | U    |                           | 1.9   | 7.7    | 1800    | U      |                          | 460  | 1800  | 820  |       | K   | 330 | 330 |
| Chrysene                   | 390000                                   | 22000    | na         | NT                        |       |       |       |        | NT                        |       |       |        |        | NT                        |       |       |        |         | NT                        |       |       |        |        |                           |       |       | 1500   | U       |                           | 150   | 1500  | 7.7  | U    |                           | 0.77  | 7.7    | 1800    | U      |                          | 180  | 1800  | 1300 |       | 330 | 330 |     |
| Fluoranthene               | 4100000                                  | 310000   | na         | NT                        |       |       |       |        | NT                        |       |       |        |        | NT                        |       |       |        |         | NT                        |       |       |        |        |                           |       |       | 1500   | U       |                           | 300   | 1500  | 7.7  | U    |                           | 1.5   | 7.7    | 1800    | U      |                          | 360  | 1800  | 3300 |       | 330 | 330 |     |
| Indeno(1,2,3-cd)pyrene     | 3900                                     | 220      | na         | NT                        |       |       |       |        | NT                        |       |       |        |        | NT                        |       |       |        |         | NT                        |       |       |        |        |                           |       |       | 1500   | U       |                           | 220   | 1500  | 7.7  | U    |                           | 1.2   | 7.7    | 1800    | U      |                          | 270  | 1800  | 540  |       | 330 | 330 |     |
| Phenanthrene               | 3100000                                  | 230000   | na         | NT                        |       |       |       |        | NT                        |       |       |        |        | NT                        |       |       |        |         | NT                        |       |       |        |        |                           |       |       | 1500   | U       |                           | 150   | 1500  | 23   |      | 0.77                      | 7.7   | 1800   | U       |        | 180                      | 1800 | 1300  |      | 330   | 330 |     |     |
| Pyrene                     | 3100000                                  | 230000   | na         | NT                        |       |       |       |        | NT                        |       |       |        |        | NT                        |       |       |        |         | NT                        |       |       |        |        |                           |       |       | 1500   | U       |                           | 150   | 1500  | 7.7  | U    |                           | 0.77  | 7.7    | 1800    | U      |                          | 180  | 1800  | 2300 |       | 330 | 330 |     |
| SVOCs (ug/kg)              |                                          |          |            |                           |       |       |       |        |                           |       |       |        |        |                           |       |       |        |         |                           |       |       |        |        |                           |       |       |        |         |                           |       |       |      |      |                           |       |        |         |        |                          |      |       |      |       |     |     |     |
| 2,4-Dinitrophenol          | 200000                                   | 16000    | na         | 210000                    | U     | UJ    | 38000 | 210000 | 75000                     | U     | UJ    | 14000  | 75000  | 1800000                   | U     | UJ    | 330000 | 1800000 | 750                       | U     |       | 140    | 750    | 150000                    | U     |       | 27000  | 150000  | 550                       | J     | J     | 140  | 770  | 180000                    | U     |        | 33000   | 180000 | 16000                    | U    |       | 3000 | 16000 |     |     |     |
| 2,4-Dinitrotoluene         | 200000                                   | 16000    | na         | 6800000                   | B     |       | 80000 | 510000 | 5900000                   | B     |       | 120000 | 750000 | 48000000                  | J     |       | 700000 | 4500000 | 1600000                   | B     |       | 290000 | 190000 | 390000000                 |       |       | 580000 | 3700000 | 28000                     |       |       | 600  | 3900 | 21000000                  |       | 350000 | 2300000 | 100000 |                          | 1300 | 8200  |      |       |     |     |     |
| 2,6-Dinitrotoluene         | 100000                                   | 7800     | na         | 2000000                   | B     |       | 55000 | 510000 | 1400000                   | B     |       | 81000  | 750000 | 11000000                  |       |       | 96000  | 900000  | 430000                    | B     |       | 20000  | 190000 | 9500000                   |       |       | 400000 | 3700000 | 6700                      |       |       | 410  | 3900 | 5000000                   |       | 240000 | 2300000 | 150000 |                          | 4400 | 41000 |      |       |     |     |     |
| 2-Nitroaniline             | na                                       | na       | na         | 100000                    | U     |       | 18000 | 100000 | 38000                     | U     |       | 6700   | 38000  | 900000                    | U     |       | 160000 | 900000  | 370                       | U     |       | 66     | 370    | 75000                     | U     |       | 13000  | 75000   | 390                       | U     |       | 68   | 390  | 91000                     | U     |        | 16000   | 91000  | 45000                    |      | 1400  | 8200 |       |     |     |     |
| 4,6-Dinitro-2-methylphenol | na                                       | na       | na         | 210000                    | U     |       | 30000 | 210000 | 75000                     | U     |       | 11000  | 75000  | 1800000                   | U     |       | 260000 | 1800000 | 2700                      |       | J     | 110    | 750    | 150000                    | U     |       | 22000  | 150000  | 2100                      |       |       | 110  | 770  | 180000                    | U     |        | 26000   |        |                          |      |       |      |       |     |     |     |

**Table 4-4  
Legend**

|           |          |                                                                       |
|-----------|----------|-----------------------------------------------------------------------|
| 12        | J        | Shading and black font indicate an industrial RBC exceedance.         |
| 12        | J        | Bold outline indicates a residential RBC exceedance.                  |
| <b>12</b> | <b>J</b> | 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**

\* = Laboratory duplicate not within control limits

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 4-5**  
**Dioxins/Furans Detected in Sludge Material and/or Grossly Contaminated Soil**  
**Page 1 of 2**

| Analyte                | Sample ID    |       |            | 51SB2B |       |       |     |     | 51SB2C |       |       |      |     | 51SB3B |       |       |      |      | 51SB3C |       |       |       |      |
|------------------------|--------------|-------|------------|--------|-------|-------|-----|-----|--------|-------|-------|------|-----|--------|-------|-------|------|------|--------|-------|-------|-------|------|
|                        | Sample Date  |       |            | 4/6/04 |       |       |     |     | 4/6/04 |       |       |      |     | 4/5/04 |       |       |      |      | 4/5/04 |       |       |       |      |
|                        | Sample Depth |       |            | 10-12  |       |       |     |     | 15-17  |       |       |      |     | 13-15  |       |       |      |      | 15-18  |       |       |       |      |
|                        | 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  |
| Dioxins/Furans (ng/kg) |              |       |            |        |       |       |     |     |        |       |       |      |     |        |       |       |      |      |        |       |       |       |      |
| 2,3,7,8-TCDF           | na           | na    | na         | 120    | A     |       | 2.1 | 1.9 | 8.2    | AJ    | J     | 2    | 1.9 | 160    | A     |       | 0.22 | 0.2  | 1.4    |       |       | 0.1   | 0.19 |
| 2,3,7,8-TCDD           | 19           | 4.3   | na         | 4.5    | A     |       | 4.5 | 1.9 | 1.9    | U     |       | 1.9  | 1.9 | 0.74   | J     | J     | 0.18 | 0.2  | 0.19   | U     |       | 0.17  | 0.19 |
| 1,2,3,7,8-PECDD        | na           | na    | na         | 9.7    | U     |       | 4.9 | 9.7 | 9.3    | U     |       | 2.5  | 9.3 | 5.5    |       |       | 0.18 | 0.98 | 0.94   | U     |       | 0.14  | 0.94 |
| 1,2,3,4,7,8-HXCDD      | 460          | 100   | na         | 10     | I     | J     | 2.8 | 9.7 | 9.3    | U     |       | 3    | 9.3 | 12     |       |       | 0.91 | 0.98 | 0.94   | U     |       | 0.075 | 0.94 |
| 1,2,3,6,7,8-HXCDD      | 460          | 100   | na         | 51     |       |       | 3   | 9.7 | 9.3    | U     |       | 3.1  | 9.3 | 63     |       | J     | 0.94 | 0.98 | 0.94   | U     |       | 0.069 | 0.94 |
| 1,2,3,7,8,9-HXCDD      | 460          | 100   | na         | 24     | J     | J     | 3.7 | 9.7 | 9.3    | U     |       | 3.1  | 9.3 | 78     |       |       | 0.51 | 0.98 | 0.94   | U     |       | 0.083 | 0.94 |
| 1,2,3,4,6,7,8-HPCDD    | na           | na    | na         | 1300   |       |       | 6.2 | 9.7 | 91     |       |       | 2.1  | 9.3 | 1600   | A     |       | 1.1  | 0.98 | 22     |       |       | 0.1   | 0.94 |
| OCDD                   | na           | na    | na         | 15000  |       |       | 7   | 19  | 1300   |       |       | 5.5  | 19  | 15000  |       |       | 0.14 | 2    | 690    |       |       | 0.22  | 1.9  |
| 1,2,3,7,8-PECDF        | na           | na    | na         | 31     | J     | J     | 1.5 | 9.7 | 9.3    | U     |       | 0.85 | 9.3 | 37     |       |       | 0.29 | 0.98 | 0.94   | U     |       | 0.08  | 0.94 |
| 2,3,4,7,8-PECDF        | na           | na    | na         | 72     |       |       | 1.5 | 9.7 | 9.3    | U     |       | 0.96 | 9.3 | 90     |       |       | 0.51 | 0.98 | 0.94   | U     |       | 0.091 | 0.94 |
| 1,2,3,4,7,8-HXCDF      | na           | na    | na         | 74     |       |       | 2.3 | 9.7 | 9.3    | U     |       | 1.5  | 9.3 | 91     |       | J     | 0.6  | 0.98 | 0.94   | U     |       | 0.075 | 0.94 |
| 1,2,3,6,7,8-HXCDF      | na           | na    | na         | 22     | J     | J     | 1.7 | 9.7 | 9.3    | U     |       | 1.4  | 9.3 | 31     |       | J     | 0.83 | 0.98 | 0.94   | U     |       | 0.081 | 0.94 |
| 2,3,4,6,7,8-HXCDF      | na           | na    | na         | 28     | J     | J     | 1.3 | 9.7 | 9.3    | U     |       | 1.9  | 9.3 | 26     |       |       | 0.29 | 0.98 | 0.94   | U     |       | 0.057 | 0.94 |
| 1,2,3,7,8,9-HXCDF      | na           | na    | na         | 14     | J     | J     | 3.4 | 9.7 | 9.3    | U     |       | 1.8  | 9.3 | 15     |       |       | 0.38 | 0.98 | 0.94   | U     |       | 0.055 | 0.94 |
| 1,2,3,4,6,7,8-HPCDF    | na           | na    | na         | 310    |       |       | 4   | 9.7 | 20     | J     | J     | 2    | 9.3 | 370    |       |       | 0.36 | 0.98 | 3.5    | J     | J     | 0.084 | 0.94 |
| 1,2,3,4,7,8,9-HPCDF    | na           | na    | na         | 31     | J     | J     | 6.9 | 9.7 | 9.3    | U     |       | 3.1  | 9.3 | 42     |       |       | 0.21 | 0.98 | 0.94   | U     |       | 0.084 | 0.94 |
| OCDF                   | na           | na    | na         | 930    |       |       | 4   | 19  | 67     | J     | J     | 4.5  | 19  | 930    |       |       | 0.15 | 2    | 11     |       |       | 0.1   | 1.9  |
| TOTAL TCDD             | na           | na    | na         | 1.9    | U     |       | 4.5 | 1.9 | 1.9    | U     |       | 1.9  | 1.9 | 3.9    |       |       | 0.18 | 0.2  | 0.19   | U     |       | 0.17  | 0.19 |
| TOTAL PECDD            | na           | na    | na         | 9.7    | U     |       | 4.9 | 9.7 | 9.3    | U     |       | 2.5  | 9.3 | 15     |       |       | 0.18 | 0.98 | 0.94   | U     |       | 0.14  | 0.94 |
| TOTAL HXCDD            | 460          | 100   | na         | 230    |       |       | 3.2 | 9.7 | 9.3    | U     |       | 3.1  | 9.3 | 340    |       |       | 0.79 | 0.98 | 1.5    | J     | J     | 0.076 | 0.94 |
| TOTAL HPCDD            | na           | na    | na         | 2200   |       |       | 6.2 | 9.7 | 160    |       |       | 2.1  | 9.3 | 2600   |       |       | 1.1  | 0.98 | 36     |       |       | 0.1   | 0.94 |
| TOTAL TCDF             | na           | na    | na         | 690    |       |       | 2.1 | 1.9 | 31     |       |       | 2    | 1.9 | 450    |       |       | 0.22 | 0.2  | 6.1    |       |       | 0.1   | 0.19 |
| TOTAL PECDF            | na           | na    | na         | 350    |       |       | 1.5 | 9.7 | 9.3    | U     |       | 0.9  | 9.3 | 270    |       |       | 0.4  | 0.98 | 1.4    | J     | J     | 0.085 | 0.94 |
| TOTAL HXCDF            | na           | na    | na         | 550    |       |       | 2.2 | 9.7 | 13     | J     | J     | 1.6  | 9.3 | 390    |       |       | 0.53 | 0.98 | 4.1    | J     | J     | 0.067 | 0.94 |
| TOTAL HPCDF            | na           | na    | na         | 1000   |       |       | 5.4 | 9.7 | 63     | J     | J     | 2.5  | 9.3 | 1100   |       |       | 0.28 | 0.98 | 12     |       |       | 0.084 | 0.94 |

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

**Table 4-5**  
**Dioxins/Furans Detected in Sludge Material and/or Grossly Contaminated Soil**  
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| Analyte             | Sample ID<br>Sample Date<br>Sample Depth |       |            | 51SB4B<br>4/1/04<br>13-15 |       |       |      |      | 51SB4C<br>4/1/04<br>17-20 |       |       |      |      | 51SB5B<br>4/1/04<br>12-14 |       |       |      |      | 51SB6B<br>3/30/04<br>6-8 |       |       |      |      |
|---------------------|------------------------------------------|-------|------------|---------------------------|-------|-------|------|------|---------------------------|-------|-------|------|------|---------------------------|-------|-------|------|------|--------------------------|-------|-------|------|------|
|                     | 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  |
|                     | Dioxins/Furans (ng/kg)                   |       |            |                           |       |       |      |      |                           |       |       |      |      |                           |       |       |      |      |                          |       |       |      |      |
| 2,3,7,8-TCDF        | na                                       | na    | na         | 130                       | A     |       | 0.54 | 0.2  | 0.47                      | J     | J     | 0.18 | 0.2  | 160                       |       |       | 0.17 | 0.2  | 82                       | A     |       | 0.39 | 0.19 |
| 2,3,7,8-TCDD        | 19                                       | 4.3   | na         | 1.1                       | IA    | J     | 0.53 | 0.2  | 0.2                       | U     |       | 0.31 | 0.2  | 0.48                      | I     | J     | 0.2  | 0.2  | 3.3                      | IA    | J     | 0.28 | 0.19 |
| 1,2,3,7,8-PECDD     | na                                       | na    | na         | 6                         |       |       | 0.55 | 0.99 | 0.98                      | U     |       | 0.22 | 0.98 | 4.6                       | J     | J     | 0.75 | 0.99 | 27                       |       |       | 0.52 | 0.94 |
| 1,2,3,4,7,8-HXCDD   | 460                                      | 100   | na         | 16                        |       |       | 0.83 | 0.99 | 0.98                      | U     |       | 0.34 | 0.98 | 14                        |       |       | 0.53 | 0.99 | 46                       |       |       | 0.88 | 0.94 |
| 1,2,3,6,7,8-HXCDD   | 460                                      | 100   | na         | 63                        |       |       | 0.73 | 0.99 | 0.98                      | U     |       | 0.27 | 0.98 | 57                        |       |       | 0.46 | 0.99 | 120                      |       |       | 0.5  | 0.94 |
| 1,2,3,7,8,9-HXCDD   | 460                                      | 100   | na         | 31                        |       |       | 0.72 | 0.99 | 0.98                      | U     |       | 0.25 | 0.98 | 28                        |       |       | 0.44 | 0.99 | 86                       |       |       | 0.48 | 0.94 |
| 1,2,3,4,6,7,8-HPCDD | na                                       | na    | na         | 1900                      | A     |       | 3.4  | 0.99 | 6.6                       |       |       | 0.52 | 0.98 | 1600                      |       |       | 0.31 | 0.99 | 2800                     |       |       | 0.58 | 0.94 |
| OCDD                | na                                       | na    | na         | 17000                     |       |       | 1.1  | 2    | 130                       |       |       | 0.74 | 2    | 16000                     |       |       | 0.34 | 2    | 23000                    |       |       | 0.66 | 1.9  |
| 1,2,3,7,8-PECDF     | na                                       | na    | na         | 43                        |       |       | 0.22 | 0.99 | 0.98                      | U     |       | 0.29 | 0.98 | 40                        |       |       | 0.31 | 0.99 | 22                       | E     | J     | 0.36 | 0.94 |
| 2,3,4,7,8-PECDF     | na                                       | na    | na         | 88                        |       |       | 0.19 | 0.99 | 0.98                      | U     |       | 0.28 | 0.98 | 85                        |       |       | 0.38 | 0.99 | 49                       | E     | J     | 0.44 | 0.94 |
| 1,2,3,4,7,8-HXCDF   | na                                       | na    | na         | 82                        |       |       | 0.25 | 0.99 | 0.98                      | U     |       | 0.17 | 0.98 | 78                        |       |       | 0.56 | 0.99 | 130                      | E     | J     | 0.87 | 0.94 |
| 1,2,3,6,7,8-HXCDF   | na                                       | na    | na         | 34                        |       |       | 0.47 | 0.99 | 0.98                      | U     |       | 0.15 | 0.98 | 31                        |       |       | 0.33 | 0.99 | 41                       |       |       | 0.39 | 0.94 |
| 2,3,4,6,7,8-HXCDF   | na                                       | na    | na         | 32                        |       |       | 0.66 | 0.99 | 0.98                      | U     |       | 0.14 | 0.98 | 34                        |       |       | 0.74 | 0.99 | 52                       |       |       | 0.58 | 0.94 |
| 1,2,3,7,8,9-HXCDF   | na                                       | na    | na         | 17                        |       |       | 0.87 | 0.99 | 0.98                      | U     |       | 0.21 | 0.98 | 12                        |       |       | 0.5  | 0.99 | 10                       |       |       | 0.43 | 0.94 |
| 1,2,3,4,6,7,8-HPCDF | na                                       | na    | na         | 400                       | A     |       | 1.7  | 0.99 | 0.98                      | U     |       | 0.33 | 0.98 | 360                       |       |       | 0.93 | 0.99 | 970                      |       |       | 0.44 | 0.94 |
| 1,2,3,4,7,8,9-HPCDF | na                                       | na    | na         | 47                        | A     |       | 2.3  | 0.99 | 0.98                      | U     |       | 0.64 | 0.98 | 42                        |       |       | 0.9  | 0.99 | 55                       | A     |       | 1.3  | 0.94 |
| OCDF                | na                                       | na    | na         | 1100                      |       |       | 1.1  | 2    | 3.2                       | J     | J     | 0.4  | 2    | 940                       |       |       | 0.36 | 2    | 2400                     |       |       | 0.82 | 1.9  |
| TOTAL TCDD          | na                                       | na    | na         | 0.2                       | U     |       | 0.53 | 0.2  | 0.2                       | U     |       | 0.31 | 0.2  | 4.2                       |       |       | 0.2  | 0.2  | 8.9                      |       |       | 0.28 | 0.19 |
| TOTAL PECDD         | na                                       | na    | na         | 15                        |       |       | 0.55 | 0.99 | 0.98                      | U     |       | 0.22 | 0.98 | 20                        |       |       | 0.75 | 0.99 | 100                      |       |       | 0.52 | 0.94 |
| TOTAL HXCDD         | 460                                      | 100   | na         | 260                       |       |       | 0.76 | 0.99 | 0.98                      | U     |       | 0.29 | 0.98 | 270                       |       |       | 0.47 | 0.99 | 780                      |       |       | 0.62 | 0.94 |
| TOTAL HPCDD         | na                                       | na    | na         | 3200                      |       |       | 3.4  | 0.99 | 12                        |       |       | 0.52 | 0.98 | 2600                      |       |       | 0.31 | 0.99 | 4900                     |       |       | 0.58 | 0.94 |
| TOTAL TCDF          | na                                       | na    | na         | 650                       |       |       | 0.54 | 0.2  | 1                         | J     | J     | 0.18 | 0.2  | 610                       |       |       | 0.17 | 0.2  | 390                      |       |       | 0.39 | 0.19 |
| TOTAL PECDF         | na                                       | na    | na         | 530                       |       |       | 0.21 | 0.99 | 0.98                      | U     |       | 0.28 | 0.98 | 600                       |       |       | 0.35 | 0.99 | 400                      |       |       | 0.4  | 0.94 |
| TOTAL HXCDF         | na                                       | na    | na         | 600                       |       |       | 0.56 | 0.99 | 0.98                      | U     |       | 0.17 | 0.98 | 700                       |       |       | 0.53 | 0.99 | 1400                     |       |       | 0.56 | 0.94 |
| TOTAL HPCDF         | na                                       | na    | na         | 970                       |       |       | 2    | 0.99 | 0.98                      | U     |       | 0.48 | 0.98 | 1200                      |       |       | 0.92 | 0.99 | 2900                     |       |       | 0.88 | 0.94 |

\*\*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 industrial RBC exceedance.         |
| 12        | J        | Bold outline indicates a residential RBC exceedance.                  |
| <b>12</b> | <b>J</b> | 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**

\* = Laboratory duplicate not within control limits

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 4-6  
Summary of Analytes Detected in Sludge Material and/or Grossly Contaminated Soil  
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| 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 |
|--------------------------------------------------------------------------|-----------|----------|------------|------------------------|------------------------|-----------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| <b>VOCs (ug/kg)</b>                                                      |           |          |            |                        |                        |                             |                 |              |                       |                       |                     |
| 1,1,1-Trichloroethane                                                    | 200000000 | 16000000 | na         | 0                      | 0                      | na                          | 4               | 8            | 1.7                   | 49                    | 51SB3B              |
| 2-Butanone                                                               | 61000000  | 4700000  | na         | 0                      | 0                      | na                          | 1               | 8            | 8.3                   | 8.3                   | 51SB3C              |
| 2-Hexanone                                                               | 4100000   | 310000   | na         | 0                      | 0                      | na                          | 4               | 8            | 6.2                   | 21                    | 51SB4B              |
| 4-Methyl-2-pentanone                                                     | 8200000   | 630000   | na         | 0                      | 0                      | na                          | 6               | 8            | 6.9                   | 160                   | 51SB3B              |
| Acetone                                                                  | 92000000  | 7000000  | na         | 0                      | 0                      | na                          | 7               | 8            | 23                    | 98                    | 51SB4B              |
| Benzene                                                                  | 52000     | 12000    | na         | 0                      | 0                      | na                          | 5               | 8            | 2.7                   | 190                   | 51SB3B              |
| Chloroform                                                               | 1000000   | 78000    | na         | 0                      | 0                      | na                          | 1               | 8            | 6.9                   | 6.9                   | 51SB3B              |
| Ethylbenzene                                                             | 10000000  | 780000   | na         | 0                      | 0                      | na                          | 3               | 8            | 24                    | 46                    | 51SB3B              |
| m- & p-Xylene                                                            | 20000000  | 1600000  | na         | 0                      | 0                      | na                          | 5               | 8            | 5.5                   | 140                   | 51SB3B              |
| Methylene chloride                                                       | 380000    | 85000    | na         | 0                      | 0                      | na                          | 6               | 8            | 2.9                   | 16                    | 51SB3B              |
| o-Xylene                                                                 | 20000000  | 1600000  | na         | 0                      | 0                      | na                          | 5               | 8            | 2.7                   | 39                    | 51SB3B              |
| Tetrachloroethene                                                        | 5300      | 1200     | na         | 0                      | 0                      | na                          | 3               | 8            | 9.3                   | 15                    | 51SB3B              |
| Toluene                                                                  | 8200000   | 630000   | na         | 0                      | 0                      | na                          | 7               | 8            | 3                     | 51000                 | 51SB3B              |
| Trichloroethene                                                          | 7200      | 1600     | na         | 0                      | 0                      | na                          | 6               | 8            | 1.7                   | 32                    | 51SB3B              |
| <b>PAHs (ug/kg)</b>                                                      |           |          |            |                        |                        |                             |                 |              |                       |                       |                     |
| Benz(a)anthracene                                                        | 3900      | 220      | na         | 0                      | 1                      | na                          | 1               | 4            | 900                   | 900                   | 51SB6B              |
| Benzo(a)pyrene                                                           | 390       | 22       | na         | 1                      | 1                      | na                          | 1               | 4            | 950                   | 950                   | 51SB6B              |
| Benzo(b)fluoranthene                                                     | 3900      | 220      | na         | 0                      | 1                      | na                          | 1               | 4            | 1600                  | 1600                  | 51SB6B              |
| Benzo(g,h,i)perylene                                                     | 3100000   | 230000   | na         | 0                      | 0                      | na                          | 1               | 4            | 590                   | 590                   | 51SB6B              |
| Benzo(k)fluoranthene                                                     | 39000     | 2200     | na         | 0                      | 0                      | na                          | 1               | 4            | 820                   | 820                   | 51SB6B              |
| Chrysene                                                                 | 390000    | 22000    | na         | 0                      | 0                      | na                          | 1               | 4            | 1300                  | 1300                  | 51SB6B              |
| Fluoranthene                                                             | 4100000   | 310000   | na         | 0                      | 0                      | na                          | 1               | 4            | 3300                  | 3300                  | 51SB6B              |
| Indeno(1,2,3-cd)pyrene                                                   | 3900      | 220      | na         | 0                      | 1                      | na                          | 1               | 4            | 540                   | 540                   | 51SB6B              |
| Phenanthrene                                                             | 3100000   | 230000   | na         | 0                      | 0                      | na                          | 2               | 4            | 23                    | 1300                  | 51SB6B              |
| Pyrene                                                                   | 3100000   | 230000   | na         | 0                      | 0                      | na                          | 1               | 4            | 2300                  | 2300                  | 51SB6B              |
| <b>SVOCs (ug/kg)</b>                                                     |           |          |            |                        |                        |                             |                 |              |                       |                       |                     |
| 2,4-Dinitrophenol                                                        | 200000    | 16000    | na         | 0                      | 0                      | na                          | 1               | 8            | 550                   | 550                   | 51SB4C              |
| 2,4-Dinitrotoluene                                                       | 200000    | 16000    | na         | 6                      | 8                      | na                          | 8               | 8            | 28000                 | 48000000              | 51SB3B              |
| 2,6-Dinitrotoluene                                                       | 100000    | 7800     | na         | 7                      | 7                      | na                          | 8               | 8            | 6700                  | 11000000              | 51SB3B              |
| 2-Nitroaniline                                                           | na        | na       | na         | na                     | na                     | na                          | 1               | 8            | 45000                 | 45000                 | 51SB6B              |
| 4,6-Dinitro-2-methylphenol                                               | na        | na       | na         | na                     | na                     | na                          | 2               | 8            | 2100                  | 2700                  | 51SB3C              |
| bis(2-Ethylhexyl)phthalate                                               | 200000    | 46000    | na         | 0                      | 0                      | na                          | 6               | 8            | 47                    | 32000                 | 51SB4B              |
| Diethylphthalate                                                         | 82000000  | 6300000  | na         | 0                      | 0                      | na                          | 1               | 8            | 440000                | 440000                | 51SB6B              |
| Di-n-butylphthalate                                                      | 10000000  | 780000   | na         | 0                      | 0                      | na                          | 2               | 8            | 200                   | 6800                  | 51SB6B              |
| Fluoranthene                                                             | 4100000   | 310000   | na         | 0                      | 0                      | na                          | 1               | 8            | 2500                  | 2500                  | 51SB6B              |
| Pyrene                                                                   | 3100000   | 230000   | na         | 0                      | 0                      | na                          | 1               | 8            | 2000                  | 2000                  | 51SB6B              |
| <b>Pesticides (ug/kg)</b> <i>Samples were not tested for this group.</i> |           |          |            |                        |                        |                             |                 |              |                       |                       |                     |
| <b>PCBs (mg/kg)</b> <i>None detected</i>                                 |           |          |            |                        |                        |                             |                 |              |                       |                       |                     |
| <b>Explosives (mg/kg)</b>                                                |           |          |            |                        |                        |                             |                 |              |                       |                       |                     |
| 1,3,5-Trinitrobenzene                                                    | 3100      | 230      | na         | 0                      | 3                      | na                          | 7               | 8            | 12                    | 850                   | 51SB6B              |
| 1,3-Dinitrobenzene                                                       | 10        | 0.78     | na         | 4                      | 4                      | na                          | 7               | 8            | 0.1                   | 460                   | 51SB2B              |
| 2,4,6-Trinitrotoluene                                                    | 51        | 3.9      | na         | 8                      | 8                      | na                          | 8               | 8            | 64                    | 61000                 | 51SB6B              |
| 2,4-Dinitrotoluene                                                       | 200       | 16       | na         | 6                      | 8                      | na                          | 8               | 8            | 79                    | 44000                 | 51SB3B              |
| 2,6-Dinitrotoluene                                                       | 100       | 7.8      | na         | 6                      | 8                      | na                          | 8               | 8            | 17                    | 11000                 | 51SB3B              |
| 2-amino-4,6-Dinitrotoluene                                               | 200       | 16       | na         | 0                      | 1                      | na                          | 1               | 8            | 32                    | 32                    | 51SB3C              |
| 2-Nitrotoluene                                                           | 1000      | 78       | na         | 4                      | 8                      | na                          | 8               | 8            | 100                   | 25000                 | 51SB3B              |
| 3-Nitrotoluene                                                           | na        | na       | na         | na                     | na                     | na                          | 8               | 8            | 9.3                   | 2100                  | 51SB3B              |
| 4-Nitrotoluene                                                           | 180       | 31       | na         | 4                      | 8                      | na                          | 8               | 8            | 60                    | 16000                 | 51SB3B              |
| Nitrobenzene                                                             | 51        | 3.9      | na         | 0                      | 0                      | na                          | 1               | 8            | 0.93                  | 0.93                  | 51SB3C              |
| RDX                                                                      | 26        | 5.8      | na         | 0                      | 0                      | na                          | 2               | 8            | 3.4                   | 5.3                   | 51SB4C              |
| Nitroglycerin                                                            | 10        | 0.78     | na         | 1                      | 1                      | na                          | 1               | 8            | 3300                  | 3300                  | 51SB6B              |
| PETN                                                                     | na        | na       | na         | na                     | na                     | na                          | 1               | 8            | 62                    | 62                    | 51SB5B              |

Table 4-6  
Summary of Analytes Detected in Sludge Material and/or Grossly Contaminated Soil  
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| 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 |
|------------------------------------------------|--------|-------|------------|------------------------|------------------------|-----------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| <b>Herbicides (ug/kg)</b>                      |        |       |            |                        |                        |                             |                 |              |                       |                       |                     |
| <i>Samples were not tested for this group.</i> |        |       |            |                        |                        |                             |                 |              |                       |                       |                     |
| <b>Metals (mg/kg)</b>                          |        |       |            |                        |                        |                             |                 |              |                       |                       |                     |
| Aluminum                                       | 100000 | 7800  | 40041      | 0                      | 0                      | 0                           | 8               | 8            | 8620                  | 29700                 | 51SB2B              |
| Antimony                                       | 41     | 3.1   | na         | 0                      | 5                      | na                          | 6               | 8            | 0.47                  | 6                     | 51SB2B              |
| Arsenic                                        | 1.9    | 0.43  | 15.8       | 0                      | 0                      | 0                           | 8               | 8            | 1                     | 15.3                  | 51SB3B              |
| Barium                                         | 20000  | 1600  | 209        | 0                      | 0                      | 0                           | 8               | 8            | 33.8                  | 177                   | 51SB3B              |
| Beryllium                                      | 200    | 16    | 1.02       | 0                      | 0                      | 1                           | 8               | 8            | 0.33                  | 1.2                   | 51SB2B              |
| Cadmium                                        | 51     | 3.9   | 0.69       | 0                      | 4                      | 5                           | 7               | 8            | 0.13                  | 6.5                   | 51SB2B              |
| Calcium                                        | na     | na    | na         | na                     | na                     | na                          | 8               | 8            | 108                   | 29600                 | 51SB6B              |
| Chromium                                       | 310    | 23    | 65.3       | 4                      | 5                      | 5                           | 8               | 8            | 16.6                  | 533                   | 51SB5B              |
| Cobalt                                         | na     | na    | 72.3       | na                     | na                     | 0                           | 8               | 8            | 3.2                   | 15.2                  | 51SB4C              |
| Copper                                         | 4100   | 310   | 53.5       | 0                      | 1                      | 5                           | 8               | 8            | 5.3                   | 360                   | 51SB6B              |
| Iron                                           | 72000  | 5500  | 50962      | 5                      | 5                      | 5                           | 8               | 8            | 15900                 | 191000                | 51SB2B              |
| Lead                                           | 800    | 400   | 26.8       | 5                      | 5                      | 5                           | 8               | 8            | 10.4                  | 4180                  | 51SB6B              |
| Magnesium                                      | na     | na    | na         | na                     | na                     | na                          | 8               | 8            | 723                   | 4950                  | 51SB6B              |
| Manganese                                      | 2000   | 160   | 2543       | 0                      | 0                      | 0                           | 8               | 8            | 140                   | 506                   | 51SB4C              |
| Mercury                                        | 31     | 2.3   | 0.13       | 0                      | 0                      | 5                           | 5               | 8            | 0.42                  | 1.1                   | 51SB3B              |
| Nickel                                         | 2000   | 160   | 62.8       | 0                      | 0                      | 4                           | 8               | 8            | 5.4                   | 129                   | 51SB2B              |
| Potassium                                      | na     | na    | na         | na                     | na                     | na                          | 8               | 8            | 538                   | 1130                  | 51SB2B              |
| Selenium                                       | 510    | 39    | na         | 0                      | 0                      | na                          | 2               | 8            | 0.17                  | 1.9                   | 51SB2B              |
| Silver                                         | 510    | 39    | na         | 0                      | 0                      | na                          | 5               | 8            | 0.24                  | 0.73                  | 51SB3B              |
| Sodium                                         | na     | na    | na         | na                     | na                     | na                          | 8               | 8            | 192                   | 3060                  | 51SB4B              |
| Thallium                                       | 7.2    | 0.55  | 2.11       | 2                      | 5                      | 5                           | 6               | 8            | 0.98                  | 11.7                  | 51SB2B              |
| Vanadium                                       | 102    | 7.8   | 108        | 0                      | 0                      | 0                           | 8               | 8            | 21.5                  | 59.7                  | 51SB2B              |
| Zinc                                           | 31000  | 2300  | 202        | 0                      | 0                      | 4                           | 8               | 8            | 19                    | 573                   | 51SB6B              |
| <b>Misc. (mg/kg)</b>                           |        |       |            |                        |                        |                             |                 |              |                       |                       |                     |
| Cyanide                                        | 2000   | 160   | na         | 0                      | 0                      | na                          | 7               | 8            | 0.56                  | 22                    | 51SB4B              |
| <b>Dioxins/Furans (ng/kg)</b>                  |        |       |            |                        |                        |                             |                 |              |                       |                       |                     |
| 2,3,7,8-TCDF                                   | na     | na    | na         | na                     | na                     | na                          | 8               | 8            | 0.47                  | 160                   | 51SB3B              |
| 2,3,7,8-TCDD                                   | 19     | 4.3   | na         | 0                      | 1                      | na                          | 5               | 8            | 0.48                  | 4.5                   | 51SB2B              |
| 1,2,3,7,8-PECDD                                | na     | na    | na         | na                     | na                     | na                          | 4               | 8            | 4.6                   | 27                    | 51SB6B              |
| 1,2,3,4,7,8-HXCDD                              | 460    | 100   | na         | 0                      | 0                      | na                          | 5               | 8            | 10                    | 46                    | 51SB6B              |
| 1,2,3,6,7,8-HXCDD                              | 460    | 100   | na         | 0                      | 1                      | na                          | 5               | 8            | 51                    | 120                   | 51SB6B              |
| 1,2,3,7,8,9-HXCDD                              | 460    | 100   | na         | 0                      | 0                      | na                          | 5               | 8            | 24                    | 86                    | 51SB6B              |
| 1,2,3,4,6,7,8-HPCDD                            | na     | na    | na         | na                     | na                     | na                          | 8               | 8            | 6.6                   | 2800                  | 51SB6B              |
| OCDD                                           | na     | na    | na         | na                     | na                     | na                          | 8               | 8            | 130                   | 23000                 | 51SB6B              |
| 1,2,3,7,8-PECDF                                | na     | na    | na         | na                     | na                     | na                          | 5               | 8            | 22                    | 43                    | 51SB4B              |
| 2,3,4,7,8-PECDF                                | na     | na    | na         | na                     | na                     | na                          | 5               | 8            | 49                    | 90                    | 51SB3B              |
| 1,2,3,4,7,8-HXCDF                              | na     | na    | na         | na                     | na                     | na                          | 5               | 8            | 74                    | 130                   | 51SB6B              |
| 1,2,3,6,7,8-HXCDF                              | na     | na    | na         | na                     | na                     | na                          | 5               | 8            | 22                    | 41                    | 51SB6B              |
| 2,3,4,6,7,8-HXCDF                              | na     | na    | na         | na                     | na                     | na                          | 5               | 8            | 26                    | 52                    | 51SB6B              |
| 1,2,3,7,8,9-HXCDF                              | na     | na    | na         | na                     | na                     | na                          | 5               | 8            | 10                    | 17                    | 51SB4B              |
| 1,2,3,4,6,7,8-HPCDF                            | na     | na    | na         | na                     | na                     | na                          | 7               | 8            | 3.5                   | 970                   | 51SB6B              |
| 1,2,3,4,7,8,9-HPCDF                            | na     | na    | na         | na                     | na                     | na                          | 5               | 8            | 31                    | 55                    | 51SB6B              |
| OCDF                                           | na     | na    | na         | na                     | na                     | na                          | 8               | 8            | 3.2                   | 2400                  | 51SB6B              |
| TOTAL TCDD                                     | na     | na    | na         | na                     | na                     | na                          | 3               | 8            | 3.9                   | 8.9                   | 51SB6B              |
| TOTAL PECDD                                    | na     | na    | na         | na                     | na                     | na                          | 4               | 8            | 15                    | 100                   | 51SB6B              |
| TOTAL HXCDD                                    | 460    | 100   | na         | 1                      | 5                      | na                          | 6               | 8            | 1.5                   | 780                   | 51SB6B              |
| TOTAL HPCDD                                    | na     | na    | na         | na                     | na                     | na                          | 8               | 8            | 12                    | 4900                  | 51SB6B              |
| TOTAL TCDF                                     | na     | na    | na         | na                     | na                     | na                          | 8               | 8            | 1                     | 690                   | 51SB2B              |
| TOTAL PECDF                                    | na     | na    | na         | na                     | na                     | na                          | 6               | 8            | 1.4                   | 600                   | 51SB5B              |
| TOTAL HXCDF                                    | na     | na    | na         | na                     | na                     | na                          | 7               | 8            | 4.1                   | 1400                  | 51SB6B              |
| TOTAL HPCDF                                    | na     | na    | na         | na                     | na                     | na                          | 7               | 8            | 12                    | 2900                  | 51SB6B              |

**PAHs.** Ten PAHs were detected in one sample (51SB6B) collected from the sludge material. One PAH [benzo(a)pyrene] was found to exceed industrial screening levels in 51SB6B. Three other PAHs [benz(a)anthracene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene] also exceeded residential screening levels in 51SB6B.

**SVOCs.** Ten SVOCs were detected in samples collected in these samples. Concentrations of 2,4-DNT and 2,6-DNT exceeded industrial screening levels in six and seven samples, respectively; however, because these compounds are explosives and were analyzed using a more sensitive analytical method, these compounds will be discussed under “*Explosives*.”

**Pesticides.** Pesticides were not analyzed for in these samples.

**PCBs.** PCBs were not detected in the soil samples.

**Explosives.** Thirteen explosives were detected in this group of samples. Seven of these explosives (1,3-DNB, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, 2- and 4-nitrotoluene, and NG) were detected at concentrations exceeding industrial screening levels. Two other explosives [1,3,5-trinitrobenzene (1,3,5-TNB) and 2-amino-4,6-DNT] exceeded residential screening levels in two of the eight samples.

**Herbicides.** Herbicides were not analyzed for in these samples.

**TAL Inorganics.** Twenty-three metals were detected in these samples. Four metals (chromium, iron, lead, and thallium) were detected at concentrations exceeding industrial screening levels. Three other metals (antimony, cadmium, and copper) were detected above residential screening levels in the samples. Cyanide was detected in seven of the eight samples at concentrations below residential screening levels.

**Dioxins/Furans.** Seventeen dioxins/furan congeners were detected in the samples. Of these congeners that have an associated RBC, 2,3,7,8-TCDD and 1,2,3,6,7,8-HXCDD were detected at concentrations exceeding their residential screening levels. Total HXCDD was above its industrial screening level in one sample and above its residential screening level in four additional samples.

**Soil Below Sludge Material and/or Deep Soil.** Thirteen soil samples were collected from soil below the trench sludge material and/or deep soil at the site. Detected constituents are presented in **Tables 4-7 and 4-8** (dioxins/furans) and summarized in **Table 4-9**. Exceedances of regulatory screening levels and background are presented on **Figure 4-1**. The vertical distribution of explosive compounds 2,4-DNT, 2,6-DNT, and 2,4,6,-TNT is illustrated on **Figure 4-2**.

**VOCs.** Six VOCs were detected in the soil samples. Concentrations were below residential screening levels.

**PAHs.** Three PAHs were detected in these samples. Concentrations were below residential screening levels.

**SVOCs.** Seven SVOCs were detected in soil below the trench sludge material and/or deep soil. Concentrations of 2,4-DNT and 2,6-DNT exceeded residential screening levels in two samples; however, because these compounds are explosives and were analyzed using a more sensitive analytical method, these compounds will be discussed under “*Explosives*.”

**Pesticides.** Pesticides were not analyzed for in these samples.

Table 4-7  
Analytes Detected in Soil Below Sludge Material and/or Deep Soil  
Page 1 of 2

| Analyte                                 | Sample ID<br>Sample Date<br>Sample Depth |          |            | 51SB1C<br>4/7/04<br>35-37 |       |       |       |      | 51SB2D<br>4/6/04<br>33-35 |       |       |        |       | 51SB3D<br>4/5/04<br>36-38 |       |       |        |       | 51SB4D<br>4/1/04<br>36-38 |       |       |        |       | 51SB5C<br>4/1/04<br>16-18 |       |       |        |      | 51SB5D<br>4/1/04<br>31-33 |       |       |        |      | 51SB6C<br>3/30/04<br>9-11 |       |       |        |      |
|-----------------------------------------|------------------------------------------|----------|------------|---------------------------|-------|-------|-------|------|---------------------------|-------|-------|--------|-------|---------------------------|-------|-------|--------|-------|---------------------------|-------|-------|--------|-------|---------------------------|-------|-------|--------|------|---------------------------|-------|-------|--------|------|---------------------------|-------|-------|--------|------|
|                                         | 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  |
| VOCs (ug/kg)                            |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| 2-Butanone                              | 61000000                                 | 47000000 | na         | 11                        | U     | R     | 2.6   | 11   | 11                        | U     | R     | 2.6    | 11    | 10                        | U     | R     | 2.5    | 10    | 11                        | U     | R     | 2.7    | 11    | 11                        | U     | R     | 2.6    | 11   | 11                        | U     | R     | 2.7    | 11   | 9.4                       | JB    | B     | 2.5    | 11   |
| 4-Methyl-2-pentanone                    | 82000000                                 | 6300000  | na         | 11                        | U     |       | 1.5   | 11   | 11                        | U     |       | 1.5    | 11    | 10                        | U     |       | 1.4    | 10    | 11                        | U     | UL    | 1.5    | 11    | 4.4                       | J     | J     | 1.5    | 11   | 11                        | U     | UL    | 1.6    | 11   | 11                        | U     |       | 1.5    | 11   |
| Acetone                                 | 92000000                                 | 70000000 | na         | 6.3                       | JB    | B     | 3     | 11   | 15                        | B     | B     | 3      | 11    | 9.6                       | J     | B     | 2.9    | 10    | 7.5                       | J     | B     | 3.1    | 11    | 15                        |       | B     | 3      | 11   | 5.7                       | J     | B     | 3.1    | 11   | 12                        |       | B     | 2.9    | 11   |
| Chloromethane                           | na                                       | na       | na         | 11                        | U     |       | 1.1   | 11   | 11                        | U     |       | 1.1    | 11    | 10                        | U     |       | 1      | 10    | 11                        | U     |       | 1.1    | 11    | 11                        | U     |       | 1.1    | 11   | 11                        | U     |       | 1.1    | 11   | 11                        | U     |       | 1      | 11   |
| Methylene chloride                      | 380000                                   | 85000    | na         | 11                        | U     |       | 1.2   | 11   | 4.1                       | JB    | B     | 1.2    | 11    | 2.8                       | JB    | B     | 1.2    | 10    | 11                        | U     |       | 1.3    | 11    | 11                        | U     |       | 1.2    | 11   | 11                        | U     |       | 1.3    | 11   | 2                         | JB    | B     | 1.2    | 11   |
| Styrene                                 | 20000000                                 | 1600000  | na         | 5.4                       | U     |       | 1.4   | 5.4  | 5.4                       | U     |       | 1.4    | 5.4   | 5.2                       | U     |       | 1.4    | 5.2   | 5.6                       | U     |       | 1.5    | 5.6   | 5.4                       | U     |       | 1.4    | 5.4  | 5.7                       | U     |       | 1.5    | 5.7  | 2.6                       | JB    | B     | 1.4    | 5.3  |
| PAHs (ug/kg)                            |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| Fluoranthene                            | 4100000                                  | 310000   | na         | 7.7                       | U     |       | 7.7   | 7.7  | 8                         | U     |       | 8      | 8     | 8.1                       | U     |       | 8.1    | 8.1   | 7.9                       | U     |       | 1.6    | 7.9   | 7.2                       | U     |       | 1.5    | 7.2  | 8.5                       | U     |       | 1.7    | 8.5  | 8.1                       | U     |       | 8.1    | 8.1  |
| Phenanthrene                            | 3100000                                  | 230000   | na         | 7.7                       | U     |       | 7.7   | 7.7  | 14                        |       | J     | 8      | 8     | 10                        |       | J     | 8.1    | 8.1   | 9.9                       |       |       | 0.79   | 7.9   | 18                        |       |       | 0.72   | 7.2  | 15                        |       |       | 0.85   | 8.5  | 8.1                       | U     |       | 8.1    | 8.1  |
| Pyrene                                  | 3100000                                  | 230000   | na         | 7.7                       | U     |       | 7.7   | 7.7  | 8                         | U     |       | 8      | 8     | 8.1                       | U     |       | 8.1    | 8.1   | 7.9                       | U     |       | 0.79   | 7.9   | 7.2                       | U     |       | 0.72   | 7.2  | 8.5                       | U     |       | 0.85   | 8.5  | 8.1                       | U     |       | 8.1    | 8.1  |
| SVOCs (ug/kg)                           |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| 2,4-Dinitrotoluene                      | 200000                                   | 16000    | na         | 230                       | J     | B     | 60    | 380  | 1800                      |       | B     | 62     | 400   | 32000                     | E     | J     | 63     | 410   | 5400                      |       |       | 62     | 400   | 44000                     |       |       | 560    | 3600 | 11000                     |       |       | 330    | 2100 | 140                       | J     | J     | 63     | 410  |
| 2,6-Dinitrotoluene                      | 100000                                   | 7800     | na         | 4600                      |       |       | 41    | 380  | 4900                      |       |       | 43     | 400   | 11000                     | E     | J     | 44     | 410   | 2900                      |       |       | 42     | 400   | 11000                     |       |       | 390    | 3600 | 4400                      |       |       | 45     | 420  | 140                       | J     | J     | 43     | 410  |
| 2-Nitroaniline                          | na                                       | na       | na         | 380                       | U     |       | 68    | 380  | 400                       | U     |       | 71     | 400   | 410                       | U     |       | 72     | 410   | 400                       | U     |       | 70     | 400   | 360                       | U     |       | 64     | 360  | 420                       | U     |       | 75     | 420  | 410                       | U     |       | 72     | 410  |
| 4,6-Dinitro-2-methylphenol              | na                                       | na       | na         | 770                       | U     |       | 110   | 770  | 150                       | J     | J     | 120    | 800   | 330                       | J     | J     | 120    | 810   | 790                       | U     |       | 120    | 790   | 200                       | J     | J     | 100    | 720  | 140                       | J     | J     | 120    | 850  | 810                       | U     |       | 120    | 810  |
| bis(2-Ethylhexyl)phthalate              | 200000                                   | 46000    | na         | 380                       | U     |       | 42    | 380  | 400                       | U     |       | 44     | 400   | 410                       | U     |       | 45     | 410   | 400                       | U     |       | 44     | 400   | 67                        | J     | J     | 40     | 360  | 420                       | U     |       | 47     | 420  | 55                        | J     | J     | 45     | 410  |
| Diethylphthalate                        | 82000000                                 | 6300000  | na         | 380                       | U     |       | 210   | 380  | 400                       | U     |       | 220    | 400   | 410                       | U     |       | 230    | 410   | 400                       | U     |       | 220    | 400   | 360                       | U     |       | 200    | 360  | 420                       | U     |       | 230    | 420  | 410                       | U     |       | 220    | 410  |
| Di-n-butylphthalate                     | 10000000                                 | 780000   | na         | 380                       | U     |       | 49    | 380  | 400                       | U     |       | 51     | 400   | 410                       | U     |       | 52     | 410   | 400                       | U     |       | 51     | 400   | 83                        | J     | B     | 46     | 360  | 150                       | J     | B     | 54     | 420  | 410                       | U     |       | 52     | 410  |
| Pesticides (ug/kg)                      |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| Samples were not tested for this group. |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| PCBs (mg/kg)                            |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| None detected                           |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| Explosives (mg/kg)                      |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| 1,3,5-Trinitrobenzene                   | 3100                                     | 230      | na         | 0.04                      | J     | L     | 0.025 | 0.1  | 3.7                       |       | J     | 0.025  | 0.1   | 2.9                       |       | J     | 0.025  | 0.1   | 1.6                       |       | J     | 0.025  | 0.1   | 5.2                       |       | J     | 0.025  | 0.1  | 5.7                       |       |       | 0.025  | 0.1  | 4                         |       |       | 0.025  | 0.1  |
| 1,3-Dinitrobenzene                      | 10                                       | 0.78     | na         | 0.1                       | U     |       | 0.01  | 0.1  | 0.32                      |       | J     | 0.01   | 0.1   | 0.13                      |       | J     | 0.01   | 0.1   | 0.09                      | J     | J     | 0.01   | 0.1   | 0.1                       | U     | UL    | 0.01   | 0.1  | 0.06                      | J     | J     | 0.01   | 0.1  | 0.1                       | U     |       | 0.01   | 0.1  |
| 2,4,6-Trinitrotoluene                   | 51                                       | 3.9      | na         | 0.3                       |       | L     | 0.03  | 0.1  | 1.5                       |       | L     | 0.03   | 0.1   | 4.7                       |       |       | 0.03   | 0.1   | 5.3                       |       |       | 0.03   | 0.1   | 8                         |       | L     | 0.03   | 0.1  | 8.9                       |       | J     | 0.03   | 0.1  | 18                        |       |       | 0.026  | 0.1  |
| 2,4-Dinitrotoluene                      | 200                                      | 16       | na         | 0.03                      | J     | J     | 0.055 | 0.1  | 2.3                       |       |       | 0.055  | 0.1   | 42                        |       |       | 0.1    | 0.2   | 9.7                       |       |       | 0.055  | 0.1   | 29                        |       | L     | 0.055  | 0.1  | 15                        |       | J     | 0.055  | 0.1  | 0.1                       | U     |       | 0.03   | 0.1  |
| 2,6-Dinitrotoluene                      | 100                                      | 7.8      | na         | 0.1                       | U     |       | 0.1   | 0.1  | 4.6                       |       | J     | 0.1    | 0.1   | 11                        |       | J     | 0.1    | 0.1   | 4                         |       | J     | 0.1    | 0.1   | 5.7                       |       | J     | 0.1    | 0.1  | 6.1                       |       | J     | 0.1    | 0.1  | 0.1                       | U     |       | 0.055  | 0.1  |
| 2-Nitrotoluene                          | 1000                                     | 78       | na         | 0.18                      | J     | J     | 0.2   | 0.2  | 1.4                       |       |       | 0.2    | 0.2   | 17                        |       | J     | 0.2    | 0.2   | 36                        |       | J     | 0.2    | 0.2   | 34                        |       | L     | 0.2    | 0.2  | 31                        |       |       | 0.2    | 0.2  | 0.2                       | U     |       | 0.15   | 0.2  |
| 3-Nitrotoluene                          | na                                       | na       | na         | 0.2                       | U     |       | 0.1   | 0.2  | 0.22                      |       | J     | 0.1    | 0.2   | 1.7                       |       | J     | 0.1    | 0.2   | 3.2                       |       | J     | 0.1    | 0.2   | 2.7                       |       | J     | 0.1    | 0.2  | 2.3                       |       | J     | 0.1    | 0.2  | 0.2                       | U     |       | 0.075  | 0.2  |
| 4-Nitrotoluene                          | 180                                      | 31       | na         | 0.2                       | U     |       | 0.1   | 0.2  | 0.91                      |       | J     | 0.1    | 0.2   | 9.4                       |       | J     | 0.1    | 0.2   | 22                        |       | J     | 0.1    | 0.2   | 20                        |       | J     | 0.1    | 0.2  | 14                        |       | J     | 0.1    | 0.2  | 0.2                       | U     |       | 0.074  | 0.2  |
| Nitrobenzene                            | 51                                       | 3.9      | na         | 0.16                      |       |       | 0.037 | 0.1  | 0.13                      |       | J     | 0.039  | 0.1   | 0.1                       | U     |       | 0.038  | 0.1   | 0.1                       | U     |       | 0.038  | 0.1   | 0.1                       | U     | UL    | 0.035  | 0.1  | 0.1                       | U     |       | 0.041  | 0.1  | 0.1                       | U     |       | 0.032  | 0.1  |
| RDX                                     | 26                                       | 5.8      | na         | 0.2                       | U     |       | 0.1   | 0.2  | 4                         |       | J     | 0.1    | 0.2   | 7.2                       |       | J     | 0.1    | 0.2   | 4.7                       |       | J     | 0.1    | 0.2   | 0.2                       | U     | UL    | 0.1    | 0.2  | 2.4                       |       | J     | 0.1    | 0.2  | 0.2                       | U     |       | 0.076  | 0.2  |
| Nitroglycerin                           | 10                                       | 0.78     | na         | 5.8                       | U     |       | 0.58  | 5.8  | 6                         | U     |       | 0.6    | 6     | 6.1                       | U     |       | 0.61   | 6.1   | 6                         | U     |       | 0.6    | 6     | 5.4                       | U     |       | 0.54   | 5.4  | 6.4                       | U     |       | 0.64   | 6.4  | 6.1                       | U     |       | 0.61   | 6.1  |
| Herbicides (ug/kg)                      |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| Samples were not tested for this group. |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| Metals (mg/kg)                          |                                          |          |            |                           |       |       |       |      |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                           |       |       |        |      |                           |       |       |        |      |                           |       |       |        |      |
| Aluminum                                | 100000                                   | 7800     | 40041      | 27700                     |       |       | 1.2   | 18.4 | 22800                     |       |       | 1.7    | 19.7  | 18800                     |       |       | 1.6    | 19.1  | 22600                     |       |       | 1.6    | 18.6  | 8650                      |       |       | 1.5    | 17.8 | 10200                     |       |       | 1.7    | 20.5 | 17600                     |       |       | 1.5    | 17.8 |
| Antimony                                | 41                                       | 3.1      | na         | 0.3                       | UN    |       | 0.3   | 1.8  | 0.82                      | BN    | B     | 0.49   | 2     | 0.48                      | UN    |       | 0.48   | 1.9   | 0.53                      | BN    | B     | 0.47   | 1.9   | 0.8                       | BN    | B     | 0.44   | 1.8  | 0.8                       | BN    | B     | 0.51   | 2.1  | 0.5                       | BN    | J     | 0.44   | 1.8  |
| Arsenic                                 | 1.9                                      | 0.43     | 15.8       | 2.2                       |       |       | 0.35  | 1.8  | 1.4                       | B     | B     | 0.2    | 2     | 1.2                       | B     | B     | 0.19   | 1.9   | 0.96                      | B     | J     | 0.19   | 1.9   | 1.5                       | B     | J     | 0.18   | 1.8  | 7.4                       |       | J     | 0.21   | 2.1  | 1.6                       | B     | J     | 0.18   | 1.8  |
| Barium                                  | 20000                                    | 1600     | 209        | 80.4                      |       |       | 0.015 | 0.46 | 76.5                      |       |       | 0.031  | 0.49  | 106                       | N     |       | 0.031  | 0.48  | 167                       |       |       | 0.03   | 0.47  | 26.3                      |       |       | 0.028  | 0.44 | 52.9                      |       |       | 0.033  | 0.51 | 36.2                      |       |       | 0.028  | 0.44 |
| Beryllium                               | 200                                      | 16       | 1.02       | 1.5                       |       |       | 0.012 | 0.18 | 1.3                       |       |       | 0.0056 | 0.2   | 1.1                       |       |       | 0.0054 | 0.19  | 0.72                      |       |       | 0.0053 | 0.19  | 0.43                      |       |       | 0.0051 | 0.18 | 2.3                       |       |       | 0.0058 | 0.21 | 0.5                       |       |       | 0.0051 | 0.18 |
| Cadmium                                 | 51                                       | 3.9      | 0.69       | 0.43                      | B     | J     | 0.032 | 0.55 | 0.19                      | B     | J     | 0.043  | 0.59  | 0.32                      | B     | J     | 0.042  | 0.57  | 0.22                      | B     | J     | 0.041  | 0.56  | 0.04                      | B     | B     | 0.039  | 0.53 | 0.23                      | B     | J     | 0.045  | 0.62 | 0.039                     | U     |       | 0.039  | 0.53 |
| Calcium                                 | na                                       | na       | na         | 1220                      |       |       | 7.1   | 92.2 | 575                       |       |       | 7.5    | 98.3  | 1100                      |       |       | 7.2    | 95.4  | 1750                      |       |       | 7      | 92.9  | 37.3                      | B     | B     | 6.7    | 88.8 | 309                       |       |       | 7.8    | 103  | 639                       |       |       | 6.7    | 88.8 |
| Chromium                                | 310                                      | 23       | 65.3       | 47.7                      |       |       | 0.042 | 0.46 | 35.4                      | *     |       | 0.12   | 0.49  | 39.1                      | N     |       | 0.11   | 0.48  | 37                        |       |       | 0.11   | 0.47  | 10.8                      |       |       | 0.11   | 0.44 | 11.5                      |       | J     | 0.12   | 0.51 | 13.4                      | *     |       | 0.11   | 0.44 |
| Cobalt                                  | na                                       | na       | 72.3       | 6.5                       |       |       | 0.08  | 0.46 | 5.2                       |       |       | 0.079  | 0.49  | 95.1                      |       |       | 0.076  | 0.48  | 4.6                       |       |       | 0.074  | 0.47  | 6.1                       |       |       | 0.071  | 0.44 | 90.7                      |       | J     | 0.082  | 0.51 | 10.9                      |       |       | 0.071  | 0.44 |
| Copper                                  | 4100                                     | 310      | 53.5       | 1.3                       | B     |       | 0.081 | 0.92 | 1.2                       |       | B     | 0.093  | 0.98  | 92.9                      |       |       | 0.091  | 0.95  | 0.59                      | BE    | B     | 0.088  | 0.93  | 4.1                       | E     |       | 0.084  | 0.89 | 12.5                      | E     | J     | 0.097  | 1    | 7.3                       |       |       | 0.084  | 0.89 |
| Iron                                    | 72000                                    | 5500     | 50962      | 37800                     |       |       | 3     | 13.8 | 34500                     |       |       | 3.9    | 14.7  | 31100                     |       |       | 3.8    | 14.3  | 29200                     |       |       | 3.7    | 13.9  | 12500                     |       |       | 3.5    | 13.3 | 44400                     |       |       | 4      | 15.4 | 21400                     |       |       | 3.5    | 13.3 |
| Lead                                    | 800                                      | 400      | 26.8       | 0.8                       | B     | J     | 0.12  | 0.92 | 0.75                      | B     | J     | 0.21   | 0.98  | 1.4                       |       | B     | 0.2    | 0.95  | 0.82                      | B*    | B     | 0.2    | 0.93  | 5.3                       | *     |       | 0.19   | 0.89 | 18.3                      | *     | J     | 0.22   | 1    | 9.7                       |       |       | 0.19   | 0.89 |
| Magnesium                               | na                                       | na       | na         | 22200                     |       |       | 0.86  | 23.1 | 17300                     | N     |       | 2.5    | 24.6  | 15200                     | N     |       | 2.4    | 23.8  | 18300                     |       |       | 2.4    | 23.2  | 548                       | N     |       | 2.3    | 22.2 | 2150                      | N     | J     | 2.6    | 25.6 | 950                       | N     |       | 2.3    | 22.2 |
| Manganese                               | 2000                                     | 160      | 2543       | 354                       |       |       | 0.015 | 0.46 | 458                       |       |       | 0.025  | 0.49  | 331                       |       |       | 0.024  | 0.48  | 221                       | *     |       | 0.023  | 0.47  | 254                       | *     |       | 0.022  | 0.44 | 945                       | *     | J     | 0.026  | 0.51 | 335                       |       |       | 0.022  | 0.44 |
| Mercury                                 | 31                                       | 2.3      | 0.13       | 0.015                     | U     |       | 0.015 | 0.03 | 0.017                     | U     |       | 0.017  | 0.033 | 0.017                     | U     |       | 0.017  | 0.033 | 0.016                     | U     |       | 0.016  | 0.032 | 0.015                     | U     |       | 0.015  |      |                           |       |       |        |      |                           |       |       |        |      |

Table 4-7  
Analytes Detected in Soil Below Sludge Material and/or Deep Soil  
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| Analyte                    | Sample ID<br>Sample Date<br>Sample Depth |         |            | 51SB6D<br>3/30/04<br>33-35 |       |       |        |       | 51SB7C<br>3/30/04<br>32-34 |       |       |        |       | 51SB8C<br>4/1/04<br>36-38 |       |       |        |       | 51SB9C<br>4/5/04<br>33-35 |       |       |        |       | 51SB10C<br>4/1/04<br>30-32 |       |       |       |       | 51SB11C<br>4/5/04<br>36-38 |       |       |        |       |
|----------------------------|------------------------------------------|---------|------------|----------------------------|-------|-------|--------|-------|----------------------------|-------|-------|--------|-------|---------------------------|-------|-------|--------|-------|---------------------------|-------|-------|--------|-------|----------------------------|-------|-------|-------|-------|----------------------------|-------|-------|--------|-------|
|                            | 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)               |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| 2-Butanone                 | 61000000                                 | 4700000 | na         | 6.9                        | JB    | B     | 2.3    | 9.8   | 10                         | U     | R     | 2.4    | 10    | 12                        | U     | UJ    | 2.9    | 12    | 11                        | U     | R     | 2.6    | 11    | 9.3                        | U     | R     | 2.3   | 9.9   | 9.8                        | U     | R     | 2.3    | 9.8   |
| 4-Methyl-2-pentanone       | 8200000                                  | 630000  | na         | 9.8                        | U     |       | 1.3    | 9.8   | 10                         | U     |       | 1.4    | 10    | 12                        | U     | UJ    | 1.7    | 12    | 11                        | U     |       | 1.5    | 11    | 9.9                        | U     | UL    | 1.4   | 9.9   | 9.8                        | U     |       | 1.3    | 9.8   |
| Acetone                    | 92000000                                 | 7000000 | na         | 7.1                        | J     | B     | 2.7    | 9.8   | 10                         | U     |       | 2.8    | 10    | 21                        |       | B     | 3.3    | 12    | 6.5                       | JB    | B     | 3.1    | 11    | 9.9                        | U     |       | 2.7   | 9.9   | 9.8                        | U     |       | 2.7    | 9.8   |
| Chloromethane              | na                                       | na      | na         | 2.8                        | J     | J     | 0.95   | 9.8   | 10                         | U     |       | 0.99   | 10    | 12                        | U     | UJ    | 1.2    | 12    | 11                        | U     |       | 1.1    | 11    | 9.9                        | U     |       | 0.96  | 9.9   | 9.8                        | U     |       | 0.95   | 9.8   |
| Methylene chloride         | 380000                                   | 85000   | na         | 1.9                        | JB    | B     | 1.1    | 9.8   | 1.6                        | JB    | B     | 1.2    | 10    | 2.4                       | JB    | B     | 1.4    | 12    | 4.2                       | JB    | B     | 1.3    | 11    | 9.9                        | U     |       | 1.1   | 9.9   | 2.3                        | JB    | B     | 1.1    | 9.8   |
| Styrene                    | 20000000                                 | 1600000 | na         | 2.3                        | JB    | B     | 1.3    | 4.9   | 2.3                        | JB    | B     | 1.3    | 5.1   | 6.1                       | U     | UJ    | 1.6    | 6.1   | 5.6                       | U     |       | 1.5    | 5.6   | 4.9                        | U     |       | 1.3   | 4.9   | 4.9                        | U     |       | 1.3    | 4.9   |
| PAHs (ug/kg)               |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| Fluoranthene               | 4100000                                  | 310000  | na         | 12                         |       |       | 8      | 8     | 8.1                        | U     |       | 8.1    | 8.1   | 9                         | U     |       | 1.8    | 9     | 7.9                       | U     |       | 7.9    | 7.9   | 7.7                        | U     |       | 1.5   | 7.7   | 7.7                        | U     |       | 7.7    | 7.7   |
| Phenanthrene               | 3100000                                  | 230000  | na         | 13                         |       |       | 8      | 8     | 9.7                        |       |       | 8.1    | 8.1   | 9                         | U     |       | 0.9    | 9     | 9.1                       |       | J     | 7.9    | 7.9   | 18                         |       |       | 0.77  | 7.7   | 13                         |       | J     | 7.7    | 7.7   |
| Pyrene                     | 3100000                                  | 230000  | na         | 10                         |       |       | 8      | 8     | 8.1                        | U     |       | 8.1    | 8.1   | 9                         | U     |       | 0.9    | 9     | 7.9                       | U     |       | 7.9    | 7.9   | 7.7                        | U     |       | 0.77  | 7.7   | 7.7                        | U     |       | 7.7    | 7.7   |
| SVOCs (ug/kg)              |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| 2,4-Dinitrotoluene         | 200000                                   | 16000   | na         | 570                        |       |       | 63     | 400   | 400                        | U     |       | 63     | 400   | 2500                      |       |       | 70     | 450   | 230                       | J     | B     | 62     | 400   | 390                        | U     |       | 60    | 390   | 270                        | J     | B     | 60     | 380   |
| 2,6-Dinitrotoluene         | 100000                                   | 7800    | na         | 2300                       |       |       | 43     | 400   | 400                        | U     |       | 43     | 400   | 2300                      |       |       | 48     | 450   | 70                        | J     | B     | 42     | 400   | 390                        | U     |       | 41    | 390   | 57                         | J     | B     | 41     | 380   |
| 2-Nitroaniline             | na                                       | na      | na         | 77                         | J     | J     | 71     | 400   | 400                        | U     |       | 71     | 400   | 450                       | U     |       | 79     | 450   | 400                       | U     |       | 70     | 400   | 390                        | U     |       | 68    | 390   | 380                        | U     |       | 68     | 380   |
| 4,6-Dinitro-2-methylphenol | na                                       | na      | na         | 800                        | U     | UJ    | 120    | 800   | 810                        | U     |       | 120    | 810   | 900                       | U     |       | 130    | 900   | 790                       | U     |       | 120    | 790   | 770                        | U     |       | 110   | 770   | 770                        | U     |       | 110    | 770   |
| bis(2-Ethylhexyl)phthalate | 200000                                   | 46000   | na         | 48                         | J     | J     | 44     | 400   | 82                         | J     | J     | 44     | 400   | 450                       | U     |       | 49     | 450   | 400                       | U     |       | 44     | 400   | 390                        | U     |       | 42    | 390   | 380                        | U     |       | 42     | 380   |
| Diethylphthalate           | 82000000                                 | 6300000 | na         | 1600                       |       |       | 220    | 400   | 400                        | U     |       | 220    | 400   | 450                       | U     |       | 250    | 450   | 400                       | U     |       | 220    | 400   | 390                        | U     |       | 210   | 390   | 380                        | U     |       | 210    | 380   |
| Di-n-butylphthalate        | 10000000                                 | 780000  | na         | 400                        | U     |       | 51     | 400   | 400                        | U     |       | 52     | 400   | 450                       | U     |       | 57     | 450   | 400                       | U     |       | 51     | 400   | 390                        | U     |       | 49    | 390   | 380                        | U     |       | 49     | 380   |
| Pesticides (ug/kg)         |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| Samples were not tested    |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| PCBs (mg/kg)               |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| None detected              |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| Explosives (mg/kg)         |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| 1,3,5-Trinitrobenzene      | 3100                                     | 230     | na         | 18                         |       |       | 0.025  | 0.1   | 0.1                        | J     | J     | 0.025  | 0.1   | 6                         |       | J     | 0.025  | 0.1   | 1.4                       |       | J     | 0.025  | 0.1   | 0.1                        | U     |       | 0.025 | 0.1   | 0.1                        | U     |       | 0.025  | 0.1   |
| 1,3-Dinitrobenzene         | 10                                       | 0.78    | na         | 0.23                       |       | J     | 0.01   | 0.1   | 0.1                        | U     |       | 0.01   | 0.1   | 0.1                       | U     |       | 0.01   | 0.1   | 0.26                      |       | J     | 0.01   | 0.1   | 0.1                        | U     |       | 0.01  | 0.1   | 0.1                        | U     |       | 0.01   | 0.1   |
| 2,4,6-Trinitrotoluene      | 51                                       | 3.9     | na         | 22                         |       | L     | 0.026  | 0.1   | 0.41                       |       |       | 0.026  | 0.1   | 1.2                       |       | J     | 0.03   | 0.1   | 0.39                      |       | L     | 0.03   | 0.1   | 0.98                       |       |       | 0.03  | 0.1   | 5.2                        |       |       | 0.03   | 0.1   |
| 2,4-Dinitrotoluene         | 200                                      | 16      | na         | 0.78                       |       | J     | 0.03   | 0.1   | 0.1                        | U     |       | 0.03   | 0.1   | 4.3                       |       |       | 0.055  | 0.1   | 0.23                      |       |       | 0.055  | 0.1   | 2.3                        |       |       | 0.055 | 0.1   | 1.6                        |       |       | 0.055  | 0.1   |
| 2,6-Dinitrotoluene         | 100                                      | 7.8     | na         | 4                          |       |       | 0.055  | 0.1   | 0.1                        | U     |       | 0.055  | 0.1   | 2.2                       |       | J     | 0.1    | 0.1   | 0.34                      |       | B     | 0.1    | 0.1   | 1.5                        |       | J     | 0.1   | 0.1   | 1.2                        |       | B     | 0.1    | 0.1   |
| 2-Nitrotoluene             | 1000                                     | 78      | na         | 9.1                        |       |       | 0.15   | 0.2   | 0.2                        | U     |       | 0.15   | 0.2   | 0.17                      | J     | J     | 0.2    | 0.2   | 1.7                       |       |       | 0.2    | 0.2   | 93                         |       |       | 0.3   | 0.4   | 81                         |       |       | 0.3    | 0.4   |
| 3-Nitrotoluene             | na                                       | na      | na         | 0.66                       |       | J     | 0.075  | 0.2   | 0.2                        | U     |       | 0.075  | 0.2   | 0.2                       | U     |       | 0.1    | 0.2   | 0.25                      |       | J     | 0.1    | 0.2   | 8.2                        |       | J     | 0.1   | 0.2   | 6.3                        |       | J     | 0.1    | 0.2   |
| 4-Nitrotoluene             | 180                                      | 31      | na         | 3.4                        |       | J     | 0.074  | 0.2   | 0.2                        | U     |       | 0.074  | 0.2   | 0.24                      |       | J     | 0.1    | 0.2   | 0.93                      |       | J     | 0.1    | 0.2   | 45                         |       |       | 0.2   | 0.4   | 35                         |       | J     | 0.1    | 0.2   |
| Nitrobenzene               | 51                                       | 3.9     | na         | 0.1                        | U     |       | 0.032  | 0.1   | 0.1                        | U     |       | 0.032  | 0.1   | 0.1                       | U     |       | 0.043  | 0.1   | 0.14                      |       |       | 0.038  | 0.1   | 0.1                        | U     |       | 0.037 | 0.1   | 0.07                       | J     | J     | 0.037  | 0.1   |
| RDX                        | 26                                       | 5.8     | na         | 7.2                        |       | J     | 0.076  | 0.2   | 0.2                        | U     |       | 0.076  | 0.2   | 4.4                       |       | J     | 0.1    | 0.2   | 0.88                      |       | J     | 0.1    | 0.2   | 2.1                        |       | J     | 0.1   | 0.2   | 0.3                        |       | J     | 0.1    | 0.2   |
| Nitroglycerin              | 10                                       | 0.78    | na         | 6.7                        |       | J     | 0.6    | 6     | 6                          | U     |       | 0.6    | 6     | 6.7                       | U     |       | 0.67   | 6.7   | 6                         | U     |       | 0.6    | 6     | 5.8                        | U     |       | 0.58  | 5.8   | 5.8                        | U     |       | 0.58   | 5.8   |
| Herbicides (ug/kg)         |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| Samples were not tested    |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| Metals (mg/kg)             |                                          |         |            |                            |       |       |        |       |                            |       |       |        |       |                           |       |       |        |       |                           |       |       |        |       |                            |       |       |       |       |                            |       |       |        |       |
| Aluminum                   | 100000                                   | 7800    | 40041      | 11600                      |       |       | 1.6    | 18.8  | 16400                      |       |       | 1.4    | 16.8  | 14300                     |       |       | 3      | 34.7  | 21900                     |       |       | 1.5    | 18    | 16100                      |       |       | 1.5   | 17.4  | 19700                      |       |       | 1.5    | 17.3  |
| Antimony                   | 41                                       | 3.1     | na         | 0.47                       | UN    |       | 0.47   | 1.9   | 0.42                       | UN    |       | 0.42   | 1.7   | 0.87                      | UN    |       | 0.87   | 3.5   | 0.45                      | UN    |       | 0.45   | 1.8   | 0.52                       | BN    | B     | 0.44  | 1.7   | 0.43                       | UN    |       | 0.43   | 1.7   |
| Arsenic                    | 1.9                                      | 0.43    | 15.8       | 5                          |       |       | 0.19   | 1.9   | 2.1                        |       |       | 0.17   | 1.7   | 6                         |       |       | 0.17   | 1.7   | 2.2                       |       | B     | 0.18   | 1.8   | 1.3                        | B     | J     | 0.17  | 1.7   | 3.1                        |       | 0.17  | 1.7    |       |
| Barium                     | 20000                                    | 1600    | 209        | 45.5                       |       |       | 0.03   | 0.47  | 51.6                       |       |       | 0.027  | 0.42  | 69.2                      |       |       | 0.056  | 0.87  | 73.5                      |       |       | 0.029  | 0.45  | 61.7                       |       |       | 0.028 | 0.44  | 66.7                       | N     |       | 0.028  | 0.43  |
| Beryllium                  | 200                                      | 16      | 1.02       | 2.1                        |       |       | 0.0054 | 0.19  | 1                          |       |       | 0.0048 | 0.17  | 1.1                       |       |       | 0.0049 | 0.17  | 0.93                      |       |       | 0.0051 | 0.18  | 1.7                        |       |       | 0.005 | 0.17  | 2.5                        |       |       | 0.0049 | 0.17  |
| Cadmium                    | 51                                       | 3.9     | 0.69       | 0.041                      | U     |       | 0.041  | 0.56  | 0.037                      | U     |       | 0.037  | 0.5   | 0.8                       | B     | J     | 0.076  | 1     | 0.04                      | U     |       | 0.04   | 0.54  | 0.038                      | U     |       | 0.038 | 0.52  | 0.53                       |       |       | 0.038  | 0.52  |
| Calcium                    | na                                       | na      | na         | 422                        |       |       | 7.1    | 93.9  | 310                        |       |       | 6.4    | 83.9  | 511                       |       |       | 6.6    | 86.7  | 718                       |       |       | 6.8    | 90.1  | 664                        |       |       | 6.6   | 87    | 1270                       |       |       | 6.6    | 86.5  |
| Chromium                   | 310                                      | 23      | 65.3       | 16.3                       | *     |       | 0.11   | 0.47  | 24.7                       | *     |       | 0.1    | 0.42  | 21.8                      |       |       | 0.21   | 0.87  | 37.5                      | *     |       | 0.11   | 0.45  | 21.2                       |       |       | 0.1   | 0.44  | 41.6                       | N     |       | 0.1    | 0.43  |
| Cobalt                     | na                                       | na      | 72.3       | 19.4                       |       |       | 0.075  | 0.47  | 11.8                       |       |       | 0.067  | 0.42  | 15.2                      |       |       | 0.069  | 0.43  | 54.8                      |       |       | 0.072  | 0.45  | 6.9                        |       |       | 0.07  | 0.44  | 16.9                       |       |       | 0.069  | 0.43  |
| Copper                     | 4100                                     | 310     | 53.5       | 10.3                       |       |       | 0.089  | 0.94  | 10.3                       |       |       | 0.08   | 0.84  | 28.7                      | E     |       | 0.082  | 0.87  | 8.3                       |       |       | 0.086  | 0.9   | 2.1                        | E     | B     | 0.083 | 0.87  | 8.3                        |       |       | 0.082  | 0.87  |
| Iron                       | 72000                                    | 5500    | 50962      | 26200                      |       |       | 3.7    | 14.1  | 29100                      |       |       | 3.3    | 12.6  | 51100                     |       |       | 6.8    | 26    | 32000                     |       |       | 3.6    | 13.5  | 23200                      |       |       | 3.4   | 13.1  | 35200                      |       |       | 3.4    | 13    |
| Lead                       | 800                                      | 400     | 26.8       | 18                         |       |       | 0.2    | 0.94  | 4.8                        |       |       | 0.18   | 0.84  | 11.3                      | *     |       | 0.36   | 1.7   | 6.2                       |       |       | 0.19   | 0.9   | 2.6                        | *     |       | 0.18  | 0.87  | 6.6                        |       |       | 0.18   | 0.87  |
| Magnesium                  | na                                       | na      | na         | 3690                       | N     |       | 2.4    | 23.5  | 5290                       | N     |       | 2.1    | 21    | 7960                      | N     |       | 4.4    | 43.3  | 8840                      | N     |       | 2.3    | 22.5  | 6920                       | N     |       | 2.2   | 21.8  | 17700                      | N     |       | 2.2    | 21.6  |
| Manganese                  | 2000                                     | 160     | 2543       | 486                        |       |       | 0.023  | 0.47  | 494                        |       |       | 0.021  | 0.42  | 1330                      | *     |       | 0.043  | 0.87  | 454                       |       |       | 0.023  | 0.45  | 406                        | *     |       | 0.022 | 0.44  | 434                        |       |       | 0.022  | 0.43  |
| Mercury                    | 31                                       | 2.3     | 0.13       | 0.016                      | U     |       | 0.016  | 0.032 | 0.016                      | U     |       | 0.016  | 0.031 | 0.018                     | U     |       | 0.018  | 0.035 | 0.016                     | U     |       | 0.016  | 0.032 | 0.015                      | U     |       | 0.015 | 0.031 | 0.016                      | U     |       | 0.016  | 0.032 |
| Nickel                     | 2000                                     | 160     | 62.8       | 29.3                       |       |       | 0.13   | 0.94  | 30.3                       |       |       | 0.12   | 0.84  | 46.5                      |       |       | 0.12   | 0.87  | 57.1                      |       |       | 0.13   | 0.9   | 38.1                       |       |       | 0.12  | 0.87  | 53.4                       |       |       | 0.12   | 0.87  |
| Potassium                  | na                                       | na      | na         | 2430                       | N     |       | 3.9    | 23.5  | 1270                       | N     |       | 3.5    | 21    | 1450                      | N     |       | 3.6    | 21.7  | 2140                      | N     |       | 3.8    | 22.5  | 2930                       | N     |       | 3.6   | 21.8  | 1150                       | N     |       | 3.6    | 21.6  |
| Sodium                     | na                                       | na      | na         | 563                        |       | B     | 31.7   | 235   | 72.4                       | B     | B     | 28.3   | 210   | 777                       |       | B     | 58.4   | 433   | 194                       | B     | B     | 30.4   | 225   | 164                        | B     | B     | 29.3  | 218   | 115                        | B     | B     | 29.2   | 216   |
| Thallium                   | 7.2                                      | 0.55    | 2.11       | 0.54                       | U     |       | 0.54   | 2.8   | 0.49                       | U     |       | 0.49   | 2.5   | 2.2                       | B     | B     | 1      | 5.2   | 1.1                       | B     | B     | 0.52   | 2.7   | 0.56                       | B     | B     | 0.51  | 2.6   | 1.4                        | B     | J     | 0.5    | 2.6   |
| Vanadium                   | 102                                      | 7.8     | 108        | 8.8                        |       |       | 0.13   | 0.94  | 24.5                       |       |       | 0.12   | 0.84  | 24.3                      |       |       | 0.24   | 1.7   | 30.6                      |       |       | 0.13   | 0.9   | 13.7                       |       |       | 0.12  | 0.87  | 28.6                       | N     |       | 0.12   | 0.87  |
| Zinc                       | 31000                                    | 2300    | 202        | 14.3                       |       |       | 0.51   | 1.9   | 21.4                       |       |       | 0.45   | 1.7   | 15.7                      |       |       | 0.94   | 3.5   | 24                        |       |       | 0.49   | 1.8   | 15.5                       |       | B     | 0.47  | 1.7   | 23.6                       |       |       | 0.47   |       |

**Table 4-7  
Legend**

|           |          |                                                                       |
|-----------|----------|-----------------------------------------------------------------------|
| 12        | J        | Shading and black font indicate an industrial RBC exceedance.         |
| 12        | J        | Bold outline indicates a residential RBC exceedance.                  |
| <b>12</b> | <b>J</b> | 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**

\* = Laboratory duplicate not within control limits

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 4-8**  
**Dioxins/Furans Detected in Soil Below Sludge Material and/or Deep Soil**  
Page 1 of 2

| Analyte                       | Sample ID<br>Sample Date<br>Sample Depth |       |            | 51SB2D<br>4/6/04<br>33-35 |       |       |       |      | 51SB3D<br>4/5/04<br>36-38 |       |       |       |      | 51SB4D<br>4/1/04<br>36-38 |       |       |       |      | 51SB5C<br>4/1/04<br>16-18 |       |       |       |      |
|-------------------------------|------------------------------------------|-------|------------|---------------------------|-------|-------|-------|------|---------------------------|-------|-------|-------|------|---------------------------|-------|-------|-------|------|---------------------------|-------|-------|-------|------|
|                               | 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  |
| <b>Dioxins/Furans (ng/kg)</b> |                                          |       |            |                           |       |       |       |      |                           |       |       |       |      |                           |       |       |       |      |                           |       |       |       |      |
| 2,3,7,8-TCDF                  | na                                       | na    | na         | 0.2                       | U     |       | 0.053 | 0.2  | 0.2                       | U     |       | 0.091 | 0.2  | 0.2                       | U     |       | 0.082 | 0.2  | 0.37                      | J     | J     | 0.088 | 0.2  |
| 1,2,3,4,6,7,8-HPCDD           | na                                       | na    | na         | 0.98                      | U     |       | 0.11  | 0.98 | 0.98                      | U     |       | 0.058 | 0.98 | 1.7                       | J     | B     | 0.21  | 0.99 | 6.3                       |       |       | 0.3   | 0.98 |
| OCDD                          | na                                       | na    | na         | 2                         | U     |       | 0.12  | 2    | 2.2                       | BJ    | B     | 0.042 | 2    | 15                        |       | B     | 0.21  | 2    | 110                       |       |       | 0.3   | 2    |
| 1,2,3,4,6,7,8-HPCDF           | na                                       | na    | na         | 0.98                      | U     |       | 0.11  | 0.98 | 0.98                      | U     |       | 0.027 | 0.98 | 0.99                      | U     |       | 0.08  | 0.99 | 1                         | J     | J     | 0.2   | 0.98 |
| OCDF                          | na                                       | na    | na         | 2                         | U     |       | 0.13  | 2    | 2                         | U     | UJ    | 0.057 | 2    | 2                         | U     |       | 0.14  | 2    | 3.2                       | J     | J     | 0.16  | 2    |
| TOTAL HPCDD                   | na                                       | na    | na         | 0.98                      | U     |       | 0.11  | 0.98 | 0.98                      | U     |       | 0.058 | 0.98 | 2.9                       | J     | B     | 0.21  | 0.99 | 6.3                       |       |       | 0.3   | 0.98 |
| TOTAL TCDF                    | na                                       | na    | na         | 0.2                       | U     |       | 0.053 | 0.2  | 0.2                       | U     |       | 0.091 | 0.2  | 0.2                       | U     |       | 0.082 | 0.2  | 0.62                      | J     | J     | 0.088 | 0.2  |
| TOTAL HPCDF                   | na                                       | na    | na         | 0.98                      | U     |       | 0.14  | 0.98 | 0.98                      | U     |       | 0.037 | 0.98 | 0.99                      | U     |       | 0.096 | 0.99 | 1                         | J     | J     | 0.2   | 0.98 |

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

**Table 4-8**  
**Dioxins/Furans Detected in Soil Below Sludge Material and/or Deep Soil**  
Page 2 of 2

| Analyte                       | Sample ID<br>Sample Date<br>Sample Depth |       |            | 51SB5D<br>4/1/04<br>31-33 |       |       |       |      | 51SB6C<br>3/30/04<br>9-11 |       |       |       |      | 51SB6D<br>3/30/04<br>33-35 |       |       |     |      |
|-------------------------------|------------------------------------------|-------|------------|---------------------------|-------|-------|-------|------|---------------------------|-------|-------|-------|------|----------------------------|-------|-------|-----|------|
|                               | 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  |
| <b>Dioxins/Furans (ng/kg)</b> |                                          |       |            |                           |       |       |       |      |                           |       |       |       |      |                            |       |       |     |      |
| 2,3,7,8-TCDF                  | na                                       | na    | na         | 0.2                       | U     |       | 0.065 | 0.2  | 0.2                       | U     |       | 0.053 | 0.2  | 20                         | UA    |       | 20  | 0.96 |
| 1,2,3,4,6,7,8-HPCDD           | na                                       | na    | na         | 0.99                      | U     |       | 0.12  | 0.99 | 3.5                       | J     | B     | 0.15  | 0.99 | 9.9                        | UA    |       | 9.9 | 4.8  |
| OCDD                          | na                                       | na    | na         | 5.2                       | BJ    | B     | 0.14  | 2    | 390                       | U     |       | 0.55  | 2    | 38                         | A     | B     | 19  | 9.6  |
| 1,2,3,4,6,7,8-HPCDF           | na                                       | na    | na         | 0.99                      | U     |       | 0.062 | 0.99 | 0.99                      | U     |       | 0.076 | 0.99 | 7.5                        | UA    |       | 7.5 | 4.8  |
| OCDF                          | na                                       | na    | na         | 2                         | U     |       | 0.089 | 2    | 2                         | U     |       | 0.16  | 2    | 22                         | UA    |       | 22  | 9.6  |
| TOTAL HPCDD                   | na                                       | na    | na         | 0.99                      | U     |       | 0.12  | 0.99 | 6.5                       | J     | B     | 0.15  | 0.99 | 4.8                        | U     |       | 9.9 | 4.8  |
| TOTAL TCDF                    | na                                       | na    | na         | 0.2                       | U     |       | 0.065 | 0.2  | 0.2                       | U     |       | 0.053 | 0.2  | 0.96                       | U     |       | 20  | 0.96 |
| TOTAL HPCDF                   | na                                       | na    | na         | 0.99                      | U     |       | 0.072 | 0.99 | 0.99                      | U     |       | 0.092 | 0.99 | 4.8                        | U     |       | 8.3 | 4.8  |

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

**Table 4-8  
Legend**

|           |          |                                                                       |
|-----------|----------|-----------------------------------------------------------------------|
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| 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.

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Lead screening values from Technical Review Workgroup for Lead: Guidance Document (April 1999).

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

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NT = analyte not tested.

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\* = Laboratory duplicate not within control limits

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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).

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K = estimated concentration bias high

L = estimated concentration bias low

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U = analyte not detected

UJ = estimated concentration non-detect

UL = estimated concentration non-detect bias low

Table 4-9  
Summary of Analytes Detected in Soil Below Sludge Material and/or Deep Soil  
Page 1 of 2

| 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 |
|--------------------------------------------------------------------------|----------|---------|------------|------------------------|------------------------|-----------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| <b>VOCs (ug/kg)</b>                                                      |          |         |            |                        |                        |                             |                 |              |                       |                       |                     |
| 2-Butanone                                                               | 61000000 | 4700000 | na         | 0                      | 0                      | na                          | 2               | 13           | 6.9                   | 9.4                   | 51SB6C              |
| 4-Methyl-2-pentanone                                                     | 8200000  | 630000  | na         | 0                      | 0                      | na                          | 1               | 13           | 4.4                   | 4.4                   | 51SB5C              |
| Acetone                                                                  | 92000000 | 7000000 | na         | 0                      | 0                      | na                          | 10              | 13           | 5.7                   | 21                    | 51SB8C              |
| Chloromethane                                                            | na       | na      | na         | na                     | na                     | na                          | 1               | 13           | 2.8                   | 2.8                   | 51SB6D              |
| Methylene chloride                                                       | 380000   | 85000   | na         | 0                      | 0                      | na                          | 8               | 13           | 1.6                   | 4.2                   | 51SB9C              |
| Styrene                                                                  | 20000000 | 1600000 | na         | 0                      | 0                      | na                          | 3               | 13           | 2.3                   | 2.6                   | 51SB6C              |
| <b>PAHs (ug/kg)</b>                                                      |          |         |            |                        |                        |                             |                 |              |                       |                       |                     |
| Fluoranthene                                                             | 4100000  | 310000  | na         | 0                      | 0                      | na                          | 1               | 13           | 12                    | 12                    | 51SB6D              |
| Phenanthrene                                                             | 3100000  | 230000  | na         | 0                      | 0                      | na                          | 10              | 13           | 9.1                   | 18                    | 51SB5C              |
| Pyrene                                                                   | 3100000  | 230000  | na         | 0                      | 0                      | na                          | 1               | 13           | 10                    | 10                    | 51SB6D              |
| <b>SVOCs (ug/kg)</b>                                                     |          |         |            |                        |                        |                             |                 |              |                       |                       |                     |
| 2,4-Dinitrotoluene                                                       | 200000   | 16000   | na         | 0                      | 2                      | na                          | 11              | 13           | 140                   | 44000                 | 51SB5C              |
| 2,6-Dinitrotoluene                                                       | 100000   | 7800    | na         | 0                      | 2                      | na                          | 11              | 13           | 57                    | 11000                 | 51SB3D              |
| 2-Nitroaniline                                                           | na       | na      | na         | na                     | na                     | na                          | 1               | 13           | 77                    | 77                    | 51SB6D              |
| 4,6-Dinitro-2-methylphenol                                               | na       | na      | na         | na                     | na                     | na                          | 4               | 13           | 140                   | 330                   | 51SB3D              |
| bis(2-Ethylhexyl)phthalate                                               | 200000   | 46000   | na         | 0                      | 0                      | na                          | 4               | 13           | 48                    | 82                    | 51SB7C              |
| Diethylphthalate                                                         | 82000000 | 6300000 | na         | 0                      | 0                      | na                          | 1               | 13           | 1600                  | 1600                  | 51SB6D              |
| Di-n-butylphthalate                                                      | 10000000 | 780000  | na         | 0                      | 0                      | na                          | 2               | 13           | 83                    | 150                   | 51SB5D              |
| <b>Pesticides (ug/kg)</b> <i>Samples were not tested for this group.</i> |          |         |            |                        |                        |                             |                 |              |                       |                       |                     |
| <b>PCBs (mg/kg)</b> <i>None detected</i>                                 |          |         |            |                        |                        |                             |                 |              |                       |                       |                     |
| <b>Explosives (mg/kg)</b>                                                |          |         |            |                        |                        |                             |                 |              |                       |                       |                     |
| 1,3,5-Trinitrobenzene                                                    | 3100     | 230     | na         | 0                      | 0                      | na                          | 11              | 13           | 0.04                  | 18                    | 51SB6D              |
| 1,3-Dinitrobenzene                                                       | 10       | 0.78    | na         | 0                      | 0                      | na                          | 6               | 13           | 0.06                  | 0.32                  | 51SB2D              |
| 2,4,6-Trinitrotoluene                                                    | 51       | 3.9     | na         | 0                      | 7                      | na                          | 13              | 13           | 0.3                   | 22                    | 51SB6D              |
| 2,4-Dinitrotoluene                                                       | 200      | 16      | na         | 0                      | 2                      | na                          | 11              | 13           | 0.03                  | 42                    | 51SB3D              |
| 2,6-Dinitrotoluene                                                       | 100      | 7.8     | na         | 0                      | 1                      | na                          | 10              | 13           | 0.34                  | 11                    | 51SB3D              |
| 2-Nitrotoluene                                                           | 1000     | 78      | na         | 0                      | 2                      | na                          | 11              | 13           | 0.17                  | 93                    | 51SB10C             |
| 3-Nitrotoluene                                                           | na       | na      | na         | na                     | na                     | na                          | 9               | 13           | 0.22                  | 8.2                   | 51SB10C             |
| 4-Nitrotoluene                                                           | 180      | 31      | na         | 0                      | 2                      | na                          | 10              | 13           | 0.24                  | 45                    | 51SB10C             |
| Nitrobenzene                                                             | 51       | 3.9     | na         | 0                      | 0                      | na                          | 4               | 13           | 0.07                  | 0.16                  | 51SB1C              |
| RDX                                                                      | 26       | 5.8     | na         | 0                      | 2                      | na                          | 9               | 13           | 0.3                   | 7.2                   | 51SB3D              |
| Nitroglycerin                                                            | 10       | 0.78    | na         | 0                      | 1                      | na                          | 1               | 13           | 6.7                   | 6.7                   | 51SB6D              |
| <b>Herbicides (ug/kg)</b> <i>Samples were not tested for this group.</i> |          |         |            |                        |                        |                             |                 |              |                       |                       |                     |
| <b>Metals (mg/kg)</b>                                                    |          |         |            |                        |                        |                             |                 |              |                       |                       |                     |
| Aluminum                                                                 | 100000   | 7800    | 40041      | 0                      | 0                      | 0                           | 13              | 13           | 8650                  | 27700                 | 51SB1C              |
| Antimony                                                                 | 41       | 3.1     | na         | 0                      | 0                      | na                          | 6               | 13           | 0.5                   | 0.82                  | 51SB2D              |
| Arsenic                                                                  | 1.9      | 0.43    | 15.8       | 0                      | 0                      | 0                           | 13              | 13           | 0.96                  | 7.4                   | 51SB5D              |
| Barium                                                                   | 20000    | 1600    | 209        | 0                      | 0                      | 0                           | 13              | 13           | 26.3                  | 167                   | 51SB4D              |
| Beryllium                                                                | 200      | 16      | 1.02       | 0                      | 0                      | 8                           | 13              | 13           | 0.43                  | 2.5                   | 51SB11C             |
| Cadmium                                                                  | 51       | 3.9     | 0.69       | 0                      | 0                      | 1                           | 8               | 13           | 0.04                  | 0.8                   | 51SB8C              |

Table 4-9  
Summary of Analytes Detected in Soil Below Sludge Material and/or Deep Soil  
Page 2 of 2

| 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 |
|-------------------------------|-------|-------|------------|------------------------|------------------------|-----------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| Calcium                       | na    | na    | na         | na                     | na                     | na                          | 13              | 13           | 37.3                  | 1750                  | 51SB4D              |
| Chromium                      | 310   | 23    | 65.3       | 0                      | 0                      | 0                           | 13              | 13           | 10.8                  | 47.7                  | 51SB1C              |
| Cobalt                        | na    | na    | 72.3       | na                     | na                     | 2                           | 13              | 13           | 4.6                   | 95.1                  | 51SB3D              |
| Copper                        | 4100  | 310   | 53.5       | 0                      | 0                      | 1                           | 13              | 13           | 0.59                  | 92.9                  | 51SB3D              |
| Iron                          | 72000 | 5500  | 50962      | 0                      | 1                      | 1                           | 13              | 13           | 12500                 | 51100                 | 51SB8C              |
| Lead                          | 800   | 400   | 26.8       | 0                      | 0                      | 0                           | 13              | 13           | 0.75                  | 18.3                  | 51SB5D              |
| Magnesium                     | na    | na    | na         | na                     | na                     | na                          | 13              | 13           | 548                   | 22200                 | 51SB1C              |
| Manganese                     | 2000  | 160   | 2543       | 0                      | 0                      | 0                           | 13              | 13           | 221                   | 1330                  | 51SB8C              |
| Mercury                       | 31    | 2.3   | 0.13       | 0                      | 0                      | 0                           | 1               | 13           | 0.036                 | 0.036                 | 51SB6C              |
| Nickel                        | 2000  | 160   | 62.8       | 0                      | 0                      | 1                           | 13              | 13           | 4.2                   | 109                   | 51SB3D              |
| Potassium                     | na    | na    | na         | na                     | na                     | na                          | 13              | 13           | 528                   | 3090                  | 51SB3D              |
| Sodium                        | na    | na    | na         | na                     | na                     | na                          | 13              | 13           | 72.4                  | 777                   | 51SB8C              |
| Thallium                      | 7.2   | 0.55  | 2.11       | 0                      | 1                      | 1                           | 7               | 13           | 0.56                  | 2.2                   | 51SB8C              |
| Vanadium                      | 102   | 7.8   | 108        | 0                      | 0                      | 0                           | 13              | 13           | 8.8                   | 41.2                  | 51SB6C              |
| Zinc                          | 31000 | 2300  | 202        | 0                      | 0                      | 0                           | 13              | 13           | 14.2                  | 25.6                  | 51SB6C              |
| <b>Misc. (mg/kg)</b>          |       |       |            |                        |                        |                             |                 |              |                       |                       |                     |
| Cyanide                       | 2000  | 160   | na         | 0                      | 0                      | na                          | 1               | 13           | 0.65                  | 0.65                  | 51SB5C              |
| <b>Dioxins/Furans (ng/kg)</b> |       |       |            |                        |                        |                             |                 |              |                       |                       |                     |
| 2,3,7,8-TCDF                  | na    | na    | na         | na                     | na                     | na                          | 1               | 7            | 0.37                  | 0.37                  | 51SB5C              |
| 1,2,3,4,6,7,8-HPCDD           | na    | na    | na         | na                     | na                     | na                          | 3               | 7            | 1.7                   | 6.3                   | 51SB5C              |
| OCDD                          | na    | na    | na         | na                     | na                     | na                          | 5               | 7            | 2.2                   | 110                   | 51SB5C              |
| 1,2,3,4,6,7,8-HPCDF           | na    | na    | na         | na                     | na                     | na                          | 1               | 7            | 1                     | 1                     | 51SB5C              |
| OCDF                          | na    | na    | na         | na                     | na                     | na                          | 1               | 7            | 3.2                   | 3.2                   | 51SB5C              |
| TOTAL HPCDD                   | na    | na    | na         | na                     | na                     | na                          | 3               | 7            | 2.9                   | 6.5                   | 51SB6C              |
| TOTAL TCDF                    | na    | na    | na         | na                     | na                     | na                          | 1               | 7            | 0.62                  | 0.62                  | 51SB5C              |
| TOTAL HXCDF                   | na    | na    | na         | na                     | na                     | na                          | 0               | 7            | na                    | na                    | na                  |
| TOTAL HPCDF                   | na    | na    | na         | na                     | na                     | na                          | 1               | 7            | 1                     | 1                     | 51SB5C              |

**PCBs.** PCBs were not detected in the soil samples.

**Explosives.** Eleven explosives were detected in these samples. Seven explosives (2,4,6-TNT, 2,4-DNT, 2,6-DNT, 2- and 4-nitrotoluene, RDX, and NG) were detected at concentrations exceeding residential screening levels. None of these compounds exceeded industrial screening levels in this sample grouping.

**Herbicides.** Herbicides were not analyzed for in these samples.

**TAL Inorganics.** Twenty-one metals were detected in these samples. Iron and thallium (in 51SB8C) were the only metals detected at concentrations exceeding residential screening levels. No other metals were detected above residential screening levels in the samples. Cyanide was detected in one sample at a concentration below residential screening levels.

**Dioxins/Furans.** Five dioxins/furan congeners were detected in the soil samples. None of these congeners that have an associated RBC.

## **4.2 Eastern Horseshoe Area Groundwater Sampling, Shaw, 2006**

As discussed in *Section 3.2*, groundwater samples were collected from thirteen monitoring wells in the EHSA in April 2006. All samples were analyzed for TCL VOCs, TCL SVOCs, PAHs, TCL pesticides/PCBs, TAL metals, and dioxins/furans. In order to focus on potential impacts to groundwater as a result of the trench sludge material and/or grossly contaminated soil, only results from the closest downgradient monitoring wells (51MW1 and 51MW2) to SWMU 51 are presented and discussed.

### **4.2.1 Analytical Results – Eastern Horseshoe Area Groundwater Sampling, Shaw, 2006**

As shown in **Table 4-10** and summarized in **Table 4-11**, sample results indicated the presence of one VOC, fourteen metals, and one dioxins/furan in groundwater immediately downgradient of SWMU 51. PAHs, SVOCs, pesticides, PCBs, and explosives were not detected in any of the samples. As illustrated on **Figure 4-3**, detected results from downgradient wells 51MW1 and 51MW2 indicated the following exceedances of regulatory screening criteria:

**VOCs.** Tetrachloroethene (PCE) [0.93 micrograms per liter (µg/L)] did not exceed its MCL, but did exceed the tap water RBC (tw-RBC) (0.1 µg/L) in 51MW1. PCE was not detected in 51MW2.

#### **TAL Inorganics.**

**Aluminum.** Aluminum exceeded its secondary MCL (50 µg/L) in both 51MW1 (282 µg/L) and 51MW2 (100 µg/L). However, both results were flagged “B,” indicating blank contamination.

**Antimony.** Antimony (3.6 µg/L) exceeded its tw-RBC (1.5 µg/L) in 51MW1. This result was also flagged “B,” indicating blank contamination. Antimony was not detected in 51MW2.

**Iron.** Iron (547 µg/L) exceeded its secondary MCL (300 µg/L) in 51MW1. The concentration (42.2 µg/L) was below screening criteria in 51MW2.

**Manganese.** Manganese (60.6 µg/L) exceeded its secondary MCL (50 µg/L) in 51MW1. The concentration (1.8 µg/L) was below screening criteria in 51MW2.

**Dioxins/furans.** OCDD was the only dioxin/furan congener detected in 51MW1. No dioxin/furan congeners were detected in 51MW2. OCDD does not have an associated screening level.

**Table 4-10**  
**Analytes Detected in SWMU 51 Downgradient Monitoring Wells - 2006 EHSA Sampling**

| Analyte                                                          | Sample ID<br>Sample Date<br>Sample Depth |        | 51MW1<br>4/11/06<br>34-35 |       |       |     |      | 51MW2<br>4/10/06<br>52-53 |       |       |        |        |
|------------------------------------------------------------------|------------------------------------------|--------|---------------------------|-------|-------|-----|------|---------------------------|-------|-------|--------|--------|
|                                                                  | MCL                                      | tw-RBC | Result                    | Lab Q | Val Q | MDL | MRL  | Result                    | Lab Q | Val Q | MDL    | MRL    |
| <b>VOCs (ug/L)</b>                                               |                                          |        |                           |       |       |     |      |                           |       |       |        |        |
| Tetrachloroethene                                                | 5                                        | 0.1    | 0.93                      | J     | J     | 0.5 | 1    | 1                         | U     |       | 0.5    | 1      |
| <b>PAHs (ug/L)</b> None detected                                 |                                          |        |                           |       |       |     |      |                           |       |       |        |        |
| <b>SVOCs (ug/L)</b> None detected                                |                                          |        |                           |       |       |     |      |                           |       |       |        |        |
| <b>Pesticides (ug/L)</b> None detected                           |                                          |        |                           |       |       |     |      |                           |       |       |        |        |
| <b>PCBs (ug/L)</b> None detected                                 |                                          |        |                           |       |       |     |      |                           |       |       |        |        |
| <b>Explosives (ug/L)</b> None detected                           |                                          |        |                           |       |       |     |      |                           |       |       |        |        |
| <b>Herbicides (ug/L)</b> Samples were not tested for this group. |                                          |        |                           |       |       |     |      |                           |       |       |        |        |
| <b>Metals (ug/L)</b>                                             |                                          |        |                           |       |       |     |      |                           |       |       |        |        |
| Aluminum                                                         | 50                                       | 3700   | 282                       |       | B     | 16  | 200  | 100                       | J     | B     | 16     | 200    |
| Antimony                                                         | 6                                        | 1.5    | 3.6                       | J     | B     | 2.2 | 5    | 2.2                       | U     |       | 2.2    | 5      |
| Barium                                                           | 2000                                     | 730    | 45.3                      | J     | J     | 0.5 | 200  | 40.8                      | J     | J     | 0.5    | 200    |
| Beryllium                                                        | 4                                        | 7.3    | 2                         | J     | B     | 0.7 | 4    | 2.1                       | J     | B     | 0.7    | 4      |
| Calcium                                                          | na                                       | na     | 18900                     |       |       | 26  | 1000 | 53700                     |       |       | 26     | 1000   |
| Chromium                                                         | 100                                      | 11     | 0.59                      | J     | J     | 0.5 | 10   | 1.3                       | J     | J     | 0.5    | 10     |
| Iron                                                             | 300                                      | 2600   | 547                       |       |       | 7.5 | 300  | 42.2                      | J     | B     | 7.5    | 300    |
| Lead                                                             | 15                                       | na     | 1.3                       | J     | B     | 1.2 | 5    | 1.2                       | U     |       | 1.2    | 5      |
| Magnesium                                                        | na                                       | na     | 7440                      |       |       | 5.8 | 5000 | 15600                     |       |       | 5.8    | 5000   |
| Manganese                                                        | 50                                       | 73     | 60.6                      |       |       | 0.2 | 15   | 1.8                       | J     | B     | 0.2    | 15     |
| Nickel                                                           | na                                       | 73     | 1.1                       | J     | J     | 1.1 | 40   | 1.1                       | U     |       | 1.1    | 40     |
| Potassium                                                        | na                                       | na     | 1070                      | J     | J     | 36  | 5000 | 1220                      | J     | J     | 36     | 5000   |
| Sodium                                                           | na                                       | na     | 256                       | J     | B     | 77  | 5000 | 713                       | J     | B     | 77     | 5000   |
| Zinc                                                             | 5000                                     | 1100   | 3.4                       | J     | J     | 0.8 | 20   | 2.1                       | J     | J     | 0.8    | 20     |
| <b>Dioxins/Furans (ng/L)</b>                                     |                                          |        |                           |       |       |     |      |                           |       |       |        |        |
| OCDD                                                             | na                                       | na     | 0.0376                    | A     | J     | NA  | NA   | 0.0208                    | U     |       | 0.0208 | 0.0208 |

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

**Table 4-10**  
**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.

**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

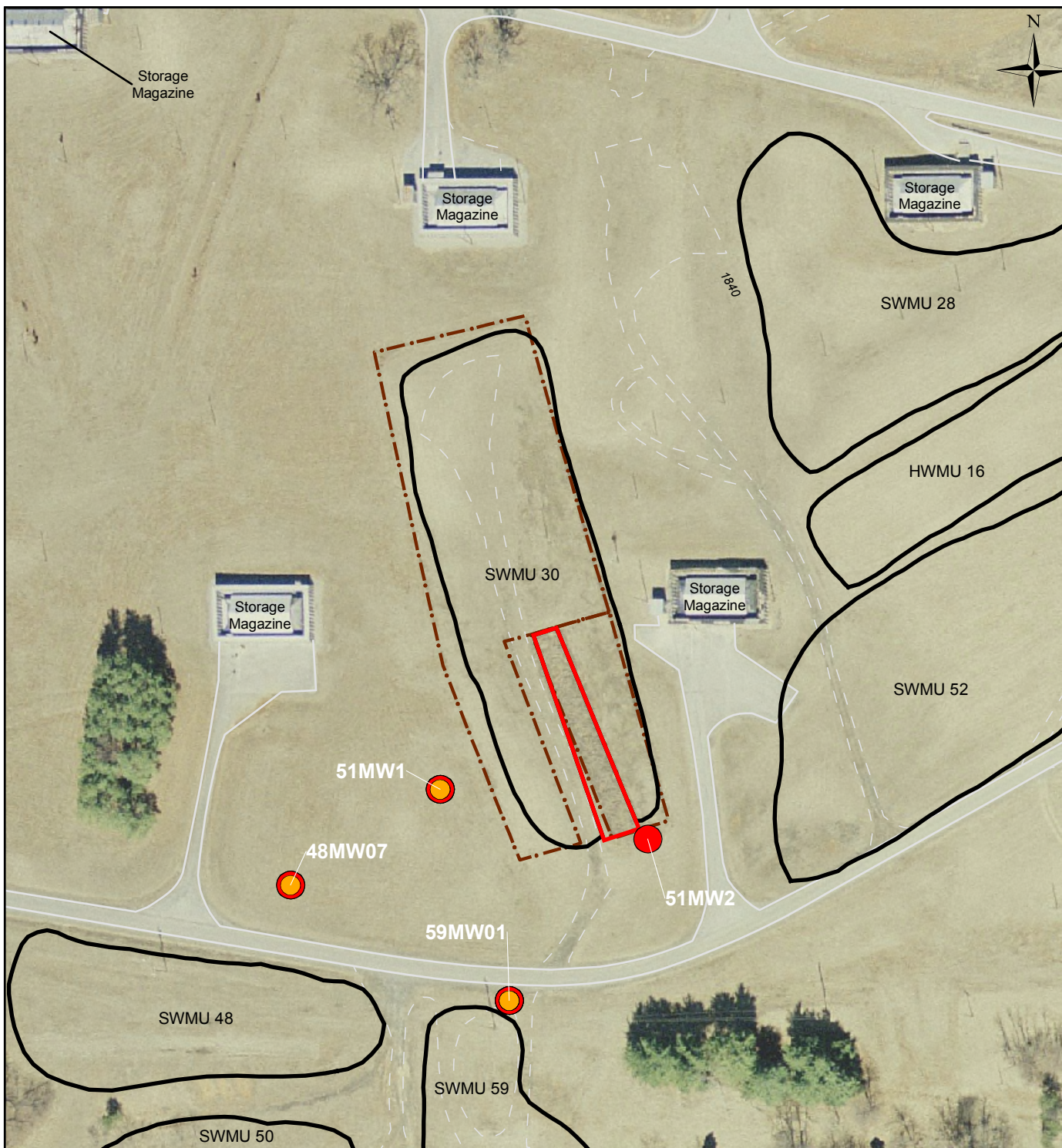
U = analyte not detected

UJ = estimated concentration non-detect

UL = estimated concentration non-detect bias low

**Table 4-11**  
**Summary of Analytes Detected in SWMU 51 Downgradient Monitoring Wells - 2006 EHSA Sampling**

| Analyte                                                                 | MCL  | tw-RBC | # of MCL Exceedances | # of tw-RBC Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|-------------------------------------------------------------------------|------|--------|----------------------|-------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| <b>VOCs (ug/L)</b>                                                      |      |        |                      |                         |                 |              |                       |                       |                     |
| Tetrachloroethene                                                       | 5    | 0.1    | 0                    | 1                       | 1               | 2            | 0.93                  | 0.93                  | 51MW1               |
| <b>PAHs (ug/L)</b> <i>None detected</i>                                 |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>SVOCs (ug/L)</b> <i>None detected</i>                                |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>Pesticides (ug/L)</b> <i>None detected</i>                           |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>PCBs (ug/L)</b> <i>None detected</i>                                 |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>Explosives (ug/L)</b> <i>None detected</i>                           |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>Herbicides (ug/L)</b> <i>Samples were not tested for this group.</i> |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>Metals (ug/L)</b>                                                    |      |        |                      |                         |                 |              |                       |                       |                     |
| Aluminum                                                                | 50   | 3700   | 2                    | 0                       | 2               | 2            | 100                   | 282                   | 51MW1               |
| Antimony                                                                | 6    | 1.5    | 0                    | 1                       | 1               | 2            | 3.6                   | 3.6                   | 51MW1               |
| Barium                                                                  | 2000 | 730    | 0                    | 0                       | 2               | 2            | 40.8                  | 45.3                  | 51MW1               |
| Beryllium                                                               | 4    | 7.3    | 0                    | 0                       | 2               | 2            | 2                     | 2.1                   | 51MW2               |
| Calcium                                                                 | na   | na     | na                   | na                      | 2               | 2            | 18900                 | 53700                 | 51MW2               |
| Chromium                                                                | 100  | 11     | 0                    | 0                       | 2               | 2            | 0.59                  | 1.3                   | 51MW2               |
| Iron                                                                    | 300  | 2600   | 1                    | 0                       | 2               | 2            | 42.2                  | 547                   | 51MW1               |
| Lead                                                                    | 15   | na     | 0                    | na                      | 1               | 2            | 1.3                   | 1.3                   | 51MW1               |
| Magnesium                                                               | na   | na     | na                   | na                      | 2               | 2            | 7440                  | 15600                 | 51MW2               |
| Manganese                                                               | 50   | 73     | 1                    | 0                       | 2               | 2            | 1.8                   | 60.6                  | 51MW1               |
| Nickel                                                                  | na   | 73     | na                   | 0                       | 1               | 2            | 1.1                   | 1.1                   | 51MW1               |
| Potassium                                                               | na   | na     | na                   | na                      | 2               | 2            | 1070                  | 1220                  | 51MW2               |
| Sodium                                                                  | na   | na     | na                   | na                      | 2               | 2            | 256                   | 713                   | 51MW2               |
| Zinc                                                                    | 5000 | 1100   | 0                    | 0                       | 2               | 2            | 2.1                   | 3.4                   | 51MW1               |
| <b>Dioxins/Furans (ng/L)</b>                                            |      |        |                      |                         |                 |              |                       |                       |                     |
| OCDD                                                                    | na   | na     | na                   | na                      | 1               | 2            | 0.0376                | 0.0376                | 51MW1               |



## LEGEND

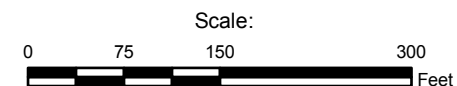
- Groundwater Sample Location  
Result  $\geq$  tw-RBC
- Groundwater Sample Location  
Result  $\geq$  MCL
- Dirt Road
- Paved Road
- - - Fence Line
- SWMU 51 Boundary
- Other SWMU/HWMU Boundary

### Notes:

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

| Sample ID | Groundwater MCL Exceedances |
|-----------|-----------------------------|
| 48MW07    | 2 Metals                    |
| 51MW1     | 3 Metals                    |
| 51MW2     | 1 Metal                     |
| 59MW01    | 2 Metals                    |

| Sample ID | Groundwater tw-RBC Exceedances |
|-----------|--------------------------------|
| 48MW07    | 1 Metal                        |
| 51MW1     | 1 Metal, 1 VOC                 |



U.S. Army Corps of Engineers



Shaw® Shaw Environmental, Inc.

**FIGURE 4-3**  
**SWMU 51 Groundwater Results**  
Radford Army Ammunition Plant,  
Radford, VA

### 4.3 2007 Investigation Groundwater Sampling, Shaw, 2007

As discussed in Section 3.3, groundwater samples were collected from newly installed monitoring wells 48MW07 and 59MW01 in August 2007. As illustrated on **Figure 2-12**, wells 48MW07 and 59MW01 are considered downgradient from SWMU 51. Samples were analyzed for TCL VOCs, TCL SVOCs, PAHs, TCL pest/PCBs, explosives, herbicides, TAL metals, dioxins/furans, and perchlorate.

#### 4.3.1 Analytical Results – 2007 Investigation Groundwater Sampling, Shaw, 2007

As shown in **Table 4-12**, summarized in **Table 4-13**, and illustrated on **Figure 4-3**, sample results from monitoring wells 48MW07 and 59MW01 indicated that organics were not present in groundwater downgradient from SWMU 51. Inorganic sample results from the two wells were as follows:

##### **TAL Inorganics.**

*Aluminum.* Aluminum exceeded its secondary MCL (50 µg/L) in both 48MW07 (457 µg/L) and 59MW01 (725 µg/L). However, both results were below the tw-RBC (3,700 µg/L).

*Chromium.* Chromium (11.9 µg/L) slightly exceeded its tw-RBC (11 µg/L) in 48MW07, but was well below the MCL of 100 µg/L.

*Iron.* Iron exceeded its secondary MCL (300 µg/L) in both 48MW07 (861 µg/L) and 59MW01 (801 µg/L). However, both results were below the tw-RBC (2,600 µg/L).

*Perchlorate.* Concentrations of perchlorate were well below the tw-RBC in both wells.

*Dioxins/furans.* OCDD was the only dioxin/furan congener detected in 48MW07. Nine dioxin/furan congeners were detected in 59MW01. None of the detected dioxin/furan congeners have an associated screening level.

### 4.4 Nature and Extent Analysis

#### 4.4.1 Soil

Pesticides, PCBs, or herbicides were not detected in any soil samples collected inside or outside of the trench limits, indicating that these chemical parameters are not a concern at SWMU 51. VOCs were detected, but did not exceed residential screening levels inside or outside the trench limits; therefore, these compounds are also not a concern at this site.

Results from the soil investigation at SWMU 51 indicate that the trench sludge material contains concentrations of PAHs, explosives, metals, and total HXCDD (dioxins/furan) at concentrations exceeding industrial screening levels. With the exception of one sample collected in native soil outside the trench boundary, which contained manganese at a concentration above the industrial screening level, industrial screening levels were not exceeded in samples from the fill/native soil or deep soil sample groupings. A summary of the screening level exceedances is described below.

##### 4.4.1.1 Clean Fill and/or Native Soil

As previously described, seventeen soil samples were collected from clean fill and/or native soil at the site. Analysis of the detected results from this group of samples indicates that clean fill above the trench and native soil has not been impacted at the site. Analytical results indicated single residential screening level exceedances of one PAH [dibenz(a,h)anthracene] and three

**Table 4-12**  
**Analytes Detected in Downgradient Wells 48MW07 and 59MW01 - 2007 Investigation**

| Analyte                      | Sample ID<br>Sample Date |        | 48MW07<br>8/30/07 |       |       |        |       | 59MW01<br>8/29/07 |       |       |        |       |
|------------------------------|--------------------------|--------|-------------------|-------|-------|--------|-------|-------------------|-------|-------|--------|-------|
|                              | MCL                      | tw-RBC | Result            | Lab Q | Val Q | MDL    | MRL   | Result            | Lab Q | Val Q | MDL    | MRL   |
| <b>VOCs (ug/L)</b>           | None detected            |        |                   |       |       |        |       |                   |       |       |        |       |
| <b>PAHs (ug/L)</b>           | None detected            |        |                   |       |       |        |       |                   |       |       |        |       |
| <b>SVOCs (ug/L)</b>          | None detected            |        |                   |       |       |        |       |                   |       |       |        |       |
| <b>Pesticides (ug/L)</b>     | None detected            |        |                   |       |       |        |       |                   |       |       |        |       |
| <b>PCBs (ug/L)</b>           | None detected            |        |                   |       |       |        |       |                   |       |       |        |       |
| <b>Explosives (ug/L)</b>     | None detected            |        |                   |       |       |        |       |                   |       |       |        |       |
| <b>Herbicides (ug/L)</b>     | None detected            |        |                   |       |       |        |       |                   |       |       |        |       |
| <b>Metals (ug/L)</b>         |                          |        |                   |       |       |        |       |                   |       |       |        |       |
| Aluminum                     | 50                       | 3700   | 457               |       |       | 79     | 200   | 725               |       |       | 79     | 200   |
| Barium                       | 2000                     | 730    | 76.8              | J     | J     | 5      | 200   | 214               |       |       | 5      | 200   |
| Calcium                      | na                       | na     | 22200             |       |       | 100    | 1000  | 30700             |       |       | 100    | 1000  |
| Chromium                     | 100                      | 11     | 11.9              |       |       | 0.92   | 10    | 9.8               | J     | J     | 0.92   | 10    |
| Copper                       | 1300                     | 150    | 1.2               | J     | B     | 1.2    | 25    | 1.2               | U     |       | 1.2    | 25    |
| Iron                         | 300                      | 2600   | 861               |       |       | 15     | 300   | 801               |       |       | 15     | 300   |
| Lead                         | 15                       | na     | 2.1               | J     | B     | 2.1    | 5     | 2.1               | U     |       | 2.1    | 5     |
| Magnesium                    | na                       | na     | 12100             |       |       | 100    | 5000  | 23800             |       |       | 100    | 5000  |
| Manganese                    | 50                       | 73     | 32.3              |       |       | 1      | 15    | 20.5              |       |       | 1      | 15    |
| Nickel                       | na                       | 73     | 6.9               | J     | J     | 1      | 40    | 5.8               | J     | J     | 1      | 40    |
| Potassium                    | na                       | na     | 2910              | J     | B     | 100    | 10000 | 2090              | J     | B     | 100    | 10000 |
| Sodium                       | na                       | na     | 2470              | J     | B     | 500    | 10000 | 1460              | J     | J     | 500    | 10000 |
| Vanadium                     | na                       | 3.7    | 1.1               | U     |       | 1.1    | 50    | 1.8               | J     | J     | 1.1    | 50    |
| <b>Misc. (ug/L)</b>          |                          |        |                   |       |       |        |       |                   |       |       |        |       |
| Perchlorate                  | na                       | 2.6    | 0.313             |       | J     | 0.0663 | 0.2   | 0.283             |       | J     | 0.0663 | 0.2   |
| <b>Dioxins/Furans (ng/L)</b> |                          |        |                   |       |       |        |       |                   |       |       |        |       |
| 1,2,3,7,8-PECDD              | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 3.02              | J     | J     | NA     | NA    |
| OCDD                         | na                       | na     | 14.6              | J     | J     | NA     | NA    | 7.03              | J     | J     | NA     | NA    |
| 1,2,3,7,8-PECDF              | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 3.7               | J     | J     | NA     | NA    |
| 2,3,4,7,8-PECDF              | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 2.98              | J     | J     | NA     | NA    |
| 1,2,3,4,7,8-HXCDF            | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 3.07              | J     | J     | NA     | NA    |
| 1,2,3,6,7,8-HXCDF            | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 2.71              | J     | J     | NA     | NA    |
| 2,3,4,6,7,8-HXCDF            | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 1.9               | EMP   | J     | 5.6    | 5.6   |
| 1,2,3,7,8,9-HXCDF            | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 2.53              | J     | J     | NA     | NA    |
| 1,2,3,4,6,7,8-HPCDF          | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 3.09              | J     | J     | NA     | NA    |
| TOTAL PECDD                  | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 3.02              |       |       | NA     | NA    |
| TOTAL PECDF                  | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 6.67              |       |       | NA     | NA    |
| TOTAL HXCDF                  | na                       | na     | 4.94              | U     |       | 4.94   | 4.94  | 10.2              |       |       | NA     | NA    |
| TOTAL HPCDF                  | na                       | na     | 5.94              | U     |       | 5.94   | 5.94  | 3.09              |       |       | NA     | NA    |

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

**Table 4-12**  
**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.

**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 4-13**  
**Summary of Analytes Detected in Downgradient Wells 48MW07 and 59MW01 - 2007 Investigation**

| Analyte                                       | MCL  | tw-RBC | # of MCL Exceedances | # of tw-RBC Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|-----------------------------------------------|------|--------|----------------------|-------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| <b>VOCs (ug/L)</b> <i>None detected</i>       |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>PAHs (ug/L)</b> <i>None detected</i>       |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>SVOCs (ug/L)</b> <i>None detected</i>      |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>Pesticides (ug/L)</b> <i>None detected</i> |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>PCBs (ug/L)</b> <i>None detected</i>       |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>Explosives (ug/L)</b> <i>None detected</i> |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>Herbicides (ug/L)</b> <i>None detected</i> |      |        |                      |                         |                 |              |                       |                       |                     |
| <b>Metals (ug/L)</b>                          |      |        |                      |                         |                 |              |                       |                       |                     |
| Aluminum                                      | 50   | 3700   | 2                    | 0                       | 2               | 2            | 457                   | 725                   | 59MW01              |
| Barium                                        | 2000 | 730    | 0                    | 0                       | 2               | 2            | 76.8                  | 214                   | 59MW01              |
| Calcium                                       | na   | na     | na                   | na                      | 2               | 2            | 22200                 | 30700                 | 59MW01              |
| Chromium                                      | 100  | 11     | 0                    | 1                       | 2               | 2            | 9.8                   | 11.9                  | 48MW07              |
| Copper                                        | 1300 | 150    | 0                    | 0                       | 1               | 2            | 1.2                   | 1.2                   | 48MW07              |
| Iron                                          | 300  | 2600   | 2                    | 0                       | 2               | 2            | 801                   | 861                   | 48MW07              |
| Lead                                          | 15   | na     | 0                    | na                      | 1               | 2            | 2.1                   | 2.1                   | 48MW07              |
| Magnesium                                     | na   | na     | na                   | na                      | 2               | 2            | 12100                 | 23800                 | 59MW01              |
| Manganese                                     | 50   | 73     | 0                    | 0                       | 2               | 2            | 20.5                  | 32.3                  | 48MW07              |
| Nickel                                        | na   | 73     | na                   | 0                       | 2               | 2            | 5.8                   | 6.9                   | 48MW07              |
| Potassium                                     | na   | na     | na                   | na                      | 2               | 2            | 2090                  | 2910                  | 48MW07              |
| Sodium                                        | na   | na     | na                   | na                      | 2               | 2            | 1460                  | 2470                  | 48MW07              |
| Vanadium                                      | na   | 3.7    | na                   | 0                       | 1               | 2            | 1.8                   | 1.8                   | 59MW01              |
| <b>Misc. (ug/L)</b>                           |      |        |                      |                         |                 |              |                       |                       |                     |
| Perchlorate                                   | na   | 2.6    | na                   | 0                       | 2               | 2            | 0.283                 | 0.313                 | 48MW07              |
| <b>Dioxins/Furans (ug/L)</b>                  |      |        |                      |                         |                 |              |                       |                       |                     |
| 1,2,3,7,8-PECDD                               | na   | na     | na                   | na                      | 1               | 2            | 3.02                  | 3.02                  | 59MW01              |
| OCDD                                          | na   | na     | na                   | na                      | 2               | 2            | 7.03                  | 14.6                  | 48MW07              |
| 1,2,3,7,8-PECDF                               | na   | na     | na                   | na                      | 1               | 2            | 3.7                   | 3.7                   | 59MW01              |
| 2,3,4,7,8-PECDF                               | na   | na     | na                   | na                      | 1               | 2            | 2.98                  | 2.98                  | 59MW01              |
| 1,2,3,4,7,8-HXCDF                             | na   | na     | na                   | na                      | 1               | 2            | 3.07                  | 3.07                  | 59MW01              |
| 1,2,3,6,7,8-HXCDF                             | na   | na     | na                   | na                      | 1               | 2            | 2.71                  | 2.71                  | 59MW01              |
| 2,3,4,6,7,8-HXCDF                             | na   | na     | na                   | na                      | 1               | 2            | 1.9                   | 1.9                   | 59MW01              |
| 1,2,3,7,8,9-HXCDF                             | na   | na     | na                   | na                      | 1               | 2            | 2.53                  | 2.53                  | 59MW01              |
| 1,2,3,4,6,7,8-HPCDF                           | na   | na     | na                   | na                      | 1               | 2            | 3.09                  | 3.09                  | 59MW01              |
| TOTAL PECDD                                   | na   | na     | na                   | na                      | 1               | 2            | 3.02                  | 3.02                  | 59MW01              |
| TOTAL PECDF                                   | na   | na     | na                   | na                      | 1               | 2            | 6.67                  | 6.67                  | 59MW01              |
| TOTAL HXCDF                                   | na   | na     | na                   | na                      | 1               | 2            | 10.2                  | 10.2                  | 59MW01              |
| TOTAL HPCDF                                   | na   | na     | na                   | na                      | 1               | 2            | 3.09                  | 3.09                  | 59MW01              |

explosive breakdown products (2,6-DNT, 2- and 4-nitrotoluene). One metal (manganese) exceeded both the industrial and residential screening levels outside the trench boundary at 8-10 ft bgs. No other constituents were detected above residential or industrial screening levels in clean fill and/or native soil at the site.

#### **4.4.1.2 Trench Sludge Material and/or Grossly Contaminated Soil**

Eight soil samples were collected from the trench sludge material and/or grossly contaminated soil at the site. Analysis of the sample results from this group of samples indicates that this is the most contaminated area at the site. With the exception of a single exceedance of manganese in one native soil sample outside the trench boundary, this is the only area at the site where industrial screening level exceedances occurred. In addition, the highest number of residential screening level exceedances originated from this group of samples. Industrial screening levels included one PAH [benzo(a)pyrene], seven explosives (1,3-DNB, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, 2- and 4-nitrotoluene, and NG), four metals (chromium, iron, lead, and thallium), and total HXCDD. Residential screening level exceedances included three PAHs [benz(a)anthracene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene], one explosive (1,3,5-TNB), three metals (antimony, cadmium, and copper), and two dioxin/furan congeners (2,3,7,8-TCDD and 1,2,3,6,7,8-HXCDD).

#### **4.4.1.3 Soil Below Sludge Material and/or Deep Soil**

As previously stated, thirteen samples were collected from soil below the trench sludge material and/or deep soil at the site. Analysis of the chemical results from this group of samples indicates that residential exceedances were limited to seven explosives (2,4,6-TNT, 2,4-DNT, 2,6-DNT, 2- and 4-nitrotoluene, RDX, and NG) and two metals (iron and thallium). Based on the consistency of the sludge material (described in *Section 4.1*) that was encountered in the trench, it is believed that the sludge material may have been smeared on the walls of the borehole during boring advancement and when the macrocore was retracted from the borehole it likely encountered the pastelike material and affected explosive concentrations detected in soil below the trench sludge material and/or deep soil.

### **4.4.2 Groundwater**

Groundwater at SWMU 51 and surrounding SWMUs/HWMUs was investigated during the 1992 RFI (*Section 2.6.3*), the April 2006 EHSA Groundwater Investigation (*Section 3.2*), and the 2007 Investigation groundwater sampling event (*Section 3.3*). For determining the nature and extent of groundwater contamination at SWMU 51, only groundwater data from the 2006 EHSA Groundwater Investigation and the 2007 Investigation Groundwater Sampling event will be used.

#### **4.4.2.1 Eastern Horseshoe Area Groundwater Sampling**

Groundwater results from the April 2006 sampling event indicated that one VOC (PCE) and four metals (aluminum, antimony, iron, and manganese) were detected at concentrations exceeding groundwater screening levels in SWMU 51 downgradient wells. Explosives were not detected in any of the EHSA (in particular SWMU 51) groundwater samples.

**VOCs.** PCE was not detected above residential soil screening levels (SSLs) in any soil samples collected from SWMU 51 or in downgradient well 51MW2 indicating that the SWMU 51 is not the source of PCE detected in well 51MW1.

**Metals.** Aluminum and antimony were both detected above groundwater screening levels in well 51MW1 (aluminum in 51MW2 also); however, the results were flagged “B,” indicating blank contamination. Iron concentrations exceeded its secondary MCL in well 51MW1, but were below the secondary MCL and tw-RBC in downgradient well 51MW2. Manganese was only detected above background in 1 of 38 soil samples collected at the site and did not exceed its tw-RBC or secondary MCL in downgradient well 51MW2. Based on these findings aluminum, antimony, iron, and manganese are not considered a concern in groundwater at the site.

**Dioxins/furans.** OCDD was the only dioxin/furan congener detected in either well (51MW1).

#### **4.4.2.2 2007 Investigation Groundwater Sampling**

Groundwater results from the August 2007 sampling event indicated that organics (most notably, explosives) were not detected in groundwater downgradient of SWMU 51 and are not a concern in groundwater at the site. Aluminum and iron were detected above secondary MCLs and chromium was detected slightly above the tw-RBC in the two wells. Perchlorate concentrations were below the tw-RBC.

#### **4.4.2.3 Soil Screening Level Comparison**

As shown in **Table 4-14** chemical concentrations detected soil samples collected from the SWMU 51 study area 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, five VOCs [benzene, chloroform, PCE, toluene, and trichloroethene (TCE)]; three PAHs [benz(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene]; one SVOC (2,4-dinitrophenol); four explosives (1,3-DNB, 2,4-DNT, 2,6-DNT, and nitrobenzene); and, three TAL metals (chromium, manganese, and thallium) 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 *Sections 3.2 and 3.3*, groundwater samples were collected from monitoring wells associated with SWMU 51 in 2006 and 2007 and analyzed for TCL VOCs, TCL SVOCs, PAHs, TCL pesticides/PCBs, explosives, TAL metals, and dioxins/furans. Results indicated that one VOC (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 analytes found to exceed both SSLs and groundwater screening criteria at SWMU 51 were PCE, chromium (one groundwater sample), and manganese. PCE was not detected in any soil samples collected either below the trench sludge material or deep soil at the site or in downgradient wells indicating that the SWMU 51 is not the source of PCE. Chromium and manganese were detected below the established background concentration in all soil samples collected either below the trench sludge material or deep soil at the site. Chromium was the only metal that slightly exceeded its tw-RBC in one downgradient well indicating that these two metals are not a concern at the site.

**Table 4-14**  
**Summary of SSL Exceedances in Soil at SWMU 51**  
Page 1 of 2

| Analyte                                        | Background | SSL Transfer | # of Background Exceedances | # of SSL Transfer Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|------------------------------------------------|------------|--------------|-----------------------------|-------------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| <b>VOCs (ug/kg)</b>                            |            |              |                             |                               |                 |              |                       |                       |                     |
| 1,1,1-Trichloroethane                          | na         | 32000        | na                          | 0                             | 4               | 38           | 1.7                   | 49                    | 51SB3B              |
| 2-Butanone                                     | na         | 29000        | na                          | 0                             | 6               | 38           | 5.6                   | 9.4                   | 51SB6C              |
| 2-Hexanone                                     | na         | na           | na                          | na                            | 4               | 38           | 6.2                   | 21                    | 51SB4B              |
| 4-Methyl-2-pentanone                           | na         | 59000        | na                          | 0                             | 7               | 38           | 4.4                   | 160                   | 51SB3B              |
| Acetone                                        | na         | 22000        | na                          | 0                             | 34              | 38           | 5.3                   | 110                   | 51SB2A              |
| Benzene                                        | na         | 1.9          | na                          | 5                             | 5               | 38           | 2.7                   | 190                   | 51SB3B              |
| Chloroform                                     | na         | 0.91         | na                          | 1                             | 1               | 38           | 6.9                   | 6.9                   | 51SB3B              |
| Chloromethane                                  | na         | na           | na                          | na                            | 1               | 38           | 2.8                   | 2.8                   | 51SB6D              |
| Ethylbenzene                                   | na         | 15000        | na                          | 0                             | 3               | 38           | 24                    | 46                    | 51SB3B              |
| m- & p-Xylene                                  | na         | 3000         | na                          | 0                             | 5               | 38           | 5.5                   | 140                   | 51SB3B              |
| Methylene chloride                             | na         | 19           | na                          | 0                             | 28              | 38           | 1.1                   | 16                    | 51SB3B              |
| o-Xylene                                       | na         | 3000         | na                          | 0                             | 5               | 38           | 2.7                   | 39                    | 51SB3B              |
| Styrene                                        | na         | 57000        | na                          | 0                             | 6               | 38           | 2.3                   | 3.1                   | 51SB7B              |
| Tetrachloroethene                              | na         | 4.7          | na                          | 3                             | 3               | 38           | 9.3                   | 15                    | 51SB3B              |
| Toluene                                        | na         | 27000        | na                          | 1                             | 8               | 38           | 1.4                   | 51000                 | 51SB3B              |
| Trichloroethene                                | na         | 0.26         | na                          | 6                             | 6               | 38           | 1.7                   | 32                    | 51SB3B              |
| <b>PAHs (ug/kg)</b>                            |            |              |                             |                               |                 |              |                       |                       |                     |
| 2-Methylnaphthalene                            | na         | 4400         | na                          | 0                             | 1               | 34           | 20                    | 20                    | 51SB10A             |
| Benz(a)anthracene                              | na         | 480          | na                          | 1                             | 2               | 34           | 36                    | 900                   | 51SB6B              |
| Benzo(a)pyrene                                 | na         | 120          | na                          | 1                             | 2               | 34           | 13                    | 950                   | 51SB6B              |
| Benzo(b)fluoranthene                           | na         | 1500         | na                          | 1                             | 2               | 34           | 54                    | 1600                  | 51SB6B              |
| Benzo(g,h,i)perylene                           | na         | 680000       | na                          | 0                             | 2               | 34           | 48                    | 590                   | 51SB6B              |
| Benzo(k)fluoranthene                           | na         | 15000        | na                          | 0                             | 2               | 34           | 70                    | 820                   | 51SB6B              |
| Chrysene                                       | na         | 48000        | na                          | 0                             | 2               | 34           | 75                    | 1300                  | 51SB6B              |
| Dibenz(a,h)anthracene                          | na         | 460          | na                          | 0                             | 1               | 34           | 85                    | 85                    | 51SB8A              |
| Fluoranthene                                   | na         | 6300000      | na                          | 0                             | 6               | 34           | 11                    | 3300                  | 51SB6B              |
| Indeno(1,2,3-cd)pyrene                         | na         | 4200         | na                          | 0                             | 2               | 34           | 59                    | 540                   | 51SB6B              |
| Naphthalene                                    | na         | 150          | na                          | 0                             | 1               | 34           | 14                    | 14                    | 51SB10A             |
| Phenanthrene                                   | na         | 680000       | na                          | 0                             | 25              | 34           | 8.9                   | 1300                  | 51SB6B              |
| Pyrene                                         | na         | 680000       | na                          | 0                             | 6               | 34           | 7.9                   | 2300                  | 51SB6B              |
| <b>SVOCs (ug/kg)</b>                           |            |              |                             |                               |                 |              |                       |                       |                     |
| 2,4-Dinitrophenol                              | na         | 0            | na                          | 1                             | 1               | 38           | 550                   | 550                   | 51SB4C              |
| 2,4-Dinitrotoluene                             | na         | 570          | na                          | 18                            | 27              | 38           | 130                   | 48000000              | 51SB3B              |
| 2,6-Dinitrotoluene                             | na         | 250          | na                          | 18                            | 25              | 38           | 44                    | 11000000              | 51SB3B              |
| 2-Nitroaniline                                 | na         | na           | na                          | na                            | 2               | 38           | 77                    | 45000                 | 51SB6B              |
| 4,6-Dinitro-2-methylphenol                     | na         | na           | na                          | na                            | 6               | 38           | 140                   | 2700                  | 51SB3C              |
| bis(2-Ethylhexyl)phthalate                     | na         | 2900000      | na                          | 0                             | 10              | 38           | 47                    | 32000                 | 51SB4B              |
| Diethylphthalate                               | na         | 450000       | na                          | 0                             | 3               | 38           | 1200                  | 440000                | 51SB6B              |
| Di-n-butylphthalate                            | na         | 5000000      | na                          | 0                             | 6               | 38           | 81                    | 6800                  | 51SB6B              |
| Fluoranthene                                   | na         | 6300000      | na                          | 0                             | 1               | 38           | 2500                  | 2500                  | 51SB6B              |
| N-nitrosodiphenylamine                         | na         | 760          | na                          | 0                             | 1               | 38           | 45                    | 45                    | 51SB7B              |
| Pyrene                                         | na         | 680000       | na                          | 0                             | 1               | 38           | 2000                  | 2000                  | 51SB6B              |
| <b>Pesticides (ug/kg)</b> <i>None detected</i> |            |              |                             |                               |                 |              |                       |                       |                     |
| <b>PCBs (mg/kg)</b> <i>None detected</i>       |            |              |                             |                               |                 |              |                       |                       |                     |
| <b>Explosives (mg/kg)</b>                      |            |              |                             |                               |                 |              |                       |                       |                     |
| 1,3,5-Trinitrobenzene                          | na         | na           | na                          | na                            | 22              | 38           | 0.04                  | 850                   | 51SB6B              |
| 1,3-Dinitrobenzene                             | na         | 0.037        | na                          | 18                            | 18              | 38           | 0.06                  | 460                   | 51SB2B              |
| 2,4,6-Trinitrotoluene                          | na         | na           | na                          | na                            | 35              | 38           | 0.04                  | 61000                 | 51SB6B              |
| 2,4-Dinitrotoluene                             | na         | 0.57         | na                          | 26                            | 33              | 38           | 0.03                  | 44000                 | 51SB3B              |
| 2,6-Dinitrotoluene                             | na         | 0.25         | na                          | 28                            | 30              | 38           | 0.07                  | 11000                 | 51SB3B              |
| 2-amino-4,6-Dinitrotoluene                     | na         | na           | na                          | na                            | 2               | 38           | 0.05                  | 32                    | 51SB3C              |
| 2-Nitrotoluene                                 | na         | na           | na                          | na                            | 31              | 38           | 0.17                  | 25000                 | 51SB3B              |
| 3-Nitrotoluene                                 | na         | na           | na                          | na                            | 27              | 38           | 0.22                  | 2100                  | 51SB3B              |

**Table 4-14**  
**Summary of SSL Exceedances in Soil at SWMU 51**  
Page 2 of 2

| Analyte                       | Background | SSL Transfer | # of Background Exceedances | # of SSL Transfer Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|-------------------------------|------------|--------------|-----------------------------|-------------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| 4-Nitrotoluene                | na         | na           | na                          | na                            | 30              | 38           | 0.15                  | 16000                 | 51SB3B              |
| Nitrobenzene                  | na         | 0.023        | na                          | 11                            | 11              | 38           | 0.07                  | 0.93                  | 51SB3C              |
| RDX                           | na         | na           | na                          | na                            | 12              | 38           | 0.3                   | 7.2                   | 51SB3D              |
| Nitroglycerin                 | na         | na           | na                          | na                            | 2               | 38           | 6.7                   | 3300                  | 51SB6B              |
| PETN                          | na         | na           | na                          | na                            | 1               | 38           | 62                    | 62                    | 51SB5B              |
| <b>Herbicides (ug/kg)</b>     |            |              |                             |                               |                 |              |                       |                       |                     |
| <i>None detected</i>          |            |              |                             |                               |                 |              |                       |                       |                     |
| <b>Metals (mg/kg)</b>         |            |              |                             |                               |                 |              |                       |                       |                     |
| Aluminum                      | 40041      | na           | 0                           | na                            | 38              | 38           | 8620                  | 29700                 | 51SB2B              |
| Antimony                      | na         | 13           | na                          | 0                             | 22              | 38           | 0.47                  | 6                     | 51SB2B              |
| Arsenic                       | 15.8       | 0.026        | 0                           | 0                             | 38              | 38           | 0.96                  | 15.3                  | 51SB3B              |
| Barium                        | 209        | 6000         | 0                           | 0                             | 38              | 38           | 26.3                  | 177                   | 51SB3B              |
| Beryllium                     | 1.02       | 1200         | 9                           | 0                             | 38              | 38           | 0.33                  | 2.5                   | 51SB11C             |
| Cadmium                       | 0.69       | 27           | 6                           | 0                             | 26              | 38           | 0.04                  | 6.5                   | 51SB2B              |
| Calcium                       | na         | na           | na                          | na                            | 38              | 38           | 24.8                  | 29600                 | 51SB6B              |
| Chromium                      | 65.3       | 42           | 5                           | 5                             | 38              | 38           | 10.8                  | 533                   | 51SB5B              |
| Cobalt                        | 72.3       | na           | 3                           | na                            | 38              | 38           | 3.2                   | 179                   | 51SB7B              |
| Copper                        | 53.5       | 11000        | 6                           | 0                             | 38              | 38           | 0.59                  | 360                   | 51SB6B              |
| Iron                          | 50962      | na           | 6                           | na                            | 38              | 38           | 11500                 | 191000                | 51SB2B              |
| Lead                          | 26.8       | na           | 7                           | na                            | 38              | 38           | 0.75                  | 4180                  | 51SB6B              |
| Magnesium                     | na         | na           | na                          | na                            | 38              | 38           | 483                   | 22200                 | 51SB1C              |
| Manganese                     | 2543       | 950          | 1                           | 1                             | 38              | 38           | 140                   | 3590                  | 51SB7B              |
| Mercury                       | 0.13       | na           | 6                           | na                            | 18              | 38           | 0.023                 | 1.1                   | 51SB3B              |
| Nickel                        | 62.8       | na           | 5                           | na                            | 38              | 38           | 4.2                   | 129                   | 51SB2B              |
| Potassium                     | na         | na           | na                          | na                            | 38              | 38           | 360                   | 3090                  | 51SB3D              |
| Selenium                      | na         | 19           | na                          | 0                             | 10              | 38           | 0.17                  | 1.9                   | 51SB2B              |
| Silver                        | na         | 31           | na                          | 0                             | 5               | 38           | 0.24                  | 0.73                  | 51SB3B              |
| Sodium                        | na         | na           | na                          | na                            | 38              | 38           | 61.9                  | 3060                  | 51SB4B              |
| Thallium                      | 2.11       | 3.6          | 6                           | 5                             | 20              | 38           | 0.56                  | 11.7                  | 51SB2B              |
| Vanadium                      | 108        | 730          | 0                           | 0                             | 38              | 38           | 8.8                   | 66.1                  | 51SB7B              |
| Zinc                          | 202        | 14000        | 4                           | 0                             | 38              | 38           | 14.2                  | 573                   | 51SB6B              |
| <b>Dioxins/Furans (ng/kg)</b> |            |              |                             |                               |                 |              |                       |                       |                     |
| 2,3,7,8-TCDF                  | na         | na           | na                          | na                            | 9               | 20           | 0.37                  | 160                   | 51SB3B              |
| 2,3,7,8-TCDD                  | na         | 8.6          | na                          | 0                             | 6               | 20           | 0.24                  | 4.5                   | 51SB2B              |
| 1,2,3,7,8-PECDD               | na         | na           | na                          | na                            | 4               | 20           | 4.6                   | 27                    | 51SB6B              |
| 1,2,3,4,7,8-HXCDD             | na         | na           | na                          | na                            | 5               | 20           | 10                    | 46                    | 51SB6B              |
| 1,2,3,6,7,8-HXCDD             | na         | na           | na                          | na                            | 5               | 20           | 51                    | 120                   | 51SB6B              |
| 1,2,3,7,8,9-HXCDD             | na         | na           | na                          | na                            | 5               | 20           | 24                    | 86                    | 51SB6B              |
| 1,2,3,4,6,7,8-HPCDD           | na         | na           | na                          | na                            | 16              | 20           | 1.7                   | 2800                  | 51SB6B              |
| OCDD                          | na         | na           | na                          | na                            | 18              | 20           | 2.2                   | 23000                 | 51SB6B              |
| 1,2,3,7,8-PECDF               | na         | na           | na                          | na                            | 5               | 20           | 22                    | 43                    | 51SB4B              |
| 2,3,4,7,8-PECDF               | na         | na           | na                          | na                            | 5               | 20           | 49                    | 90                    | 51SB3B              |
| 1,2,3,4,7,8-HXCDF             | na         | na           | na                          | na                            | 5               | 20           | 74                    | 130                   | 51SB6B              |
| 1,2,3,6,7,8-HXCDF             | na         | na           | na                          | na                            | 5               | 20           | 22                    | 41                    | 51SB6B              |
| 2,3,4,6,7,8-HXCDF             | na         | na           | na                          | na                            | 5               | 20           | 26                    | 52                    | 51SB6B              |
| 1,2,3,7,8,9-HXCDF             | na         | na           | na                          | na                            | 5               | 20           | 10                    | 17                    | 51SB4B              |
| 1,2,3,4,6,7,8-HPCDF           | na         | na           | na                          | na                            | 9               | 20           | 1                     | 970                   | 51SB6B              |
| 1,2,3,4,7,8,9-HPCDF           | na         | na           | na                          | na                            | 5               | 20           | 31                    | 55                    | 51SB6B              |
| OCDF                          | na         | na           | na                          | na                            | 11              | 20           | 2.1                   | 2400                  | 51SB6B              |
| TOTAL TCDD                    | na         | na           | na                          | na                            | 5               | 20           | 0.26                  | 8.9                   | 51SB6B              |
| TOTAL PECDD                   | na         | na           | na                          | na                            | 5               | 20           | 2.6                   | 100                   | 51SB6B              |
| TOTAL HXCDD                   | na         | na           | na                          | na                            | 11              | 20           | 1.5                   | 780                   | 51SB6B              |
| TOTAL HPCDD                   | na         | na           | na                          | na                            | 16              | 20           | 2.9                   | 4900                  | 51SB6B              |
| TOTAL TCDF                    | na         | na           | na                          | na                            | 10              | 20           | 0.22                  | 690                   | 51SB2B              |
| TOTAL PECDF                   | na         | na           | na                          | na                            | 6               | 20           | 1.4                   | 600                   | 51SB5B              |
| TOTAL HXCDF                   | na         | na           | na                          | na                            | 7               | 20           | 4.1                   | 1400                  | 51SB6B              |
| TOTAL HPCDF                   | na         | na           | na                          | na                            | 9               | 20           | 1                     | 2900                  | 51SB6B              |

#### 4.4.2.4 Nature and Extent Conclusions

**Soil.** As shown on **Figures 2-3 and 4-1**, several borings have been advanced and representative samples have been collected to fully delineate the trench and characterize the site. Chemical results indicate that VOCs, non-explosive SVOCs, pesticides, PCBs, herbicides, and dioxins/furans are not a concern at the study area. With the exception of a single industrial exceedance of manganese in native soil outside the trench, there were no industrial screening level exceedances in soil samples collected from the clean fill overlying the trench or in soil below the trench sludge material; therefore, these two areas are not a concern at the site.

The main concern at the site is the trench sludge material and grossly contaminated soil immediately below the sludge material. The main parameters of concern are explosives and metals predominantly found in the trench sludge material.

**Groundwater.** Three groundwater sampling events have occurred in the vicinity of SWMU 51. Groundwater results from the April 2006 and August 2007 sampling events indicated that PCE, aluminum, antimony, chromium, iron, and manganese were detected at concentrations exceeding groundwater screening levels in SWMU 51 downgradient wells. Explosives were not detected in any of the groundwater samples, indicating that explosives have not migrated downward from the trench sludge material at SWMU 51. PCE was only detected in one of four close downgradient wells at a concentration below the MCL.

#### 4.5 Conceptual Site Model

A site-specific CSM was developed for SWMU 51 in MWP Addendum 017 (Shaw, 2004) to identify potential contaminant sources, exposure pathways, and human and ecological receptors. Each media type potentially present at the site (i.e., surface and subsurface soil) was evaluated to assess whether human (site worker) or biotic (terrestrial) receptors would be impacted by contamination. Three exposure routes (ingestion, inhalation and dermal absorption) were evaluated for each media type. Historical site use information was employed to identify types of potential contamination and locations of potentially contaminated areas. Site topography and physical land features, such as creeks, or drainage ditches, were used to approximate contaminant migration pathways.

As described in *Section 3.0*, sampling locations were selected based on preliminary geophysical data, site visit observations, negotiations with regulators, and the CSM. Based on the evaluation of the SWMU 51 data (*Section 4.4*), changes to the CSM were not required. Three additional human receptors (i.e., excavation worker and adult and child residents) were considered, based on comments from regulators on previous RFI reports. The revised CSM is presented as **Table 4-15**.

**Table 4-15**  
**Potential Exposure Pathways and Receptors - SWMU 51**

| Media           | Potentially Affected Media | Exposure Pathways and Media |                   |                        |             | Comments                                                       |
|-----------------|----------------------------|-----------------------------|-------------------|------------------------|-------------|----------------------------------------------------------------|
|                 |                            | Humans                      |                   |                        | Biota       |                                                                |
|                 |                            | Maintenance Worker          | Excavation Worker | Resident (adult/child) | Terrestrial |                                                                |
| Surface Soil    | Yes                        | IN, INH, DA                 | IN, INH, DA       | IN, INH, DA            | IN, INH, DA | Inhalation of dust. During construction activity, burrowing.   |
| Surface Water   | No                         | ---                         | ---               | ---                    | ---         | Not present at the site. No groundwater discharge at the site. |
| Sediment        | No                         | ---                         | ---               | ---                    | ---         | Not present at the site. No groundwater discharge at the site. |
| Subsurface Soil | Yes                        | IN, INH, DA                 | IN, INH, DA       | IN, INH, DA            | ---         | During construction activity, future land use.                 |
| Groundwater     | Yes                        | IN, DA                      | IN, DA            | IN, DA                 | ---         | Potential future use of groundwater.                           |

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

## 5.0 CONTAMINANT FATE AND TRANSPORT

### 5.1 Physical and Chemical Properties of Soil at SWMU 51

Physical and chemical properties of the impacted media and of the contaminant(s) affect the fate and persistence of contamination in the environment (Rosenblatt, 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**. Samples were collected from SWMU 51 during the 2004 RFI and analyzed for chemical and physical parameters to assess the site soil characteristics. Results from the geotechnical data are presented in **Table 5-1**. A summary of grain size distribution, pH, and TOC 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. 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 cations and to retain soil moisture. The sludge lining the bottom of SWMU 51 was mainly clay-based as well as the subsoil beneath it being red clay. Therefore, chemical compounds should not be able to easily pass through the soil. 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. Clays also have weak electrical charges, which retard some COCs like metals. This, in turn, can affect Redox values and eH.

Soil grain size distribution results indicated that the soil at SWMU 51 is primarily silt, clay, and fine sands, with an average distribution of 1.5% gravel, 5.7% coarse sand, 14.1% medium sand, 35.1% fine sand, and 40.4% silt and clay. Therefore, the grain size distribution at SWMU 51 is poorly-sorted and should have a fairly low permeability.

**Soil pH.** Soil pH is a measure of acidity or alkalinity and is an important chemical property because it is an indication of the reaction potential. The reaction potential influences the fate of many pollutants, affecting their breakdown and potential movement. 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 (pKa), 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 ranges in pH from 4.0 to 9.61, with a median of 6.48. A review of pH results during the *Facility Wide Background Study* across soil types at the HSA did not yield outstanding trends. Higher soil pH results were generally associated with limestone and shale parent material. (IT, 2001).

Table 5-1  
Geotechnical Laboratory Data Summary

| Sample ID | Depth<br>(ft) | Soil Moisture<br>Content | Atterberg Limits |                  |                  | USCS<br>Symbol<br>(1) | TOC                                    | pH                 |                            | Soil Porosity                      | Bulk Density                     |                         | Calculated Soil Porosities |                      |                        | Hydraulic Conductivity   | Silt/Clay | % Fine Sand | % Medium Sand | % Coarse Sand | Gravel |
|-----------|---------------|--------------------------|------------------|------------------|------------------|-----------------------|----------------------------------------|--------------------|----------------------------|------------------------------------|----------------------------------|-------------------------|----------------------------|----------------------|------------------------|--------------------------|-----------|-------------|---------------|---------------|--------|
|           |               | Water Content<br>(%)     | Liquid<br>Limit  | Plastic<br>Limit | Plastic<br>Index |                       | Organic<br>Content<br>(burnoff)<br>(%) | Distilled<br>Water | 0.01 M<br>CaCl<br>Solution | Soil<br>Particle<br>Density<br>(-) | Soil<br>Bulk<br>Density<br>(pcf) | Dry<br>Density<br>(pcf) | Total<br>(-)               | Air<br>Filled<br>(-) | Water<br>Filled<br>(-) | Permeability<br>(cm/sec) |           |             |               |               |        |
| 51SB3A    | 0-1           |                          |                  |                  |                  |                       |                                        |                    |                            |                                    | 90.9                             |                         |                            |                      |                        |                          |           |             |               |               |        |
|           | 0.25          | 19.2                     | 33               | 16               | 17               | SC                    | 3.9                                    | 5.0                | 4.2                        | 2.702                              | 122.7                            | 102.9                   | 0.39                       | 0.05                 | 0.34                   | 1.4E-05                  | 37.6      | 41.8        | 13.1          | 2.6           | 2.6    |
|           | 0.5           | 17.7                     |                  |                  |                  |                       |                                        |                    |                            |                                    |                                  |                         |                            |                      |                        |                          |           |             |               |               |        |
| 51SB3B    | 13-14         |                          |                  |                  |                  |                       |                                        |                    |                            |                                    | 83.2                             |                         |                            |                      |                        |                          |           |             |               |               |        |
|           | 13.2          | 155.3                    |                  |                  |                  |                       |                                        |                    |                            |                                    |                                  |                         |                            |                      |                        |                          |           |             |               |               |        |
|           | 13.75         | 175.3                    |                  |                  |                  |                       |                                        |                    |                            |                                    |                                  |                         |                            |                      |                        |                          |           |             |               |               |        |
|           | 14            | 145.4                    | 78               | 64               | 14               | OH                    | 30.4                                   | 7.8                | 7.2                        | 2.806                              | 84.4                             | 34.4                    | 0.80                       | 0.00                 | 0.80                   | 5.0E-08                  | 69.2      | 24.6        | 3.1           | 1             | 0      |
| 51SB3C    | 15-16         |                          |                  |                  |                  |                       |                                        |                    |                            |                                    | 113.9                            |                         |                            |                      |                        |                          |           |             |               |               |        |
|           | 15.6          | 8.7                      |                  |                  |                  |                       |                                        |                    |                            |                                    |                                  |                         |                            |                      |                        |                          |           |             |               |               |        |
|           | 15.85         | 15.8                     | np               | np               | np               | SP-SM                 | 1.5                                    | 5.9                | 5.7                        | 2.659                              | 117.5                            | 101.4                   | 0.39                       | 0.09                 | 0.30                   | 2.2E-05                  | 23.7      | 45          | 23            | 4             | 3.5    |
| 51SB3D    | 37-38         |                          |                  |                  |                  |                       |                                        |                    |                            |                                    | 92.4                             |                         |                            |                      |                        |                          |           |             |               |               |        |
|           | 37.5          | 37.4                     |                  |                  |                  |                       |                                        |                    |                            |                                    |                                  |                         |                            |                      |                        |                          |           |             |               |               |        |
|           | 37.75         | 65.2                     | 44               | 38               | 6                | SM                    | 1.7                                    | 5.9                | 5.1                        | 2.734                              | 97.0                             | 58.7                    | 0.66                       | 0.02                 | 0.64                   | 1.4E-05                  | 31        | 29          | 17.3          | 15.2          | 0      |

Notes: (1) USCS symbol based on visual observation and Atterberg Limits reported.

Soil pH results from SWMU 51 ranged from 5.0 to 7.8, with an average pH of 6.15. The pH value of 7.8 was measured in the trench sludge material. A pH value of 7.8 indicates that trench sludge material is relatively neutral, which inhibits the mobility of metals found in this material. This is indicated by the lack of metals found above screening levels in soil below the trench floor.

**Total Organic Content.** 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 varies dependent on the properties of the chemical itself.

TOC concentrations in soil at RFAAP range in from 0.075% to 30.4%, with a median value of 1.5%. TOC soil results from samples at SWMU 51 ranged from 1.5% to 30.4%, with an average concentration of 9.4%. The TOC of the sludge material was 30.4%. Therefore, in general, most contaminants will not pass through these layers with the greatest of ease.

## **5.2 Fate and Transport of Compounds at SWMU 51**

This section presents a discussion of the fate and transport of the chemicals identified in the nature and extent assessment as exceeding both the residential screening level and the established background concentrations (metals) (IT, 2001).

As discussed in *Section 4.0*, eight metals (antimony, cadmium, chromium, copper, iron, lead, manganese, and thallium), five PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene], and ten explosives (1,3,5-TNB, 1,3-DNB, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, 2-amino-4,6-DNT, 2- and 4-nitrotoluene, RDX, and NG) were detected at concentrations exceeding residential and facility-wide background (metals) screening levels. A generalized fate and transport discussion for these constituents is presented in *Section 5.2.1*. A detailed evaluation of groundwater sampling results to assess the site-specific fate and transport observed at SWMU 51 is presented in *Section 5.2.2*.

### **5.2.1 Generalized Fate and Transport of Constituents Above Screening Criteria**

#### **5.2.1.1 Metals**

Eight metals (antimony, cadmium, chromium, copper, iron, lead, manganese, and thallium) were detected in soil samples with concentrations exceeding residential and facility-wide background screening levels. Specific characteristics of metals with concentrations found to exceed residential screening levels are discussed in more detail in the following sections.

**Antimony.** Antimony (Sb) was detected above the residential screening level of 3.1 milligrams per kilogram (mg/kg) in five samples. The residential screening level exceedances occurred in four trench sludge material samples (51SB2B, 51SB4B, 51SB5B, and 51SB6B) at concentrations

ranging from 3.7 mg/kg (51SB6B) to 6 mg/kg (51SB2B). Antimony was not detected above residential screening levels in the samples collected from soil above or below the sludge material or from outside of the trench limits. Industrial screening levels for antimony were not exceeded in soil samples collected from the site. Because antimony was not detected during the Facility-Wide Background Study, there is no background value established for antimony at RFAAP (IT, 2001).

Antimony exists in the +3 oxidation state under reducing conditions, which are prevalent in SWMU 51 soil. The dominant species under these conditions is  $\text{Sb(OH)}_3^0$ . Because most antimony compounds are highly soluble, antimony concentrations in soil are usually not solubility-limited (Rai et al., 1984). Therefore, adsorption may play an important role in limiting antimony mobility at the SWMU 51 study area. This mechanism appears to be effectively preventing migration of antimony from the sludge, based on the low levels of antimony observed in soil under the sludge material (maximum concentration of 0.8 mg/kg).

**Cadmium.** Cadmium (Cd) exceeded the residential screening level of 3.9 mg/kg in four trench sludge material samples at concentrations ranging from 5.0 mg/kg (51SB6B) to 6.5 mg/kg (51SB2B). The established background value for cadmium is 0.69 mg/kg (IT, 2001). No samples contained cadmium above the industrial screening level of 51 mg/kg. Cadmium was not detected above background in samples collected from soil above or below the sludge material or from outside of the trench limits.

Clay content, levels of humic and fulvic acids, cation-exchange capacity, and alkalinity are factors in controlling Cd transport in soil (USEPA, 1997a and **Appendix D**). Dissolved organic material and hydroxides, such as iron and manganese, are responsible for the adsorption of the Cd ion. The cation exchange capacity, pH of the soil, and the solution pH play a significant role in controlling both adsorption and precipitation of Cd.

The pH of the surface soil in the SWMU 51 study area is 6.15. At this pH, cadmium would tend to be in the  $\text{Cd}^{+2}$  state rather than the  $\text{Cd(OH)}_2$  state. The slightly acidic pH in site soil would favor the precipitation of cadmium onto surface soil. As  $\text{Cd}^{+2}$ , cadmium would have a tendency to adsorb to clayey soil. The pH values detected in soil at SWMU 51 (6.15) do not exceed the lower critical threshold ( $\text{pH} < 5$ ) that inhibits mobilization and migration. The lack of deep soil detections suggests that the high clay and silt content of soil at the site inhibit vertical migration of cadmium.

Although some transport of cadmium may occur as stormwater runoff, the physical data suggests that cadmium is not being transported to a significant extent based on the low levels of cadmium observed in the soil under the sludge material (less than background). It is possible that acid rain might cause the cadmium to mobilize as a dissolved metal. Due to the limited vertical migration, it is unlikely that cadmium would migrate to a deep bedrock aquifer potentially present under the site and therefore, would not be expected to impact groundwater.

**Chromium.** Chromium (Cr) was detected above the chromium VI residential screening level (23 mg/kg), industrial screening level (310 mg/kg), and background (65.3 mg/kg) in five trench sludge samples at concentrations ranging from 218 mg/kg (51SB4B) to 533 mg/kg (51SB5B). In addition, the industrial screening level of 310 mg/kg was exceeded in four of the samples. Chromium was not detected above background in samples collected from the soil above or below the sludge material or from outside of the trench limits. Because chromium was not speciated during analysis, the screening level for chromium VI was applied as a conservative measure.

The residential screening level value for chromium III is 23,000 mg/kg. No samples, including those collected from the trench sludge material, contained concentrations of chromium that exceeded the chromium III residential screening level.

Chromium exists in two valence states in the environment: trivalent (Cr III) or hexavalent (Cr VI). Typically, Cr (III) in an aqueous environment would be associated with particles, while Cr (VI) would remain in solution. The valence state of chromium is dependent on the pH. Adsorption of Cr (III) will occur at slightly acidic pHs. Site surface soil pH was measured at 6.15, making it slightly acidic with increased adsorption and decreased mobility of chromium. The mobility of chromium is further inhibited and adsorption increased by soil with high clay content, like the subsurface soil found at SWMU 51. It is assumed that the chromium in the soil at this site would be Cr III.

**Copper.** Copper (Cu) was detected in one trench sludge sample (51SB6B) at a concentration of 360 mg/kg, which exceeds the residential screening level (310 mg/kg) and background (53.5 mg/kg), but is below the industrial screening level of 4,100 mg/kg. Copper was not detected above background in samples collected from soil above or below the sludge material or from soil outside of the trench limits.

Copper 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.

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 samples collected at SWMU 51 are slightly acidic (pH 6.15). At this pH, the presence of copper in solution will increase the concentration of ionic copper and impact microorganism populations.

**Iron.** Iron (Fe) was detected above the residential (2,300 mg/kg) and industrial screening (31,000 mg/kg) in every sample collected from the trench sludge material at concentrations ranging from 156,000 mg/kg (51SB5B) to 191,000 mg/kg (51SB2B). In addition, iron was detected (51,100 mg/kg) above the residential screening level in one deep soil sample (51SB8C) collected outside the trench limits at a depth of 36-38 ft bgs. The established background value for iron is 50,962 mg/kg (IT, 2001). No other sample collected from soil above or below the sludge material or from outside of the trench limits contained iron above the established background concentration.

Corrosion (chemical and biological) of sludge containing metallic compounds is the primary environmental degradation process for iron at SWMU 51. Corrosion of iron is an electrochemical phenomenon in which ions go into solution (anodic reaction) and the electrons generated by the reaction diffuse through the metal to the cathode where they are consumed (cathodic reaction). Biologically induced corrosion occurs when microorganisms are able to initiate, facilitate, or accelerate the corrosion reaction without changing the electrochemical nature of the process.

The locations of anodes and cathodes on a metal surface area can be a grain size apart. The surface characteristics and oxygen availability vary slightly from one grain to another. At a

given time, therefore, some of the grains would act as anodes while others would act as cathodes. This condition may be reversed a fraction of a second later. This changing anodic and cathodic sites explains the occurrence of uniform corrosion over an entire area. Thus, when a piece of iron encounters a low pH environment, such as the soil at SWMU 51, the metal would tend to dissolve uniformly over its entire surface, the surface would become thinner, and would eventually fail. In general, biological activity that enhances or restricts either the anodic or cathodic reactions or permanently separates the reaction sites will promote corrosion.

Evaluation of the physical data indicates that iron is undergoing corrosion reactions at the SWMU 51 study area. Iron is anticipated to migrate from the surface to the subsurface where it is not anticipated to impact human health or ecological receptors.

**Lead.** Lead (Pb) was detected above its residential screening level (400 mg/kg), industrial screening level (800 mg/kg), and background (26.8 mg/kg) in every sample collected from the trench sludge material. Lead concentrations in the sludge material ranged from 1,850 mg/kg (51SB4B) to 4,180 mg/kg (51SB6B). With the exception of two soil samples (51SB7A and 51SB7B) collected from clean fill and/or native soil, lead was not detected above background in samples collected from soil above or below the sludge material or from outside of the trench limits.

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 the soil at the SWMU 51 study area.

Adsorption of lead increases with increasing pH with most lead precipitating out at a pH greater than 6 (USEPA, 1990). The average pH of the soil in the SWMU 51 study area is 6.15. Because lead was not detected above background in soil samples collected immediately below the trench floor or in deep subsurface soil samples, it is unlikely that lead will precipitate out of the sludge material in the trench. Therefore, lead is not expected to impact groundwater beneath SWMU 51.

**Manganese.** Manganese (Mn) was detected in one native soil sample (51SB7B) at a concentration of 3,590 mg/kg, which exceeds the residential screening level (160 mg/kg), industrial screening level (2,000 mg/kg), and background (2,543 mg/kg). This sample was collected outside the trench limits, south of the SWMU 51 trench at a depth of 8-10 ft bgs. Manganese was not detected above background in all remaining samples collected from the site.

Manganese is an essential element, in trace amounts, for plants and animals. The primary concerns for manganese in drinking water are its objectionable taste and its capacity to stain plumbing and laundry. Manganese comprises approximately 0.085% to 0.95% of the earth's crust at an average concentration of 950 mg/kg. Manganese in rocks and minerals is naturally released into the environment from weathering.

**Thallium.** Thallium (Tl) was detected above the residential screening level (0.55 mg/kg) and background (2.11 mg/kg) in every sample collected from the trench sludge material at concentrations ranging from 5.8 mg/kg (51SB5B) to 11.7 mg/kg (51SB2B). Thallium was also

detected above the industrial screening level (7.2 mg/kg) in two of the samples. In addition, thallium was detected above the residential screening level and background in one deep soil sample (51SB8C) collected outside the trench limits at a depth of 36-38 ft bgs. No other sample collected from soil above or below the sludge material or from outside of the trench limits contained thallium above the established background concentration. This indicates that elevated concentrations of thallium are limited to the trench sludge material.

Pure thallium is a bluish-white metal that is found in trace amounts in the earth's crust. In the past, thallium was obtained as a by-product from smelting other metals; however, it has not been produced in the United States since 1984. Currently, thallium is obtained from imports and from thallium reserves. Thallium stays in the air, water, and soil for a long time, as it does not readily biodegrade. Some thallium compounds are removed from the atmosphere in rain and snow. Thallium is absorbed by plants and thereby enters the food chain.

#### **5.2.1.2 PAHs**

Four PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene] were detected in one trench sludge sample, 51SB6B, [900, 950, 1,600, and 540 micrograms per kilogram ( $\mu\text{g/kg}$ ), respectively] above their residential screening levels (220, 22, 220, and 220  $\mu\text{g/kg}$ ). One PAH [dibenz(a,h)anthracene] was detected at a concentration of 85  $\mu\text{g/kg}$ , exceeding its residential screening level (22  $\mu\text{g/kg}$ ) in one native soil sample (51SB8A) collected outside the trench limits. In addition, benzo(a)pyrene exceeded its industrial screening level of 390  $\text{mg/kg}$  in trench sludge sample 51SB6B.

PAHs are a group of more than 100 organic compounds of two or more aromatic rings. As a general rule, when PAH compounds grow in molecular weight, their solubility in water decreases, solubility in fat tissues increases, and their melting and boiling points increase (Environment Canada, 1997). The solubility ranges of the PAHs detected at SWMU 51 indicate that the present PAHs are not soluble in water. PAHs were not detected in groundwater samples collected downgradient of the site indicating that PAHs have not migrated from the trench sludge material.

In addition, the vapor pressure ranges of the present PAHs indicate that these compounds do not readily volatilize into the atmosphere and this is further supported by the values of the Henry's law constants. The organic carbon/water partition coefficient ( $K_{oc}$ ) is a measure of the tendency of a chemical to be sorbed to the organic fraction of soil. The logarithm ( $\log_{10}$ ) of the  $K_{oc}$  values for the PAHs detected indicates that these PAHs have high sorption potentials and will not tend to leach into surface water runoff. This is further supported by the octanol/water partition coefficient,  $K_{ow}$ , which is an indication of whether a compound will dissolve in a solvent (i.e., n-octanol) or water. The PAHs detected at SWMU 51 are nonpolar and hydrophobic and, as mentioned above, will tend to sorb to soil rather than partition into the polar water phase.

#### **5.2.1.3 Explosives**

Ten explosives compounds (1,3,5-TNB, 1,3-DNB, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, 2-amino-4,6-DNT, 2- and 4-nitrotoluene, RDX, and NG) were detected above the residential and, with the exception of 1,3,5-TNB, 2-amino-4,6-DNT, and RDX, industrial screening levels at SWMU 51.

An unknown quantity of TNT neutralization sludge from the treatment of red water, a waste product generated during the production of TNT, was disposed of in this unlined trench in the 1970s. The sludge contains 2,4,6-TNT transformation products and other associated explosive

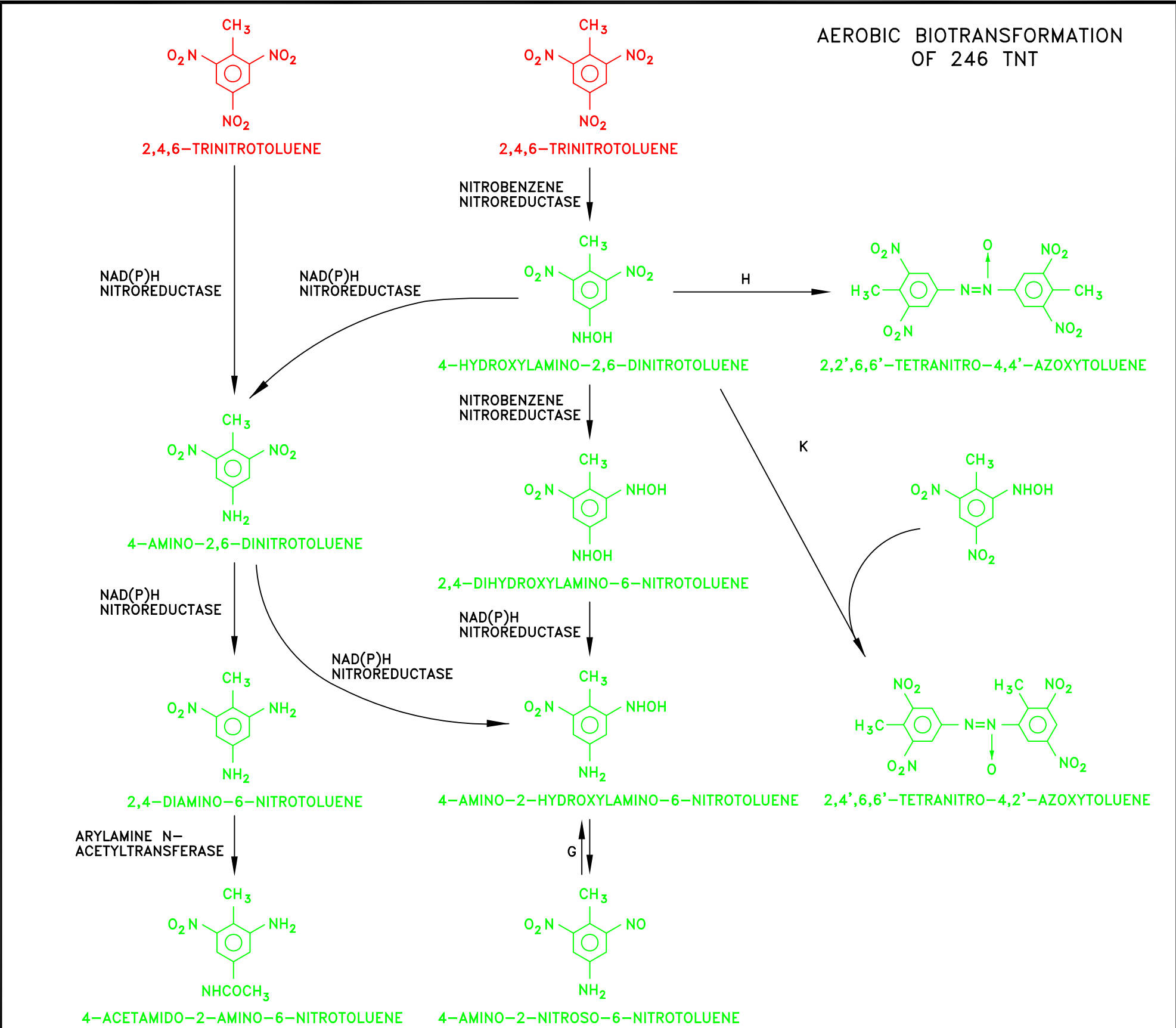
compounds. In addition to sludge disposal, an estimated 10 tons of red water ash was reportedly disposed of in the trench from 1968 to 1972. This material is created during the production and formulation of TNT and TNT containing formulations and products. Red water was concentrated by evaporation and the sludge was burned in rotary kilns located in the TNT manufacturing area (USATHAMA, 1976). The ash from the red water sludge produced from these kilns is known as red water ash. 2,6-DNT and 2,4-DNT are commonly found at former TNT production sites and in the wastewater from the commercial production of feedstocks for polyurethane foam (Popp and Leonard, 1985). One of the most common binary mixtures of TNT is cyclotols (mixtures with RDX) (Eveleth and Kollonitsch, 1990; Gibbs and Popolato, 1980). While not a constituent of red water or neutralization sludge, NG is an explosive compound with a history of use at RFAAP; therefore, it is assumed to be present from disposal practices that occurred in the 1960s through the 1970s.

The primary explosive compounds detected at SWMU 51 (TNT, DNT, RDX, and NG) are discussed in this section. The remaining explosive compounds (1,3,5-TNB, 1,3-DNB, 4-amino-2,6-DNT, and 2- and 4-nitrotoluene) are breakdown products of TNT, and their presence is considered evidence of the breakdown of this compound at SWMU 51. Therefore, their environmental fate is discussed by reference in the TNT discussion.

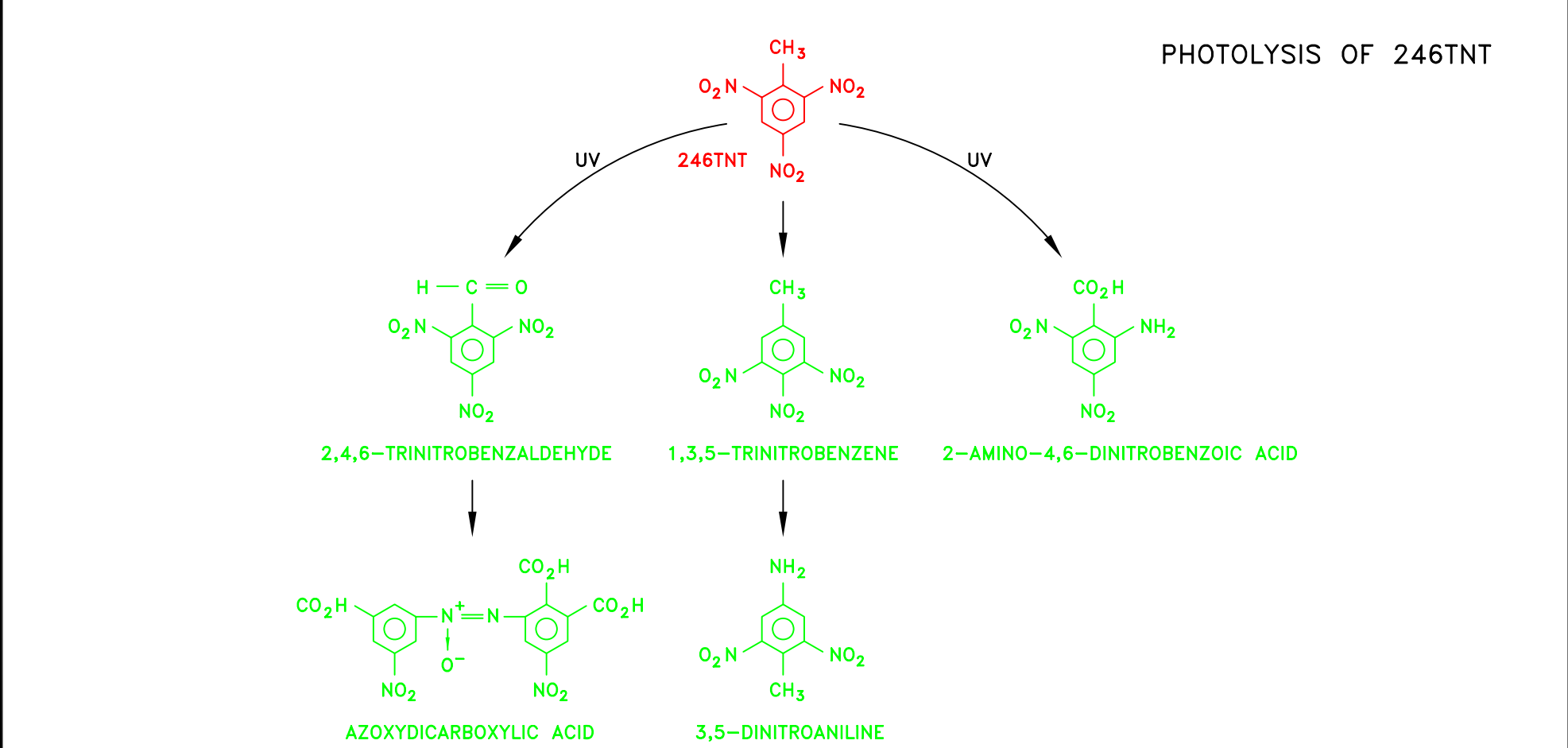
**TNT.** TNT was detected in 35 of 38 samples collected, at concentrations ranging from 0.04 mg/kg to 61,000 mg/kg. Fifteen samples had concentrations exceeding the residential screening level of 3.9 mg/kg, and eight had concentrations exceeding the industrial screening level of 51 mg/kg. While primarily detected in the trench sludge material, TNT was also detected in soil samples below the sludge material. However, as discussed in *Section 5.2.2*, migration of TNT from the sludge to groundwater has not occurred.

TNT is a munitions compound currently used for commercial and military purposes. The water solubility of TNT is 2 milligrams per liter (mg/L). Therefore, TNT is characterized as being insoluble in water. The vapor pressure of TNT is  $1.28 \times 10^{-6}$  millimeters mercury (mm Hg), which indicates that it will not volatilize to the atmosphere. This is further supported by the Henry's law constants, which for TNT is equal to  $1.10 \times 10^{-8}$  atm-m<sup>3</sup>/mole. The logarithm ( $\log_{10}$ ) of the organic carbon/water partition coefficient ( $K_{oc}$ ) is 0.43. This value indicates that TNT will not tend to sorb to the organic fraction of soil and will tend to leach into groundwater or surface water runoff. The logarithm of the octanol/water partition coefficient ( $K_{ow}$ ) is 2.06, which indicates that TNT will partition to the polar water phase instead of sorbing to soil.

TNT can be biotransformed, mineralized, or conjugated into higher molecular weight complex products. It has been shown that a reductive pathway exists for biotransformation of TNT (**Figure 5-1**) (McCormick et al., 1976; Carpenter et al., 1978; Kaplan and Kaplan 1982a-e, 1985; Kaplan et al., 1985; Greene et al., 1985). This pathway has been observed in a number of systems including aqueous, sewage, soil, and compost (Walker et al., 1992). Under anoxic conditions, one or more of the nitro groups is reduced through nitroso and hydroxylamino intermediates to form aminodinitrotoluenes (2-amino-4,6-DNT and 4-amino-2,6-DNT) and diaminonitrotoluenes (2,4-diamino-6-nitrotoluene and 2,6-diamino-4-nitrotoluene). Nitroaromatic compounds such as TNT are usually considered resistant to oxidation by oxygenase enzymes due to the presence of the electron withdrawing nitro groups on the ring. Carpenter, McCormick, Cornell, and Kaplan (1978) conducted experiments using radiolabeled TNT in an activated sludge system (aggressive, aerobic conditions) and found no indication of aromatic ring cleavage and mineralization of the TNT to carbon dioxide and water. The authors



SOURCE: UNIVERSITY OF MINNESOTA, 2001



SOURCE: BRANNON AND PENINGTON, 2002

postulated the one reason that TNT metabolites were not capable of subsequent degradation was the formation of polyamides (a general group of polymers) that are resistant to further microbial attack. However, recent laboratory-scale experiments conducted on TNT contaminated soil from Weldon Springs, Missouri show that aerobic microbiological mineralization of TNT can occur (Bradley and Chapelle, 1995). In addition, studies with fungal systems (*Phanerochaete chrysosporium*) have provided substantive evidence for mineralization of the aromatic ring of TNT (Fernando and Aust, 1991; Lebron et al., 1992). In addition, 2-, 3-, and 4-nitrotoluene have been detected in the effluent from the RFAAP TNT manufacturing plant, thereby indicating that these compounds are associated with the breakdown of TNT. One study demonstrated that the breakdown of TNT by two strains of the bacterium, *Pseudomonas* sp. strain C1S1, as a nitrogen source involved the successive removal of nitro groups to yield 2,4-DNT, 2,6-DNT, 2-nitrotoluene, and toluene (Duque et al., 1993).

Biodegradation is the most probable degradative process that may occur for 2,4,6-TNT in soil at SWMU 51. Research has shown that TNT can be completely biotransformed through a series of successive denitration steps. The presence of breakdown products (2,4-DNT, 2,6-DNT, 1,3-DNB, 2-, 3-, and 4-nitrotoluene, and 4-amino-2,6-DNT) in the area provide evidence that biodegradation is occurring. Complete degradation of these compounds is anticipated.

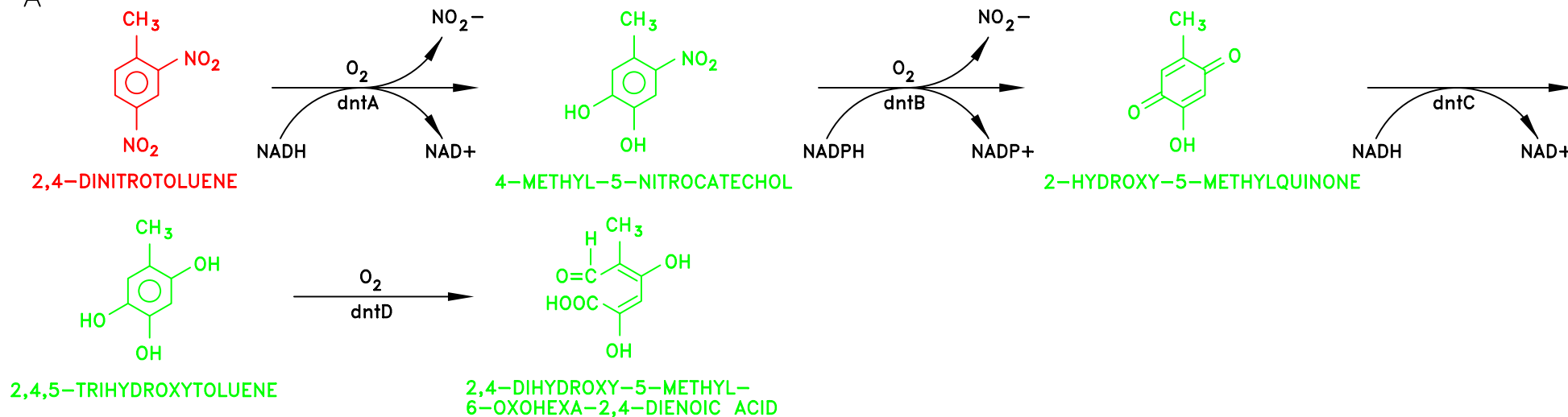
**DNT.** 2,4-DNT was detected in 33 of 38 samples collected, at concentrations ranging from 0.03 mg/kg to 44,000 mg/kg. Ten samples had concentrations exceeding the residential screening level of 16 mg/kg, and six had concentrations exceeding the industrial screening level of 200 mg/kg. 2,6-DNT was detected in 30 of 38 samples collected, at concentrations ranging from 0.07 mg/kg to 11,000 mg/kg. Ten samples had concentrations exceeding the residential screening level of 7.8 mg/kg, and six had concentrations exceeding the industrial screening level of 100 mg/kg. While primarily detected in the trench sludge material, DNT was also detected in soil samples below the sludge. However, as discussed in Section 5.2.2, migration of DNT from the sludge to groundwater has not occurred.

DNT exists as one of six isomers. In the munitions industry, two isomers are commonly found: 2,4-DNT and 2,6-DNT. These compounds are ingredients of explosives used by commercial and military personnel and are also used as stabilizers in the manufacture of smokeless powder (Popp and Leonard, 1985).

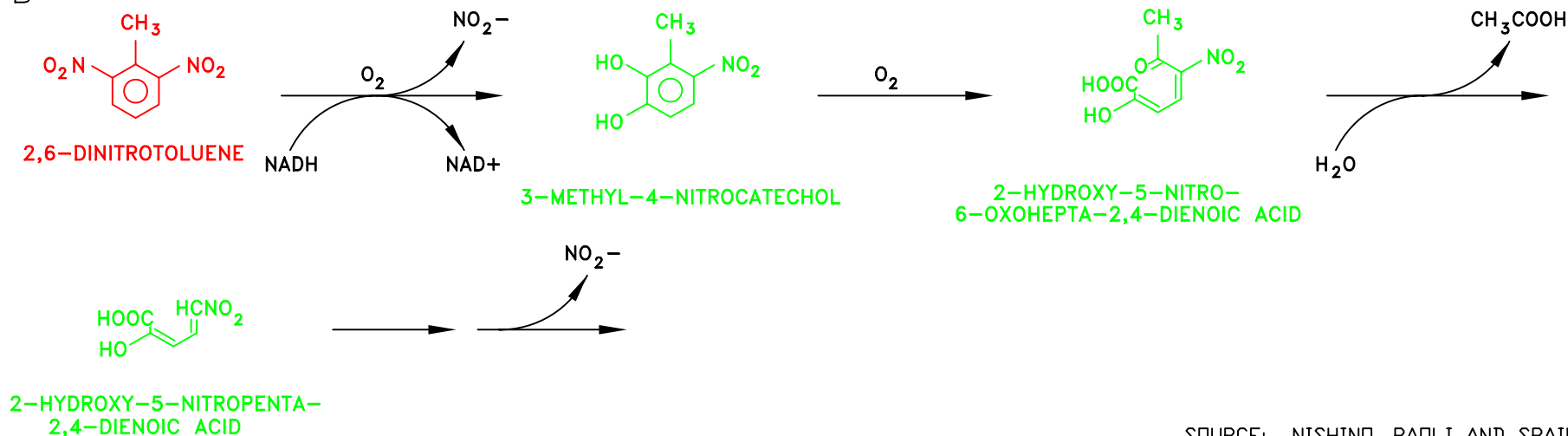
The estimated soil adsorption coefficient ( $K_{oc}$ ) values for 2,4-DNT and 2,6-DNT are 251 and 78, respectively (Burrows et al., 1989), indicating that their sorption to soil is negligible. Coupled with estimated water solubilities of 280 and 206 mg/L at 25 degrees Celsius ( $^{\circ}\text{C}$ ) (Burrows et al., 1989), 2,4-DNT and 2,6-DNT are expected to be mobile in the soil/groundwater system with little retardation in subsurface and sandy soil. With estimated vapor pressures of 0.000217 and 0.000567 mmHg at  $25^{\circ}\text{C}$  for 2,4-DNT and 2,6-DNT, respectively (Burrows et al., 1989), these compounds are not volatile. Consequently, movement through the air-filled pores in near-surface soil is presumed to be an insignificant migration pathway.

No evidence exists for other chemical transformation processes, such as hydrolysis or oxidation, under environmental conditions (Burrows et al., 1989). The DNTs may be biodegraded or at least biotransformed, as the nitro groups are reduced under aerobic conditions to ammo- and azoxyaromatic compounds (Burrows et al., 1989). Biodegradation pathways for 2,4-DNT and 2,6-DNT are presented as **Figure 5-2**.

A



B



SOURCE: NISHINO, PAOLI AND SPAIN, 2000

LEGEND:

RED = EXPLOSIVES COMPOUND  
 GREEN = BREAKDOWN PRODUCTS

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FIG5-2

FIGURE 5-2

2,4-DNT & 2,6-DNT  
 CATABOLIC  
 BIODEGRADATION  
 PATHWAYS

**RDX.** RDX was detected in 12 of the 38 samples collected from the site. It was detected in two deep soil samples, 51SB3D (7.2 mg/kg) and 51SB6D (7.2 mg/kg), at concentrations exceeding the residential screening level (5.8 mg/kg), but below the industrial screening level of 26 mg/kg. RDX was not detected above the residential screening level in any of the remaining samples.

RDX is a widely used military explosive. It is a synthetic compound and is not known to exist in nature. Effluents and emissions from Army ammunition plants are responsible for the release of RDX into the environment. When released to the atmosphere, RDX may be removed by reaction with photochemically generated hydroxyl radicals (half-life = 1.5 hours). When released to water, RDX is subject to photolysis (half-life = 9-13 hours). Photoproducts include formaldehyde and nitrosamines.

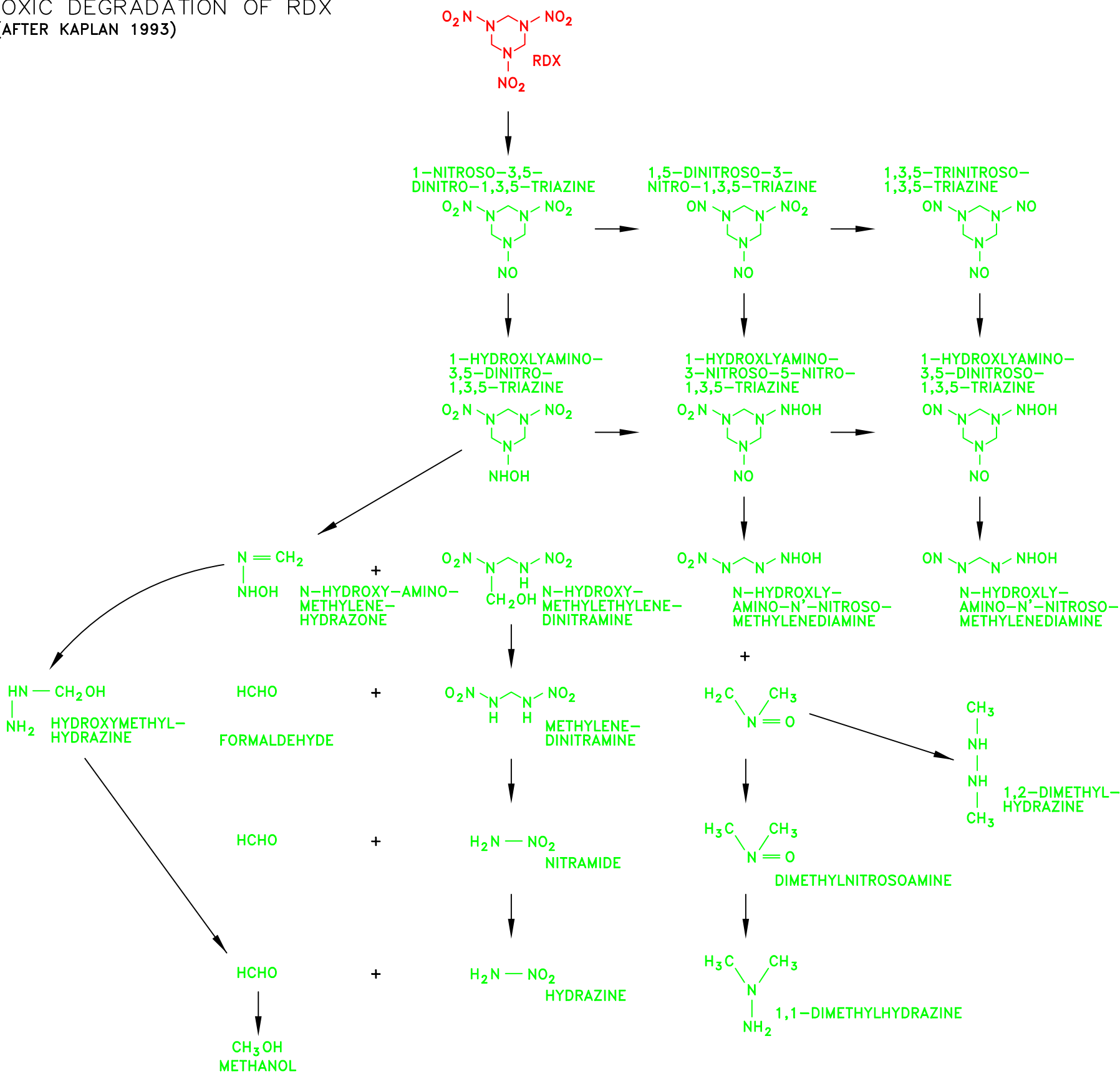
RDX undergoes biodegradation in water and soil under anaerobic conditions. Its biodegradation products include hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine; hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine (DNX); hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX); hydrazine; 1,1-dimethyl-hydrazine, 1,2-dimethyl-hydrazine; formaldehyde; and methanol. RDX is mobile in soil and can leach into groundwater, and can be transported from soil to plants. Biodegradation pathways for RDX are presented as **Figure 5-3**.

RDX has a vapor pressure of  $1.0 \times 10^{-6}$  mm Hg (Army, 1987). It may exist in both the vapor phase and particulate phase in the atmosphere (Eisenreich et al., 1981). The solubility of RDX in water is low to negligible (Merck, 1989; HSDB, 1994). However, the following water solubility values have been reported: 21.8-21.9 mg/L at 10°C, 38.4-38.9 mg/L at 20°C, and 66.7-67 mg/L at 30°C (Army, 1983). RDX is slightly soluble in methanol, ether, ethyl acetate, and glacial acetic acid (Merck, 1989). The Henry's law constant for RDX ( $1.2 \times 10^{-5}$  atm-m<sup>3</sup>/mol) (McKone and Layton, 1986) indicates that RDX tends to partition equally between the atmosphere and water (Eisenreich et al., 1981) and that volatilization is a slow transport process (Lyman et al., 1982).

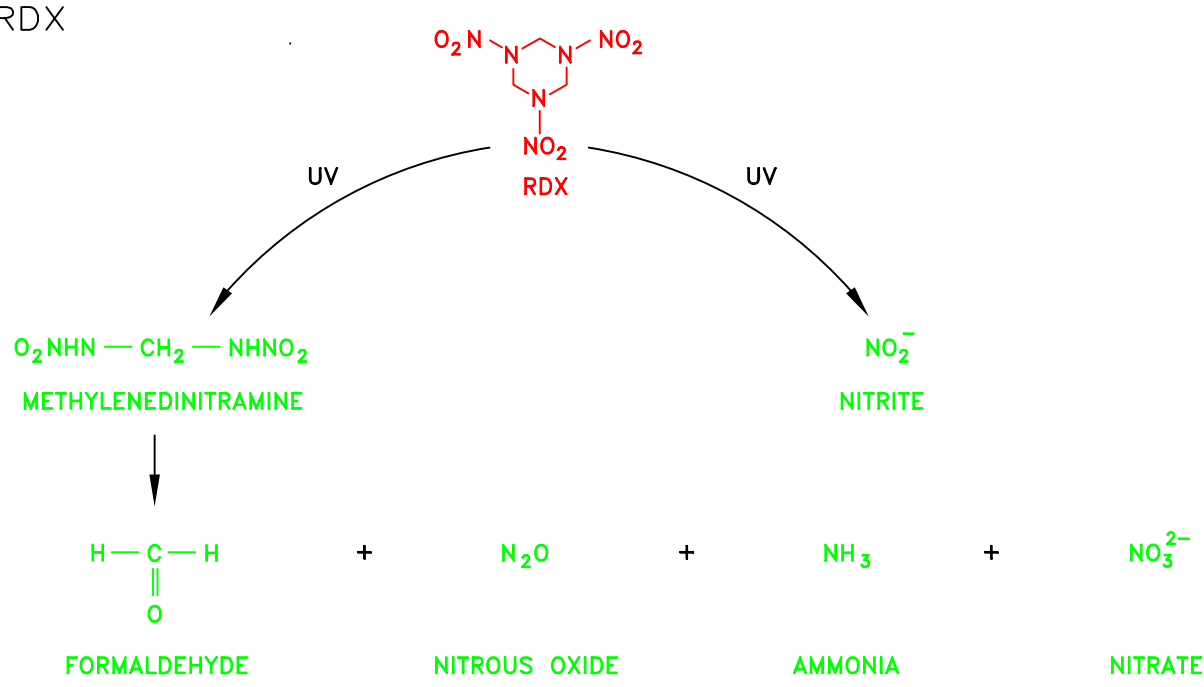
The calculated soil sorption coefficient ( $K_{oc}$ ) values for RDX range from 63.1 (Army, 1987) to 270 (Army, 1983). These  $K_{oc}$  values are indicative of medium-to-high mobility in soil (Swann et al., 1983); therefore, RDX can be expected to leach into groundwater. Experimental data have shown that RDX is not readily bound or retained in soil as evidenced by its early breakthrough in column leachates (Army, 1985). A lysimeter study of the migration of RDX in soil showed that RDX was found in leachate from the soil columns (Navy, 1982). Although RDX does not significantly adsorb to sediment, greater adsorption occurs with an increase in organic matter or clay content (Army, 1980). However, the clay content seems to be more important than organic matter content in influencing the amount of RDX adsorbed (Army, 1980). In a later study sponsored by the U.S. Army Medical Research and Development Command, the adsorption rate constant of RDX in soil was found to be low ( $k_d$  of <1 mg/g). The adsorption constant was linearly correlated with a combination of soil properties, such as organic carbon and clay content, pH, and cation exchange capacity (Ainsworth et al., 1993). It appears that sorption of RDX in soil is not solely the result of hydrophobic partitioning of RDX to the organic carbon phase of the soil.

The logarithm of the octanol/water partition coefficient ( $\log K_{ow}$ ) is a useful preliminary indicator of potential bioaccumulation of a compound. The  $\log K_{ow}$  for RDX was estimated to be 0.87 (HSDB, 1994), indicating RDX is not very lipid soluble and therefore has a low potential for bioaccumulation. Data indicate that RDX can be taken up by plants (Army, 1990; Harvey et

ANOXIC DEGRADATION OF RDX  
(AFTER KAPLAN 1993)



PHOTOLYSIS OF RDX



LEGEND:

RED = EXPLOSIVES COMPOUND

GREEN = BREAKDOWN PRODUCTS

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|                            |                 |
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| CHECKED BY: MT             | SHAW DWG NO:    |
| DATE: REVISED OCTOBER 2004 | FIG5-3          |

FIGURE 5-3

RDX BIODEGRADATION  
PATHWAYS

al., 1991). Studies of bean plants grown in 10 mg/kg RDX hydroponic solutions and exposed for 1 or 7 days indicated that uptake of RDX readily occurred. In a later study, plants were grown in soil containing 10 mg/kg RDX for a period of 60 days, and the extent of plant uptake was found to be dependent both on soil type and plant species (Cataldo et al., 1993). RDX was transported unchanged from soil to plants and the plant uptake increased as the organic matter content of soil decreased. After plant uptake occurred, RDX storage in the tissues of plants (i.e., roots and stems) mostly metabolized to unidentified polar metabolites or non-extractable products, while RDX remained mostly unchanged (>50%) in leaves and seed tissues (Cataldo et al., 1993).

**Nitroglycerin.** NG was detected in one trench sludge sample (51SB6B) at a concentration of 3,300 mg/kg, which exceeds the residential screening level (130 mg/kg) and the industrial screening level (1,700 mg/kg). NG was also detected in one deep soil sample (51SB6D: 6.7 mg/kg), collected from beneath the sample where the exceedance was detected.

NG is a liquid at environmental temperatures, so it is used in double- and triple-based propellants imbibed within a nitrocellulose (polymer) matrix. Thus, NG is generally found dispersed in the environment within a solid material.

Even at lower concentrations, NG is often present in soil as discrete particles. This has a large impact on the nature of the distribution of this substance at contaminated sites. NG may decompose or explode before it boils. The fact that this compound is thermally labile was the major reason that the initial development of methods for their determination in environmental samples was based on high performance liquid chromatography rather than gas chromatography.

The vapor pressure of NG is  $2.6 \times 10^{-6}$  torr (mm Hg) at room temperature. Thus, evaporative losses to the atmosphere are minimal. The solubility of NG in water is 1,500 mg/L at 20°C, indicating that it has a low solubility in water.

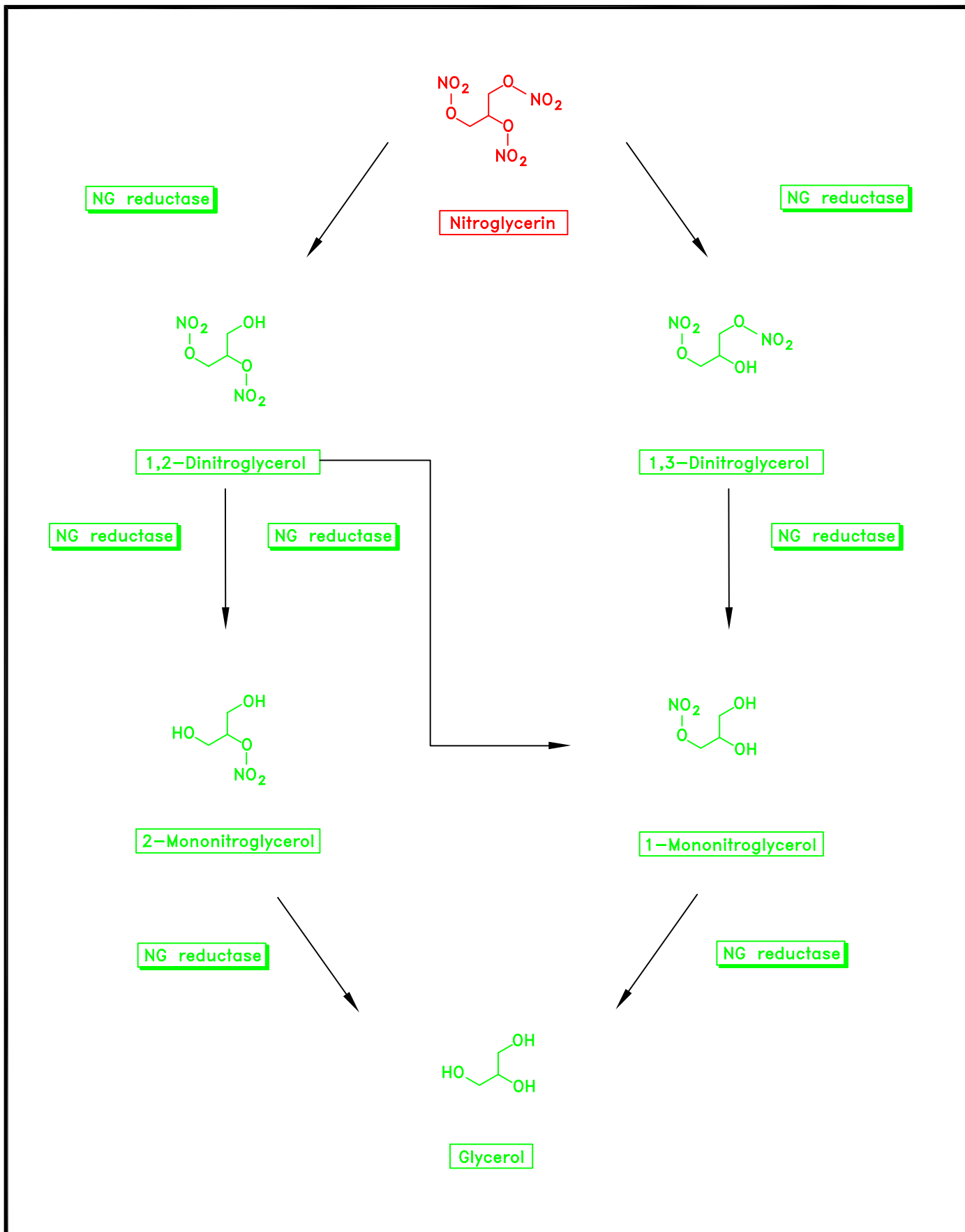
Once dissolved, NG does not sorb strongly to soil and hence is quite mobile in the environment relative to more hydrophobic organic compounds. This property can lead to transport of NG through vadose zone soil to groundwater.

*Pseudomonas putida* II-B and *Pseudomonas fluorescens* I-C are capable of utilizing NG as a sole nitrogen source (Blehert et al., 1997). Biodegradation pathways for NG are presented on **Figure 5-4**. NG reductase catalyzes the NADPH-dependent denitration of NG. The *Pseudomonas* NG reductases were shown not to be reactive with mononitrate glycerol esters. Yet, NG has been shown to be mineralized under anaerobic conditions (Chritodoulatos et al., 1997). Thus, the last step shown on **Figure 5-4** is hypothesized to indicate that bacterial NG metabolism enters intermediary metabolism.

#### 5.2.1.4 Dioxins/Furans

Seventeen dioxin/furan congeners were detected in samples collected from SWMU 51. Of these that have an associated SSL, only 2,3,7,8-TCDD and 1,2,3,6,7,8-HXCDD were found to exceed residential screening levels solely in the trench sludge material. In addition, total HXCDD concentrations were found to exceed residential and industrial screening levels in the trench sludge material. Dioxin/furan congeners were not found to exceed residential screening levels in any samples other than in trench sludge material samples.

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



LEGEND:

RED = EXPLOSIVES COMPOUND  
 GREEN = BREAKDOWN PRODUCTS

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DATE: REVISED OCTOBER 2004

FIG5-4

FIGURE 5-4

NITROGLYCERINE  
 BIODEGRADATION  
 PATHWAYS

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, as well as 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  $2.0 \times 10^{-4}$  mg/L at 25°C. Dioxins/furans also have low vapor pressures (e.g.,  $1.0 \times 10^{-6}$  mm Hg for TCDD at 25°C), which means that these compounds do not readily volatilize to the atmosphere. Dioxins and furans have high  $K_{oc}$  values (i.e.,  $3.30 \times 10^{+6}$  for TCDD) indicating that dioxins and furans have high sorption potentials and will not tend to leach into groundwater or surface water runoff.

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; Nestricks 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.

In summary, dioxins and furans appear to be relatively immobile in soil due to their strong sorption behavior and limited water solubility. In soil systems, photolysis is the most significant degradation mechanism for dioxins/furans. However, degradation rates tend to be extremely slow and confined to the surface layer of the soil. Therefore, any dioxins/furans found in the trench sludge most likely did not degrade due to the lack of light at that depth.

### **5.2.2 Site-Specific Fate and Transport Evaluation**

An analysis of the data from the trench sludge samples shows that explosives are the primary contaminants, with 1,3-DNB, 2,4-DNT, 2,6-DNT, 2,4,6-TNT, 2-NT and 4-NT exceeding their respective industrial screening levels in at least 50% of the sludge samples. Three metals (chromium, iron, and lead) also exceeded their industrial screening levels in approximately 50% of the samples from the sludge material.

Groundwater samples were collected from wells at SWMU 51 in 2006, and additional downgradient samples were collected from nearby SWMUs 48, 49, and 59 in 2007. This section presents an expanded data set from those sampling events to demonstrate that explosives constituents detected in the sludge material have not migrated downward to the water table in sufficient quantities to be detected in nearby, downgradient wells.

The wells included in this analysis are:

- 51MW1 (downgradient and slightly crossgradient to the west).
- 51MW2 (downgradient).
- 59MW01 (downgradient).
- 48MW1 (downgradient).
- 48MW2 (downgradient).
- 48MW3 (downgradient).
- 49MW01 (downgradient).
- 48MW06 (downgradient and slightly crossgradient to the west).
- 48MW07 (downgradient and slightly crossgradient to the west).
- 16-4 (upgradient/crossgradient to the east).
- C1 (upgradient).

Detected results from these wells are presented in **Table 5-2** and summarized in **Table 5-3**. In cases where the wells were sampled during both the 2006 and 2007 events, the more recent data is used in this discussion.

Several chlorinated VOCs were detected in the wells at concentrations greater than tw-RBCs or MCLs. Carbon tetrachloride, TCE, and PCE exceeded their MCLs in one (PCE) or two (carbon tetrachloride and TCE) wells. These VOCs are not detected in wells immediately downgradient from SWMU 51. Based on the current distribution of these constituents in groundwater, they appear to have originated from SWMU 49.

SVOCs (including PAHs) were not detected in the groundwater samples. PCBs and herbicides were also not detected in the groundwater samples. Two pesticides (alpha-chlordane and heptachlor epoxide) were detected in well 16-4. Neither of these compounds was detected in site soil and this well is upgradient and slightly cross-gradient from SWMU 51. In addition, these compounds were not detected in any of the downgradient wells, indicating that SWMU 51 is not the source of these compounds.

Explosives, as mentioned above, are the primary contaminants in the trench sludge samples. No explosives or explosives-related compounds were detected in the groundwater samples downgradient from SWMU 51. This provides strong evidence that there is very little migration downward from the sludge material. A second line of evidence to support the lack of migration is the decrease in concentration in explosives constituents between the sludge samples and samples collected from below the sludge material.

Sample 51SB6B, collected from 6-8 ft bgs, contained the highest concentration of 2,4,6-TNT at the site, with a concentration of 61,000 mg/kg. Sample 51SB6C was collected from 9-11 ft bgs in the same boring and had a 2,4,6-TNT concentration of 18 mg/kg. These concentrations demonstrate a more than 99.9% drop in concentration in 3 ft. A similar calculation for other explosives compounds between the sample with the highest concentration and a sample from the same boring below the sludge material shows:

| <b>Chemical</b> | <b>Max Conc. (mg/kg)</b> | <b>Depth (ft)</b> | <b>Next Sample Conc. (mg/kg)</b> | <b>Next Sample Depth (ft)</b> | <b>% Reduction</b> |
|-----------------|--------------------------|-------------------|----------------------------------|-------------------------------|--------------------|
| 1,3-DNB         | 460                      | 11                | 0.32                             | 34                            | 99.93              |
| 2,4-DNT         | 44000                    | 14                | 42                               | 36                            | 99.90              |
| 2,6-DNT         | 11000                    | 14                | 11                               | 36                            | 99.90              |
| 2-NT            | 25000                    | 14                | 93                               | 36                            | 99.63              |
| 4-NT            | 16000                    | 14                | 45                               | 36                            | 99.72              |

Metals were detected in groundwater samples collected throughout the area with the highest concentrations generally in wells 48MW06 and 48MW2. Concentrations of chromium and lead were below their respective MCLs and tw-RBCs in wells 51MW2 and 59MW01, the two downgradient wells closest to SWMU 51. The iron concentration in well 59MW01 was greater than its secondary MCL, but below the tw-RBC. The groundwater concentrations for metals constituents of the TNT sludge do not exhibit a pattern consistent with SWMU 51 being the source for these metals in groundwater.

Based on these results, it is concluded that contaminants present in the trench sludge material in SWMU 51 are not migrating beyond the soil immediately below the sludge layer and have not impacted groundwater.

**Table 5-2**  
**Analytes Detected in SWMU 51 Vicinity Wells - 2006 and 2007**  
**Page 1 of 2**

| Analyte                         | Sample ID<br>Sample Date |         | 51MW1<br>4/11/06 |       |       |         |         | 51MW2<br>4/10/06 |       |       |         |         | 16-4<br>4/10/06 |       |       |         |         | C1<br>4/12/06 |       |       |         |         | 48MW06<br>8/30/07 |       |       |        |       | 48MW07<br>8/30/07 |       |       |        |       |       |    |
|---------------------------------|--------------------------|---------|------------------|-------|-------|---------|---------|------------------|-------|-------|---------|---------|-----------------|-------|-------|---------|---------|---------------|-------|-------|---------|---------|-------------------|-------|-------|--------|-------|-------------------|-------|-------|--------|-------|-------|----|
|                                 | 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     | Result            | Lab Q | Val Q | MDL    | MRL   | Result            | Lab Q | Val Q | MDL    | MRL   |       |    |
| VOCs (ug/L)                     |                          |         |                  |       |       |         |         |                  |       |       |         |         |                 |       |       |         |         |               |       |       |         |         |                   |       |       |        |       |                   |       |       |        |       |       |    |
| 1,1,1-Trichloroethane           | 200                      | 910     | 1                | U     |       | 0.5     | 1       | 1                | U     |       | 0.5     | 1       | 1               | U     |       | 0.5     | 1       | 1.3           |       | J     | 0.5     | 1       | 1.8               |       |       | 0.29   | 1     | 1                 | U     |       | 0.29   | 1     |       |    |
| 1,1-Dichloroethane              | na                       | 90      | 1                | U     |       | 0.5     | 1       | 1                | U     |       | 0.5     | 1       | 1               | U     |       | 0.5     | 1       | 8.5           |       |       | 0.5     | 1       | 3.4               |       |       | 0.25   | 1     | 1                 | U     |       | 0.25   | 1     |       |    |
| Carbon tetrachloride            | 5                        | 0.16    | 1                | U     |       | 0.5     | 1       | 1                | U     |       | 0.5     | 1       | 1               | U     |       | 0.5     | 1       | 1             | U     |       | 0.5     | 1       | 1                 | U     |       | 0.29   | 1     | 1                 | U     |       | 0.29   | 1     |       |    |
| Chloroethane                    | na                       | 3.6     | 2                | U     |       | 1       | 2       | 2                | U     |       | 1       | 2       | 2               | U     |       | 1       | 2       | 4             |       |       | 1       | 2       | 2                 | U     |       | 0.46   | 2     | 2                 | U     |       | 0.46   | 2     |       |    |
| cis-1,2-Dichloroethene          | 70                       | 6.1     | 1                | U     |       | 0.5     | 1       | 1                | U     |       | 0.5     | 1       | 1               | U     |       | 0.5     | 1       | 1             | U     |       | 0.5     | 1       | 2.9               |       |       | 0.28   | 1     | 1                 | U     |       | 0.28   | 1     |       |    |
| Methylene chloride              | 5                        | 4.1     | 5                | U     |       | 1       | 5       | 5                | U     |       | 1       | 5       | 5               | U     |       | 1       | 5       | 8             |       |       | 1       | 5       | 5                 | U     |       | 1      | 5     | 5                 | U     |       | 1      | 5     |       |    |
| Tetrachloroethene               | 5                        | 0.1     | 0.93             | J     | J     | 0.5     | 1       | 1                | U     |       | 0.5     | 1       | 1               | U     |       | 0.5     | 1       | 1             | U     |       | 0.5     | 1       | 1                 | U     |       | 0.25   | 1     | 1                 | U     |       | 0.25   | 1     |       |    |
| Trichloroethene                 | 5                        | 0.026   | 1                | U     |       | 0.5     | 1       | 1                | U     |       | 0.5     | 1       | 1               | U     |       | 0.5     | 1       | 1             | U     |       | 0.5     | 1       | 3.7               |       |       | 0.38   | 1     | 1                 | U     |       | 0.38   | 1     |       |    |
| PAHs (ug/L) None detected       |                          |         |                  |       |       |         |         |                  |       |       |         |         |                 |       |       |         |         |               |       |       |         |         |                   |       |       |        |       |                   |       |       |        |       |       |    |
| SVOCs (ug/L) None detected      |                          |         |                  |       |       |         |         |                  |       |       |         |         |                 |       |       |         |         |               |       |       |         |         |                   |       |       |        |       |                   |       |       |        |       |       |    |
| Pesticides (ug/L)               |                          |         |                  |       |       |         |         |                  |       |       |         |         |                 |       |       |         |         |               |       |       |         |         |                   |       |       |        |       |                   |       |       |        |       |       |    |
| alpha-Chlordane                 | 2                        | 0.19    | 0.066            | U     |       | 0.013   | 0.066   | 0.063            | U     |       | 0.013   | 0.063   | 0.21            |       | 0.013 | 0.067   | 0.063   | U             |       | 0.013 | 0.063   | 0.05    | U                 |       | 0.01  | 0.05   | 0.049 | U                 |       | 0.009 | 0.049  |       |       |    |
| Heptachlor epoxide              | 0.2                      | 0.0074  | 0.066            | U     |       | 0.013   | 0.066   | 0.063            | U     |       | 0.013   | 0.063   | 0.015           |       | J     | J       | 0.013   | 0.067         | 0.063 | U     |         | 0.013   | 0.063             | 0.05  | U     |        | 0.01  | 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    | 282              |       | B     | 16      | 200     | 100              | J     | B     | 16      | 200     | 236             |       | B     | 16      | 200     | 57            | J     | B     | 16      | 200     | 26600             |       |       | 79     | 200   | 457               |       |       | 79     | 200   |       |    |
| Antimony                        | 6                        | 1.5     | 3.6              | J     | B     | 2.2     | 5       | 2.2              | U     |       | 2.2     | 5       | 3.2             | J     | B     | 2.2     | 5       | 2.6           | J     | B     | 2.2     | 5       | 6.9               |       |       | B      | 3.3   | 6                 | 3.3   | U     |        | 3.3   | 6     |    |
| Arsenic                         | 10                       | 0.045   | 2.9              | U     |       | 2.9     | 10      | 2.9              | U     |       | 2.9     | 10      | 2.9             | U     |       | 2.9     | 10      | 2.9           | U     |       | 2.9     | 10      | 11.9              |       |       |        | 3.7   | 10                | 3.7   | U     |        | 3.7   | 10    |    |
| Barium                          | 2000                     | 730     | 45.3             | J     | J     | 0.5     | 200     | 40.8             | J     | J     | 0.5     | 200     | 149             | J     | J     | 0.5     | 200     | 181           | J     | J     | 0.5     | 200     | 335               |       |       | 5      | 200   | 76.8              | J     | J     | 5      | 200   |       |    |
| Beryllium                       | 4                        | 7.3     | 2                | J     | B     | 0.7     | 4       | 2.1              | J     | B     | 0.7     | 4       | 2               | J     | B     | 0.7     | 4       | 1.9           | J     | B     | 0.7     | 4       | 1.5               | J     | K     | 1      | 4     | 1                 | U     |       | 1      | 4     |       |    |
| Calcium                         | na                       | na      | 18900            |       |       | 26      | 1000    | 53700            |       |       | 26      | 1000    | 36300           |       |       | 26      | 1000    | 105000        |       |       | 26      | 1000    | 157000            |       |       | 100    | 1000  | 22200             |       |       | 100    | 1000  |       |    |
| Chromium                        | 100                      | 11      | 0.59             | J     | J     | 0.5     | 10      | 1.3              | J     | J     | 0.5     | 10      | 0.74            | J     | J     | 0.5     | 10      | 0.5           | U     |       | 0.5     | 10      | 140               |       |       | 0.92   | 10    | 11.9              |       |       | 0.92   | 10    |       |    |
| Cobalt                          | na                       | na      | 0.4              | U     |       | 0.4     | 50      | 0.4              | U     |       | 0.4     | 50      | 0.4             | U     |       | 0.4     | 50      | 0.4           | U     |       | 0.4     | 50      | 42.8              | J     | J     | 1      | 50    | 1                 | U     |       | 1      | 50    |       |    |
| Copper                          | 1300                     | 150     | 0.8              | U     |       | 0.8     | 25      | 0.8              | U     |       | 0.8     | 25      | 0.8             | U     |       | 0.8     | 25      | 0.8           | U     |       | 0.8     | 25      | 119               |       |       | 1.2    | 25    | 1.2               | J     | B     | 1.2    | 25    |       |    |
| Iron                            | 300                      | 2600    | 547              |       |       | 7.5     | 300     | 42.2             | J     | B     | 7.5     | 300     | 174             | J     | J     | 7.5     | 300     | 7.5           | U     |       | 7.5     | 300     | 89800             |       |       | 15     | 300   | 861               |       |       | 15     | 300   |       |    |
| Lead                            | 15                       | na      | 1.3              | J     | B     | 1.2     | 5       | 1.2              | U     |       | 1.2     | 5       | 2               | J     | B     | 1.2     | 5       | 1.2           | U     |       | 1.2     | 5       | 8.4               |       | B     | 2.1    | 5     | 2.1               | J     | B     | 2.1    | 5     |       |    |
| Magnesium                       | na                       | na      | 7440             |       |       | 5.8     | 5000    | 15600            |       |       | 5.8     | 5000    | 22700           |       |       | 5.8     | 5000    | 38100         |       |       | 5.8     | 5000    | 119000            |       |       | 100    | 5000  | 12100             |       |       | 100    | 5000  |       |    |
| Manganese                       | 50                       | 73      | 60.6             |       |       | 0.2     | 15      | 1.8              | J     | B     | 0.2     | 15      | 5.1             | J     | J     | 0.2     | 15      | 7.1           | J     | J     | 0.2     | 15      | 2550              |       |       | 1      | 15    | 32.3              |       |       | 1      | 15    |       |    |
| Nickel                          | na                       | 73      | 1.1              | J     | J     | 1.1     | 40      | 1.1              | U     |       | 1.1     | 40      | 1.1             | U     |       | 1.1     | 40      | 1.1           | U     |       | 1.1     | 40      | 117               |       |       | 1      | 40    | 6.9               | J     | J     | 1      | 40    |       |    |
| Potassium                       | na                       | na      | 1070             | J     | J     | 36      | 5000    | 1220             | J     | J     | 36      | 5000    | 1030            | J     | J     | 36      | 5000    | 2720          | J     | J     | 36      | 5000    | 9740              | J     | J     | 100    | 10000 | 2910              | J     | B     | 100    | 10000 |       |    |
| Selenium                        | 50                       | 18      | 2.4              | U     |       | 2.4     | 10      | 2.4              | U     |       | 2.4     | 10      | 2.4             | U     |       | 2.4     | 10      | 2.8           | J     | J     | 2.4     | 10      | 10                |       | K     | 4      | 10    | 4                 | U     |       | 4      | 10    |       |    |
| Sodium                          | na                       | na      | 256              | J     | B     | 77      | 5000    | 713              | J     | B     | 77      | 5000    | 385             | J     | B     | 77      | 5000    | 4250          | J     | L     | 77      | 5000    | 60500             |       |       | 500    | 10000 | 2470              | J     | B     | 500    | 10000 |       |    |
| Vanadium                        | na                       | 3.7     | 0.6              | U     |       | 0.6     | 50      | 0.6              | U     |       | 0.6     | 50      | 0.7             | J     | B     | 0.6     | 50      | 0.82          | J     | B     | 0.6     | 50      | 46.3              |       |       | J      | J     | 1.1               | 50    | 1.1   | U      |       | 1.1   | 50 |
| Zinc                            | 5000                     | 1100    | 3.4              | J     | J     | 0.8     | 20      | 2.1              | J     | J     | 0.8     | 20      | 0.91            | J     | J     | 0.8     | 20      | 0.8           | U     |       | 0.8     | 20      | 41.8              |       |       | 5      | 20    | 5                 | U     |       | 5      | 20    |       |    |
| Misc. (ug/L)                    |                          |         |                  |       |       |         |         |                  |       |       |         |         |                 |       |       |         |         |               |       |       |         |         |                   |       |       |        |       |                   |       |       |        |       |       |    |
| Perchlorate                     | na                       | 2.6     | NT               |       |       |         |         | NT               |       |       |         |         | NT              |       |       |         |         | NT            |       |       |         |         | 0.236             |       | J     | 0.0663 | 0.2   | 0.313             |       | J     | 0.0663 | 0.2   |       |    |
| Dioxins/Furans (ng/L)           |                          |         |                  |       |       |         |         |                  |       |       |         |         |                 |       |       |         |         |               |       |       |         |         |                   |       |       |        |       |                   |       |       |        |       |       |    |
| 2,3,7,8-TCDF                    | na                       | na      | 0.00329          | U     |       | 0.00329 | 0.00329 | 0.00358          | U     |       | 0.00358 | 0.00358 | 0.00372         | U     |       | 0.00372 | 0.00372 | 0.00348       | U     |       | 0.00348 | 0.00348 | 5.08              | U     |       | 5.08   | 5.08  | 2.53              | U     |       | 2.53   | 2.53  |       |    |
| 2,3,7,8-TCDD                    | 0.03                     | 0.00045 | 0.00332          | U     |       | 0.00332 | 0.00332 | 0.00368          | U     |       | 0.00368 | 0.00368 | 0.00365         | U     |       | 0.00365 | 0.00365 | 0.00427       | U     |       | 0.00427 | 0.00427 | 1.96              | U     |       | 1.96   | 1.96  | 3.69              | U     |       | 3.69   | 3.69  |       |    |
| 1,2,3,7,8-PECDD                 | na                       | na      | 0.0061           | U     |       | 0.0061  | 0.0061  | 0.00651          | U     |       | 0.00651 | 0.00651 | 0.0061          | U     |       | 0.0061  | 0.0061  | 0.00612       | U     |       | 0.00612 | 0.00612 | 5.08              | U     |       | 5.08   | 5.08  | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 1,2,3,4,7,8-HXCDD               | na                       | 0.011   | 0.0089           | U     |       | 0.0089  | 0.0089  | 0.0131           | U     |       | 0.0131  | 0.0131  | 0.00871         | U     |       | 0.00871 | 0.00871 | 0.0107        | U     |       | 0.0107  | 0.0107  | 5.08              | U     |       | 5.08   | 5.08  | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 1,2,3,6,7,8-HXCDD               | na                       | 0.011   | 0.00821          | U     |       | 0.00821 | 0.00821 | 0.0121           | U     |       | 0.0121  | 0.0121  | 0.00803         | U     |       | 0.00803 | 0.00803 | 0.00985       | U     |       | 0.00985 | 0.00985 | 5.08              | U     |       | 5.08   | 5.08  | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 1,2,3,7,8,9-HXCDD               | na                       | 0.011   | 0.00901          | U     |       | 0.00901 | 0.00901 | 0.0132           | U     |       | 0.0132  | 0.0132  | 0.00882         | U     |       | 0.00882 | 0.00882 | 0.0108        | U     |       | 0.0108  | 0.0108  | 5.08              | U     |       | 5.08   | 5.08  | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 1,2,3,4,6,7,8-HPCDD             | na                       | na      | 0.00875          | U     |       | 0.00875 | 0.00875 | 0.0103           | U     |       | 0.0103  | 0.0103  | 0.00915         | U     |       | 0.00915 | 0.00915 | 0.0126        | U     |       | 0.0126  | 0.0126  | 5.08              | U     |       | 5.08   | 5.08  | 8.01              | U     |       | 8.01   | 8.01  |       |    |
| OCDD                            | na                       | na      | 0.0376           | A     | J     | NA      | NA      | 0.0208           | U     |       | 0.0208  | 0.0208  | 0.0348          | U     |       | 0.0348  | 0.0348  | 0.0378        | U     |       | 0.0378  | 0.0378  | 8.59              | J     | J     | NA     | NA    | 14.6              | J     | J     | NA     | NA    |       |    |
| 1,2,3,7,8-PECDF                 | na                       | na      | 0.0034           | U     |       | 0.0034  | 0.0034  | 0.0036           | U     |       | 0.0036  | 0.0036  | 0.0033          | U     |       | 0.0033  | 0.0033  | 0.00365       | U     |       | 0.00365 | 0.00365 | 5.08              | U     |       | 5.08   | 5.08  | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 2,3,4,7,8-PECDF                 | na                       | na      | 0.00332          | U     |       | 0.00332 | 0.00332 | 0.00352          | U     |       | 0.00352 | 0.00352 | 0.00322         | U     |       | 0.00322 | 0.00322 | 0.00357       | U     |       | 0.00357 | 0.00357 | 5.08              | U     |       | 5.08   | 5.08  | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 1,2,3,4,7,8-HXCDF               | na                       | na      | 0.00529          | U     |       | 0.00529 | 0.00529 | 0.00683          | U     |       | 0.00683 | 0.00683 | 0.00554         | U     |       | 0.00554 | 0.00554 | 0.00518       | U     |       | 0.00518 | 0.00518 | 5.08              | U     |       | 5.08   | 5.08  | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 1,2,3,6,7,8-HXCDF               | na                       | na      | 0.00466          | U     |       | 0.00466 | 0.00466 | 0.00602          | U     |       | 0.00602 | 0.00602 | 0.00489         | U     |       | 0.00489 | 0.00489 | 0.00456       | U     |       | 0.00456 | 0.00456 | 5.08              | U     |       | 5.08   | 5.08  | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 2,3,4,6,7,8-HXCDF               | na                       | na      | 0.00528          | U     |       | 0.00528 | 0.00528 | 0.00681          | U     |       | 0.00681 | 0.00681 | 0.00553         | U     |       | 0.00553 | 0.00553 | 0.00517       | U     |       | 0.00517 | 0.00517 | 5.08              | U     |       | 5.08   | 5.08  | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 1,2,3,7,8,9-HXCDF               | na                       | na      | 0.00631          | U     |       | 0.00631 | 0.00631 | 0.00814          | U     |       | 0.00814 | 0.00814 | 0.00661         | U     |       | 0.00661 | 0.00661 | 0.00618       | U     |       | 0.00618 | 0.00618 | 5.08              | U     |       | 5.08   | 5.08  | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 1,2,3,4,6,7,8-HPCDF             | na                       | na      | 0.00541          | U     |       | 0.00541 | 0.00541 | 0.00613          | U     |       | 0.00613 | 0.00613 | 0.00578         | U     |       | 0.00578 | 0.00578 | 0.00708       | U     |       | 0.00708 | 0.00708 | 1.77              | J     | J     | NA     | NA    | 4.94              | U     |       | 4.94   | 4.94  |       |    |
| 1,2,3,4,7,8,9-HPCDF             | na                       | na      | 0.00701          | U     |       | 0.00701 | 0.00701 | 0.00794          | U     |       | 0.00794 | 0.00794 | 0.00749         | U     |       | 0.00749 | 0.00749 | 0.00917       | U     |       | 0.00917 | 0.00917 | 5.08              | U     |       | 5.08   | 5.08  | 5.94              | U     |       | 5.94   | 5.94  |       |    |
| OCDF                            | na                       | na      | 0.0167           | U     |       | 0.0167  | 0.0167  | 0.0166           | U     |       | 0.0166  | 0.0166  | 0.0209          | U     |       | 0.0209  | 0.0209  | 0.019         | U     |       | 0.019   | 0.019   | 10.2              | U     |       | 10.2   | 10.2  | 12.7              | U     |       | 12.7   | 12.7  |       |    |
| TOTAL TCDD                      | na                       | na      | 0.00332          | U     |       | 0.00332 | 0.00332 | 0.00368          | U     |       | 0.00368 | 0.00368 | 0.00365         | U     |       | 0.00365 | 0.00365 | 0.00427       | U     |       | 0.00427 | 0.00427 | 1.96              | U     |       | 1.96   | 1.96  | 3.69              | U     |       | 3.69   | 3.69  |       |    |
| TOTAL PECDD                     | na                       | na      | 0.0061           | U     |       | 0.0061  | 0.0061  | 0.0              |       |       |         |         |                 |       |       |         |         |               |       |       |         |         |                   |       |       |        |       |                   |       |       |        |       |       |    |

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

Table 5-2  
Analytes Detected in SWMU 51 Vicinity Wells - 2006 and 2007  
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| Analyte                         | Sample ID<br>Sample Date |         | 48MW1<br>8/29/07 |       |       |        |       | 48MW2<br>8/29/07 |       |       |        |       | 48MW3<br>8/29/07 |       |       |        |       | 49MW01<br>8/29/07 |       |       |        |       | 59MW01<br>8/29/07 |       |       |        |       |
|---------------------------------|--------------------------|---------|------------------|-------|-------|--------|-------|------------------|-------|-------|--------|-------|------------------|-------|-------|--------|-------|-------------------|-------|-------|--------|-------|-------------------|-------|-------|--------|-------|
|                                 | 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   | Result            | Lab Q | Val Q | MDL    | MRL   |
| VOCs (ug/L)                     |                          |         |                  |       |       |        |       |                  |       |       |        |       |                  |       |       |        |       |                   |       |       |        |       |                   |       |       |        |       |
| 1,1,1-Trichloroethane           | 200                      | 910     | 0.46             | J     | J     | 0.29   | 1     | 1                | U     |       | 0.29   | 1     | 1                | U     |       | 0.29   | 1     | 1                 | U     |       | 0.29   | 1     | 1                 | U     |       | 0.29   | 1     |
| 1,1-Dichloroethane              | na                       | 90      | 1                | U     |       | 0.25   | 1     | 1                | U     |       | 0.25   | 1     | 1                | U     |       | 0.25   | 1     | 1                 | U     |       | 0.25   | 1     | 1                 | U     |       | 0.25   | 1     |
| Carbon tetrachloride            | 5                        | 0.16    | 1                | U     |       | 0.29   | 1     | 94.6             |       |       | 0.29   | 1     | 60.3             |       |       | 0.29   | 1     | 3.8               |       |       | 0.29   | 1     | 1                 | U     |       | 0.29   | 1     |
| Chloroethane                    | na                       | 3.6     | 2                | U     |       | 0.46   | 2     | 2                | U     |       | 0.46   | 2     | 2                | U     |       | 0.46   | 2     | 2                 | U     |       | 0.46   | 2     | 2                 | U     |       | 0.46   | 2     |
| cis-1,2-Dichloroethene          | 70                       | 6.1     | 1                | U     |       | 0.28   | 1     | 1                | U     |       | 0.28   | 1     | 1                | U     |       | 0.28   | 1     | 1                 | U     |       | 0.28   | 1     | 1                 | U     |       | 0.28   | 1     |
| Methylene chloride              | 5                        | 4.1     | 5                | U     |       | 1      | 5     | 5                | U     |       | 1      | 5     | 5                | U     |       | 1      | 5     | 5                 | U     |       | 1      | 5     | 5                 | U     |       | 1      | 5     |
| Tetrachloroethene               | 5                        | 0.1     | 1                | U     |       | 0.25   | 1     | 1                | U     |       | 0.25   | 1     | 1                | U     |       | 0.25   | 1     | 1                 | U     |       | 0.25   | 1     | 1                 | U     |       | 0.25   | 1     |
| Trichloroethene                 | 5                        | 0.026   | 1.6              |       |       | 0.38   | 1     | 11.2             |       |       | 0.38   | 1     | 10.1             |       |       | 0.38   | 1     | 1                 | U     |       | 0.38   | 1     | 1                 | U     |       | 0.38   | 1     |
| PAHs (ug/L) None detected       |                          |         |                  |       |       |        |       |                  |       |       |        |       |                  |       |       |        |       |                   |       |       |        |       |                   |       |       |        |       |
| SVOCs (ug/L) None detected      |                          |         |                  |       |       |        |       |                  |       |       |        |       |                  |       |       |        |       |                   |       |       |        |       |                   |       |       |        |       |
| Pesticides (ug/L)               |                          |         |                  |       |       |        |       |                  |       |       |        |       |                  |       |       |        |       |                   |       |       |        |       |                   |       |       |        |       |
| alpha-Chlordane                 | 2                        | 0.19    | 0.05             | U     |       | 0.01   | 0.05  | 0.048            | U     |       | 0.009  | 0.048 | 0.049            | U     |       | 0.009  | 0.049 | 0.05              | U     |       | 0.01   | 0.05  | 0.05              | U     |       | 0.01   | 0.05  |
| Heptachlor epoxide              | 0.2                      | 0.0074  | 0.05             | U     |       | 0.01   | 0.05  | 0.048            | U     |       | 0.009  | 0.048 | 0.049            | U     |       | 0.009  | 0.049 | 0.05              | U     |       | 0.01   | 0.05  | 0.05              | U     |       | 0.01   | 0.05  |
| PCBs (ug/L) None detected       |                          |         |                  |       |       |        |       |                  |       |       |        |       |                  |       |       |        |       |                   |       |       |        |       |                   |       |       |        |       |
| Explosives (ug/L) None detected |                          |         |                  |       |       |        |       |                  |       |       |        |       |                  |       |       |        |       |                   |       |       |        |       |                   |       |       |        |       |
| Herbicides (ug/L) None detected |                          |         |                  |       |       |        |       |                  |       |       |        |       |                  |       |       |        |       |                   |       |       |        |       |                   |       |       |        |       |
| Metals (ug/L)                   |                          |         |                  |       |       |        |       |                  |       |       |        |       |                  |       |       |        |       |                   |       |       |        |       |                   |       |       |        |       |
| Aluminum                        | 50                       | 3700    | 79               | U     |       | 79     | 200   | 14300            |       |       | 79     | 200   | 79               | U     |       | 79     | 200   | 437               |       |       | 79     | 200   | 725               |       |       | 79     | 200   |
| Antimony                        | 6                        | 1.5     | 3.3              | U     |       | 3.3    | 6     | 3.3              | U     |       | 3.3    | 6     | 3.3              | U     |       | 3.3    | 6     | 3.3               | U     |       | 3.3    | 6     | 3.3               | U     |       | 3.3    | 6     |
| Arsenic                         | 10                       | 0.045   | 3.7              | U     |       | 3.7    | 10    | 4.4              | J     | J     | 3.7    | 10    | 3.7              | U     |       | 3.7    | 10    | 3.7               | U     |       | 3.7    | 10    | 3.7               | U     |       | 3.7    | 10    |
| Barium                          | 2000                     | 730     | 75.5             | J     | J     | 5      | 200   | 607              |       |       | 5      | 200   | 66               | J     | J     | 5      | 200   | 137               | J     | J     | 5      | 200   | 214               |       |       | 5      | 200   |
| Beryllium                       | 4                        | 7.3     | 1                | U     |       | 1      | 4     | 1                | U     |       | 1      | 4     | 1                | U     |       | 1      | 4     | 1                 | U     |       | 1      | 4     | 1                 | U     |       | 1      | 4     |
| Calcium                         | na                       | na      | 96400            |       |       | 100    | 1000  | 185000           |       |       | 100    | 1000  | 93600            |       | L     | 100    | 1000  | 40800             |       | L     | 100    | 1000  | 30700             |       |       | 100    | 1000  |
| Chromium                        | 100                      | 11      | 9.9              | J     | J     | 0.92   | 10    | 195              |       |       | 0.92   | 10    | 8.1              | J     | J     | 0.92   | 10    | 23.8              |       |       | 0.92   | 10    | 9.8               | J     | J     | 0.92   | 10    |
| Cobalt                          | na                       | na      | 1                | U     |       | 1      | 50    | 13.8             | J     | J     | 1      | 50    | 1                | U     |       | 1      | 50    | 3.1               | J     | J     | 1      | 50    | 1                 | U     |       | 1      | 50    |
| Copper                          | 1300                     | 150     | 1.2              | U     |       | 1.2    | 25    | 19.7             | J     | J     | 1.2    | 25    | 1.2              | U     |       | 1.2    | 25    | 1.2               | U     |       | 1.2    | 25    | 1.2               | U     |       | 1.2    | 25    |
| Iron                            | 300                      | 2600    | 36               | J     | J     | 15     | 300   | 17200            |       |       | 15     | 300   | 15               | U     | UL    | 15     | 300   | 623               |       | L     | 15     | 300   | 801               |       |       | 15     | 300   |
| Lead                            | 15                       | na      | 2.1              | U     |       | 2.1    | 5     | 2.1              | U     |       | 2.1    | 5     | 3.5              | J     | B     | 2.1    | 5     | 2.1               | U     |       | 2.1    | 5     | 2.1               | U     |       | 2.1    | 5     |
| Magnesium                       | na                       | na      | 44300            |       |       | 100    | 5000  | 109000           |       |       | 100    | 5000  | 42700            |       |       | 100    | 5000  | 31000             |       |       | 100    | 5000  | 23800             |       |       | 100    | 5000  |
| Manganese                       | 50                       | 73      | 7.4              | J     | J     | 1      | 15    | 286              |       |       | 1      | 15    | 7                | J     | J     | 1      | 15    | 15.1              |       |       | 1      | 15    | 20.5              |       |       | 1      | 15    |
| Nickel                          | na                       | 73      | 5.7              | J     | J     | 1      | 40    | 132              |       |       | 1      | 40    | 5                | J     | J     | 1      | 40    | 14.5              | J     | J     | 1      | 40    | 5.8               | J     | J     | 1      | 40    |
| Potassium                       | na                       | na      | 1950             | J     | B     | 100    | 10000 | 6080             | J     | J     | 100    | 10000 | 3160             | J     | J     | 100    | 10000 | 3420              | J     | J     | 100    | 10000 | 2090              | J     | B     | 100    | 10000 |
| Selenium                        | 50                       | 18      | 4                | U     |       | 4      | 10    | 4                | U     |       | 4      | 10    | 4                | U     |       | 4      | 10    | 4                 | U     |       | 4      | 10    | 4                 | U     |       | 4      | 10    |
| Sodium                          | na                       | na      | 2090             | J     | J     | 500    | 10000 | 2240             | J     | J     | 500    | 10000 | 3660             | J     | B     | 500    | 10000 | 11400             |       | K     | 500    | 10000 | 1460              | J     | J     | 500    | 10000 |
| Vanadium                        | na                       | 3.7     | 1.1              | J     | J     | 1.1    | 50    | 35.6             | J     | J     | 1.1    | 50    | 1.1              | U     |       | 1.1    | 50    | 1.1               | U     |       | 1.1    | 50    | 1.8               | J     | J     | 1.1    | 50    |
| Zinc                            | 5000                     | 1100    | 6.3              | J     | J     | 5      | 20    | 36.5             |       |       | 5      | 20    | 5                | U     |       | 5      | 20    | 5.4               | J     | J     | 5      | 20    | 5                 | U     |       | 5      | 20    |
| Misc. (ug/L)                    |                          |         |                  |       |       |        |       |                  |       |       |        |       |                  |       |       |        |       |                   |       |       |        |       |                   |       |       |        |       |
| Perchlorate                     | na                       | 2.6     | 0.19             | J     | J     | 0.0663 | 0.2   | 0.548            |       | J     | 0.0663 | 0.2   | 0.407            |       | J     | 0.0663 | 0.2   | 0.193             | J     | J     | 0.0663 | 0.2   | 0.283             |       | J     | 0.0663 | 0.2   |
| Dioxins/Furans (ng/L)           |                          |         |                  |       |       |        |       |                  |       |       |        |       |                  |       |       |        |       |                   |       |       |        |       |                   |       |       |        |       |
| 2,3,7,8-TCDF                    | na                       | na      | 2.71             | U     |       | 2.71   | 2.71  | 2.62             | U     |       | 2.62   | 2.62  | 2.33             | U     |       | 2.33   | 2.33  | 3.8               | J     | J     | NA     | NA    | 2.48              | U     |       | 2.48   | 2.48  |
| 2,3,7,8-TCDD                    | 0.03                     | 0.00045 | 4.09             | U     |       | 4.09   | 4.09  | 3.1              | U     |       | 3.1    | 3.1   | 3.05             | U     |       | 3.05   | 3.05  | 4.71              | U     |       | 4.71   | 4.71  | 3.14              | U     |       | 3.14   | 3.14  |
| 1,2,3,7,8-PECDD                 | na                       | na      | 5.14             | U     | UJ    | 5.14   | 5.14  | 5.24             | U     | UJ    | 5.24   | 5.24  | 4.83             | U     | UJ    | 4.83   | 4.83  | 5                 | U     | UJ    | 5      | 5     | 3.02              | J     | J     | NA     | NA    |
| 1,2,3,4,7,8-HXCDD               | na                       | 0.011   | 5.14             | U     |       | 5.14   | 5.14  | 5.24             | U     |       | 5.24   | 5.24  | 4.83             | U     |       | 4.83   | 4.83  | 5.7               | U     |       | 5.7    | 5.7   | 5.6               | U     |       | 5.6    | 5.6   |
| 1,2,3,6,7,8-HXCDD               | na                       | 0.011   | 5.14             | U     |       | 5.14   | 5.14  | 5.24             | U     |       | 5.24   | 5.24  | 4.83             | U     |       | 4.83   | 4.83  | 5.43              | U     |       | 5.43   | 5.43  | 5.6               | U     |       | 5.6    | 5.6   |
| 1,2,3,7,8,9-HXCDD               | na                       | 0.011   | 5.14             | U     |       | 5.14   | 5.14  | 5.24             | U     |       | 5.24   | 5.24  | 4.83             | U     |       | 4.83   | 4.83  | 5.71              | U     |       | 5.71   | 5.71  | 5.6               | U     |       | 5.6    | 5.6   |
| 1,2,3,4,6,7,8-HPCDD             | na                       | na      | 5.14             | U     |       | 5.14   | 5.14  | 5.24             | U     |       | 5.24   | 5.24  | 4.83             | U     |       | 4.83   | 4.83  | 11                | J     | J     | NA     | NA    | 5.6               | U     |       | 5.6    | 5.6   |
| OCDD                            | na                       | na      | 6.52             | EMP   | J     | 10.3   | 10.3  | 48               | J     | J     | NA     | NA    | 9.65             | U     |       | 9.65   | 9.65  | 391               |       |       | NA     | NA    | 7.03              | J     | J     | NA     | NA    |
| 1,2,3,7,8-PECDF                 | na                       | na      | 5.14             | U     | UJ    | 5.14   | 5.14  | 5.24             | U     | UJ    | 5.24   | 5.24  | 4.83             | U     | UJ    | 4.83   | 4.83  | 5                 | U     | UJ    | 5      | 5     | 3.7               | J     | J     | NA     | NA    |
| 2,3,4,7,8-PECDF                 | na                       | na      | 5.14             | U     | UJ    | 5.14   | 5.14  | 5.24             | U     | UJ    | 5.24   | 5.24  | 4.83             | U     | UJ    | 4.83   | 4.83  | 5                 | U     | UJ    | 5      | 5     | 2.98              | J     | J     | NA     | NA    |
| 1,2,3,4,7,8-HXCDF               | na                       | na      | 5.14             | U     |       | 5.14   | 5.14  | 5.24             | U     |       | 5.24   | 5.24  | 4.83             | U     |       | 4.83   | 4.83  | 5.51              | U     |       | 5.51   | 5.51  | 3.07              | J     | J     | NA     | NA    |
| 1,2,3,6,7,8-HXCDF               | na                       | na      | 5.14             | U     |       | 5.14   | 5.14  | 5.24             | U     |       | 5.24   | 5.24  | 4.83             | U     |       | 4.83   | 4.83  | 5.23              | U     |       | 5.23   | 5.23  | 2.71              | J     | J     | NA     | NA    |
| 2,3,4,6,7,8-HXCDF               | na                       | na      | 5.14             | U     |       | 5.14   | 5.14  | 5.24             | U     |       | 5.24   | 5.24  | 4.83             | U     |       | 4.83   | 4.83  | 5.56              | U     |       | 5.56   | 5.56  | 1.9               | EMP   | J     | 5.6    | 5.6   |
| 1,2,3,7,8,9-HXCDF               | na                       | na      | 5.14             | U     |       | 5.14   | 5.14  | 5.24             | U     |       | 5.24   | 5.24  | 4.83             | U     |       | 4.83   | 4.83  | 6.53              | U     |       | 6.53   | 6.53  | 2.53              | J     | J     | NA     | NA    |
| 1,2,3,4,6,7,8-HPCDF             | na                       | na      | 5.14             | U     |       | 5.14   | 5.14  | 5.24             | U     |       | 5.24   | 5.24  | 4.83             | U     |       | 4.83   | 4.83  | 5.94              | J     | J     | NA     | NA    | 3.09              | J     | J     | NA     | NA    |
| 1,2,3,4,7,8,9-HPCDF             | na                       | na      | 5.14             | U     |       | 5.14   | 5.14  | 5.24             | U     |       | 5.24   | 5.24  | 4.83             | U     |       | 4.83   | 4.83  | 5.94              | U     |       | 5.94   | 5.94  | 5.6               | U     |       | 5.6    | 5.6   |
| OCDF                            | na                       | na      | 10.3             | U     |       | 10.3   | 10.3  | 10.5             | U     |       | 10.5   | 10.5  | 9.65             | U     |       | 9.65   | 9.65  | 10.9              | EMP   | J     | 10.5   | 10.5  | 11.2              | U     |       | 11.2   | 11.   |

**Table 5-2  
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.

**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 5-3  
Summary of Analytes Detected in SWMU 51 Vicinity Wells - 2006 and 2007  
Page 1 of 2

| Analyte                                       | MCL  | tw-RBC  | # of MCL Exceedances | # of tw-RBC Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|-----------------------------------------------|------|---------|----------------------|-------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| <b>VOCs (ug/L)</b>                            |      |         |                      |                         |                 |              |                       |                       |                     |
| 1,1,1-Trichloroethane                         | 200  | 910     | 0                    | 0                       | 3               | 11           | 0.46                  | 1.8                   | 48MW06              |
| 1,1-Dichloroethane                            | na   | 90      | na                   | 0                       | 2               | 11           | 3.4                   | 8.5                   | C1                  |
| Carbon tetrachloride                          | 5    | 0.16    | 2                    | 3                       | 3               | 11           | 3.8                   | 94.6                  | 48MW2               |
| Chloroethane                                  | na   | 3.6     | na                   | 1                       | 1               | 11           | 4                     | 4                     | C1                  |
| cis-1,2-Dichloroethene                        | 70   | 6.1     | 0                    | 0                       | 1               | 11           | 2.9                   | 2.9                   | 48MW06              |
| Methylene chloride                            | 5    | 4.1     | 1                    | 1                       | 1               | 11           | 8                     | 8                     | C1                  |
| Tetrachloroethene                             | 5    | 0.1     | 0                    | 1                       | 1               | 11           | 0.93                  | 0.93                  | 51MW1               |
| Trichloroethene                               | 5    | 0.026   | 2                    | 4                       | 4               | 11           | 1.6                   | 11.2                  | 48MW2               |
| <b>PAHs (ug/L)</b> <i>None detected</i>       |      |         |                      |                         |                 |              |                       |                       |                     |
| <b>SVOCs (ug/L)</b> <i>None detected</i>      |      |         |                      |                         |                 |              |                       |                       |                     |
| <b>Pesticides (ug/L)</b>                      |      |         |                      |                         |                 |              |                       |                       |                     |
| alpha-Chlordane                               | 2    | 0.19    | 0                    | 1                       | 1               | 11           | 0.21                  | 0.21                  | 16-4                |
| Heptachlor epoxide                            | 0.2  | 0.0074  | 0                    | 1                       | 1               | 11           | 0.015                 | 0.015                 | 16-4                |
| <b>PCBs (ug/L)</b> <i>None detected</i>       |      |         |                      |                         |                 |              |                       |                       |                     |
| <b>Explosives (ug/L)</b> <i>None detected</i> |      |         |                      |                         |                 |              |                       |                       |                     |
| <b>Herbicides (ug/L)</b> <i>None detected</i> |      |         |                      |                         |                 |              |                       |                       |                     |
| <b>Metals (ug/L)</b>                          |      |         |                      |                         |                 |              |                       |                       |                     |
| Aluminum                                      | 50   | 3700    | 9                    | 2                       | 9               | 11           | 57                    | 26600                 | 48MW06              |
| Antimony                                      | 6    | 1.5     | 1                    | 4                       | 4               | 11           | 2.6                   | 6.9                   | 48MW06              |
| Arsenic                                       | 10   | 0.045   | 1                    | 2                       | 2               | 11           | 4.4                   | 11.9                  | 48MW06              |
| Barium                                        | 2000 | 730     | 0                    | 0                       | 11              | 11           | 40.8                  | 607                   | 48MW2               |
| Beryllium                                     | 4    | 7.3     | 0                    | 0                       | 5               | 11           | 1.5                   | 2.1                   | 51MW2               |
| Calcium                                       | na   | na      | na                   | na                      | 11              | 11           | 18900                 | 185000                | 48MW2               |
| Chromium                                      | 100  | 11      | 2                    | 4                       | 10              | 11           | 0.59                  | 195                   | 48MW2               |
| Cobalt                                        | na   | na      | na                   | na                      | 3               | 11           | 3.1                   | 42.8                  | 48MW06              |
| Copper                                        | 1300 | 150     | 0                    | 0                       | 3               | 11           | 1.2                   | 119                   | 48MW06              |
| Iron                                          | 300  | 2600    | 6                    | 2                       | 9               | 11           | 36                    | 89800                 | 48MW06              |
| Lead                                          | 15   | na      | 0                    | na                      | 5               | 11           | 1.3                   | 8.4                   | 48MW06              |
| Magnesium                                     | na   | na      | na                   | na                      | 11              | 11           | 7440                  | 119000                | 48MW06              |
| Manganese                                     | 50   | 73      | 3                    | 2                       | 11              | 11           | 1.8                   | 2550                  | 48MW06              |
| Nickel                                        | na   | 73      | na                   | 2                       | 8               | 11           | 1.1                   | 132                   | 48MW2               |
| Potassium                                     | na   | na      | na                   | na                      | 11              | 11           | 1030                  | 9740                  | 48MW06              |
| Selenium                                      | 50   | 18      | 0                    | 0                       | 2               | 11           | 2.8                   | 10                    | 48MW06              |
| Sodium                                        | na   | na      | na                   | na                      | 11              | 11           | 256                   | 60500                 | 48MW06              |
| Vanadium                                      | na   | 3.7     | na                   | 2                       | 6               | 11           | 0.7                   | 46.3                  | 48MW06              |
| Zinc                                          | 5000 | 1100    | 0                    | 0                       | 7               | 11           | 0.91                  | 41.8                  | 48MW06              |
| <b>Misc. (ug/L)</b>                           |      |         |                      |                         |                 |              |                       |                       |                     |
| Perchlorate                                   | na   | 2.6     | na                   | 0                       | 7               | 7            | 0.19                  | 0.548                 | 48MW2               |
| <b>Dioxins/Furans (ng/L)</b>                  |      |         |                      |                         |                 |              |                       |                       |                     |
| 2,3,7,8-TCDF                                  | na   | na      | na                   | na                      | 1               | 11           | 3.8                   | 3.8                   | 49MW01              |
| 2,3,7,8-TCDD                                  | 0.03 | 0.00045 | 0                    | 0                       | 0               | 11           | na                    | na                    | na                  |
| 1,2,3,7,8-PECDD                               | na   | na      | na                   | na                      | 1               | 11           | 3.02                  | 3.02                  | 59MW01              |

Table 5-3  
Summary of Analytes Detected in SWMU 51 Vicinity Wells - 2006 and 2007  
Page 2 of 2

| Analyte             | MCL | tw-RBC | # of MCL Exceedances | # of tw-RBC Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---------------------|-----|--------|----------------------|-------------------------|-----------------|--------------|-----------------------|-----------------------|---------------------|
| 1,2,3,4,7,8-HXCDD   | na  | 0.011  | na                   | 0                       | 0               | 11           | na                    | na                    | na                  |
| 1,2,3,6,7,8-HXCDD   | na  | 0.011  | na                   | 0                       | 0               | 11           | na                    | na                    | na                  |
| 1,2,3,7,8,9-HXCDD   | na  | 0.011  | na                   | 0                       | 0               | 11           | na                    | na                    | na                  |
| 1,2,3,4,6,7,8-HPCDD | na  | na     | na                   | na                      | 1               | 11           | 11                    | 11                    | 49MW01              |
| OCDD                | na  | na     | na                   | na                      | 7               | 11           | 0.0376                | 391                   | 49MW01              |
| 1,2,3,7,8-PECDF     | na  | na     | na                   | na                      | 1               | 11           | 3.7                   | 3.7                   | 59MW01              |
| 2,3,4,7,8-PECDF     | na  | na     | na                   | na                      | 1               | 11           | 2.98                  | 2.98                  | 59MW01              |
| 1,2,3,4,7,8-HXCDF   | na  | na     | na                   | na                      | 1               | 11           | 3.07                  | 3.07                  | 59MW01              |
| 1,2,3,6,7,8-HXCDF   | na  | na     | na                   | na                      | 1               | 11           | 2.71                  | 2.71                  | 59MW01              |
| 2,3,4,6,7,8-HXCDF   | na  | na     | na                   | na                      | 1               | 11           | 1.9                   | 1.9                   | 59MW01              |
| 1,2,3,7,8,9-HXCDF   | na  | na     | na                   | na                      | 1               | 11           | 2.53                  | 2.53                  | 59MW01              |
| 1,2,3,4,6,7,8-HPCDF | na  | na     | na                   | na                      | 3               | 11           | 1.77                  | 5.94                  | 49MW01              |
| 1,2,3,4,7,8,9-HPCDF | na  | na     | na                   | na                      | 0               | 11           | na                    | na                    | na                  |
| OCDF                | na  | na     | na                   | na                      | 1               | 11           | 10.9                  | 10.9                  | 49MW01              |
| TOTAL TCDD          | na  | na     | na                   | na                      | 0               | 11           | na                    | na                    | na                  |
| TOTAL PECDD         | na  | na     | na                   | na                      | 1               | 11           | 3.02                  | 3.02                  | 59MW01              |
| TOTAL HXCDD         | na  | 0.011  | na                   | 0                       | 0               | 11           | na                    | na                    | na                  |
| TOTAL HPCDD         | na  | na     | na                   | na                      | 1               | 11           | 20                    | 20                    | 49MW01              |
| TOTAL TCDF          | na  | na     | na                   | na                      | 1               | 11           | 3.8                   | 3.8                   | 49MW01              |
| TOTAL PECDF         | na  | na     | na                   | na                      | 1               | 11           | 6.67                  | 6.67                  | 59MW01              |
| TOTAL HXCDF         | na  | na     | na                   | na                      | 1               | 11           | 10.2                  | 10.2                  | 59MW01              |
| TOTAL HPCDF         | na  | na     | na                   | na                      | 3               | 11           | 1.77                  | 5.94                  | 49MW01              |

## 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 HHRA was conducted for the site consistent with guidance included in EPA's *Interim Final Risk Assessment Guidance for Superfund* (RAGS) and other current EPA/EPA 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 SWMU 51. Refer to *Section 4.0* for complete data tables for detected analytes for each media. Additional information regarding the data used in the HHRA 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) to assess risks due to exposure to dioxins and/or furans. Each congener is assigned a

**Table 6-1**  
**SWMU 51 Sample Groupings**

| <b>SURFACE SOIL<sup>a</sup> (Baseline HHRA)</b> |         |         |
|-------------------------------------------------|---------|---------|
| 51SB1A                                          | 51SB5A  | 51SB9A  |
| 51SB2A                                          | 51SB6A  | 51SB10A |
| 51SB3A                                          | 51SB7A  | 51SB11A |
| 51SB4A                                          | 51SB8A  |         |
| <b>TOTAL SOIL<sup>b</sup> (Baseline HHRA)</b>   |         |         |
| 51SB1A                                          | 51SB10A | 51SB8B  |
| 51SB2A                                          | 51SB11A | 51SB9B  |
| 51SB3A                                          | 51SB1B  | 51SB10B |
| 51SB4A                                          | 51SB2B  | 51SB11B |
| 51SB5A                                          | 51SB3B  | 51SB2C  |
| 51SB6A                                          | 51SB4B  | 51SB3C  |
| 51SB7A                                          | 51SB5B  | 51SB4C  |
| 51SB8A                                          | 51SB6B  |         |
| 51SB9A                                          | 51SB7B  |         |
| <b>GROUNDWATER (Baseline HHRA)</b>              |         |         |
| 48MW01                                          | 51MW2   | 59MW01  |
| 51MW1                                           |         |         |
| <b>COVER SOIL<sup>c</sup> (CMS)</b>             |         |         |
| 51SB1A                                          | 51SB7A  | 51SB1B  |
| 51SB2A                                          | 51SB8A  | 51SB7B  |
| 51SB3A                                          | 51SB9A  | 51SB8B  |
| 51SB4A                                          | 51SB10A | 51SB9B  |
| 51SB5A                                          | 51SB11A | 51SB10B |
| 51SB6A                                          |         | 51SB11B |
| <b>SLUDGE LAYER<sup>d</sup> (CMS)</b>           |         |         |
| 51SB2B                                          | 51SB5B  | 51SB2C  |
| 51SB3B                                          | 51SB6B  | 51SB3C  |
| 51SB4B                                          |         | 51SB4C  |
| <b>DEEP SOIL<sup>e</sup> (CMS)</b>              |         |         |
| 51SB1C                                          | 51SB9C  | 51SB3D  |
| 51SB5C                                          | 51SB10C | 51SB4D  |
| 51SB6C                                          | 51SB11C | 51SB5D  |
| 51SB7C                                          | 51SB2D  | 51SB6D  |
| 51SB8C                                          |         |         |

HHRA = Human Health Risk Assessment

CMS = Corrective Measures Study

(a) Surface soil samples consist of samples collected from depths of zero to one foot.

(b) Total soil consists of samples collected from both the native cover material and the sludge layer.

(c) Cover soil consists of samples collected from the native cover material above the sludge layer.

(d) Sludge layer consists of samples collected from the sludge layer.

(e) Deep soil consists of samples collected below the sludge layer.

toxicity equivalence factor (TEF), which corresponds to its toxicity relative to 2,3,7,8-TCDD. Each congener detection is multiplied by its corresponding TEF; the adjusted concentrations are then summed to derive one total 2,3,7,8-TCDD equivalent concentration for each sample. This concentration is then compared with toxicity criteria for 2,3,7,8-TCDD to calculate risks. 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 SWMU 51 was greater than 50 percent, one-half of the SQL was used to represent the concentration. If the proportion of B-qualified results in the data set was less than 50 percent, the B-qualified data for the analyte were eliminated. (The exception to this approach was the dioxin/furan results used to estimate a 2,3,7,8-TCDD toxicity equivalent concentration.) For screening purposes, the B-qualified data were included in calculations of the dioxin toxicity equivalence (TCDD TE), as described in the sections below.
- 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 2004 for the RFI were used for the COPC screenings. As presented in **Table 6-1**, the soil samples for SWMU 51 have been divided into surface soil (0-1 ft bgs) and total (0-20 ft bgs). 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. Subsurface soil samples collected down to 20 ft were included in the total soil data set to represent the sludge layer within

the pit at SWMU 51. Although sample 51SB5C was collected at a depth of 16-18 ft bgs and sample 51SB6C was collected at a depth of 9-11 ft, it should be noted that these samples were not included in the total soil data set because they were collected below the sludge layer. A total of 11 surface soil samples and 25 subsurface soil samples were used for the HHRA.

In addition to the data sets analyzed for the baseline HHRA, a subset of the total soil data set was used to represent the native cover material at SWMU 51. These samples are listed as cover soil samples in **Table 6-1** and vary in depth from 0-20 ft bgs. In support of the CMS, analytical data for the cover soil were evaluated separately in this HHRA. Risks and hazards were calculated to determine whether cover soil could be placed back in the pit at SWMU 51 after the sludge layer is removed. A total of 17 cover soil samples were used in this evaluation.

Soil samples collected below the sludge layer are also shown in **Table 6-1**. These samples were collected down to depths of 38 ft. Analytical data for the deeper soil were also evaluated separately in this HHRA. Although no exposures are expected at these depths, risks and hazards were calculated for the industrial scenario to determine whether deep soil can be left in place. A total of 13 deep soil samples were used in this evaluation.

#### **6.1.1.2 Groundwater**

Groundwater samples collected during sampling events completed in 2006 and 2007 for the RFI were used for the COPC screenings. A total of four samples were collected. Two groundwater monitoring wells (51MW1 and 51MW2) were located within SWMU 51. Two additional wells (48MW07 and 59MW01) 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 site 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, lead action levels of 400 mg/kg for residential receptors were used in the COPC identification since toxicity criteria were not available for lead (USEPA, 1994b).

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. 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. If iron concentrations in soil or water resulted in an HQ of 1.0 or greater, a “margin of exposure” evaluation was also performed. Risks from exposure to iron were characterized by comparing estimated iron intake to the Recommended Daily Allowance (RDA) and concentrations known to cause effects in children (USEPA, 1996b).

Analytes detected at a maximum concentration greater than the corresponding adjusted RBC or screening values for nutrients and lead as identified above 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.1-3** (Non-Detect Screening- Surface Soil), **E.1-4** (COPC Determination Detects-Total Soil),

**E.1-5** (Non-Detect Screening-Soil), **E.1-6** (COPC Determination Detects-Groundwater), and **E.1-7** (Non-Detect Screening-Groundwater). Detected constituents identified as COPCs are carried through the quantitative risk assessment. The reporting limits for constituents that were 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*).

As discussed in *Section 6.1.1.1*, samples 51SB5C and 51SB6C were not included in the total soil data set because they were collected below the sludge layer. The analytical results for these samples, however, were evaluated to determine whether their inclusion in the total soil data set would have impacted the COPC selection process or the conclusions of the HHRA. It was determined that inclusion of either of these samples would not have resulted in additional COPCs. The majority of the detected concentrations were below the respective screening criterion. For those results that exceeded screening criteria, the concentrations were well below the MDC for that constituent in the data set.

## **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 SWMU 51 are presented on **Figures 6-1 and 6-2** for current and future exposure scenarios, respectively. SWMU 51 is located in the HSA. This area is not highly developed and land use in the vicinity of the facility is mostly rural, with less rugged areas having been primarily used for agriculture. Residential and recreational areas are located adjacent to the facility (IT, 2001). It is unlikely, however, that the uses of land within the HSA will change significantly in the future. The HSA contains numerous buildings and facilities, and it is likely that the area will remain industrial in nature.

SWMU 51 is not currently in use and the site is fenced. It was conservatively assumed, however, that maintenance workers are the most likely receptors at the site. Due to installation security, it is unlikely that trespassers could gain access to SWMU 51; 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 SWMU 51 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 site include maintenance workers, industrial workers, excavation workers, child residents, adult residents, and lifetime residents. In **Appendix E-1, Table E.1-1** summarizes the selection of exposure pathways for each receptor listing the

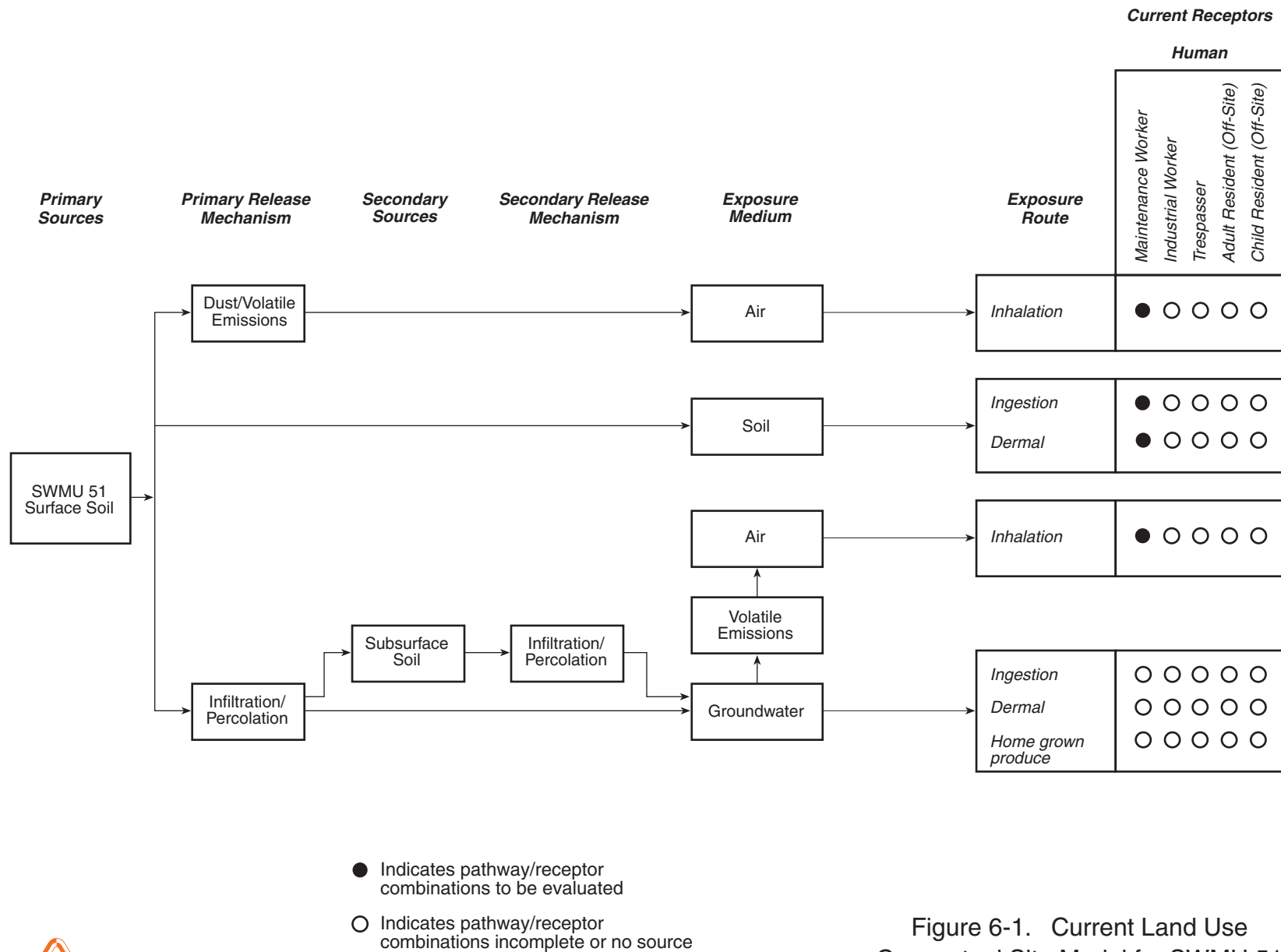


Figure 6-1. Current Land Use  
Conceptual Site Model for SWMU 51  
Radford Army Ammunition Plant, Virginia

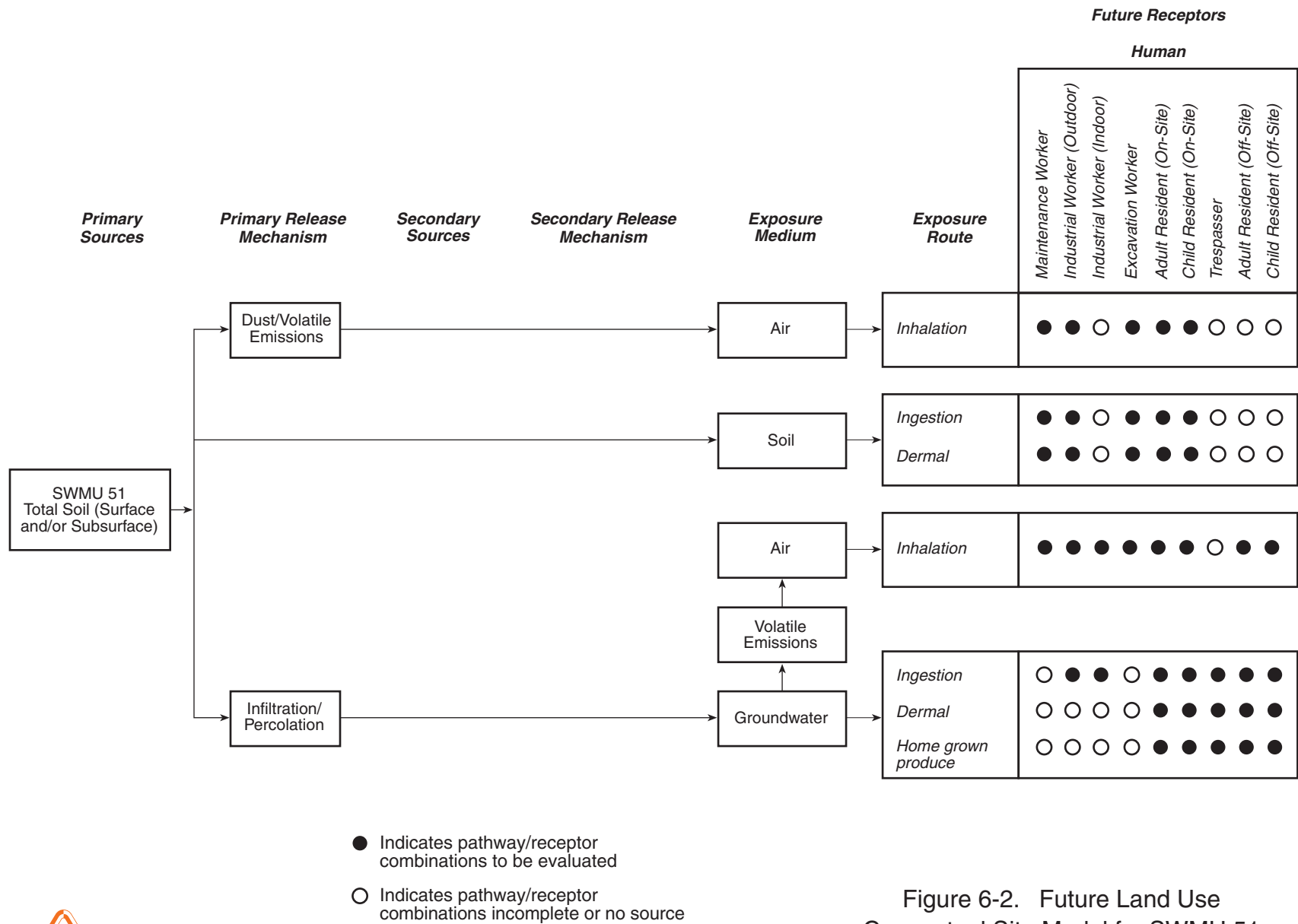


Figure 6-2. Future Land Use  
Conceptual Site Model for SWMU 51  
Radford Army Ammunition Plant, Virginia

rationale for the inclusion or exclusion of each pathway. Conceptual site diagrams for the site are presented on **Figures 6-1 and 6-2**.

### **6.2.3 Calculation of EPCs**

To calculate intakes, the mean concentration of each COPC is estimated and is referred to as the EPC. To account for uncertainty when estimating EPCs from sample data, the 95% upper confidence limit of the mean (95% UCL) is used instead of the mean itself (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).

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 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 make for COPCs with a high rate of non-detects. Based on the technical guide for ProUCL, the results for the non-detects are set at zero. USEPA's ProUCL 4.0 statistical program (USEPA, 2007b) is used to calculate EPCs for the site with the exception of data sets with less than 5% detects for which the bootstrap technique was used. Non-detect values were represented by random numbers generated by the iterative process used in the bootstrap technique. 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 were 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**.

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.1-28 through E.1-32**. For this scenario, the volatilization model outlined in ASTM Risk-Based Corrective Action Guidance (ASTM, 1995) for volatilization from groundwater to ambient air was used. The equations used to calculate the volatilization factor to ambient air for VOCs in SWMU 51 groundwater are presented in **Appendix E-1, Table E.1-28**.

The Johnson and Ettinger model (USEPA, 2004a) is used to estimate indoor air concentrations of volatiles migrating from groundwater through the soil and into a structure. Spreadsheets for this model were used to estimate air concentrations of VOCs in office buildings and residences for this HHRA. The spreadsheet is found in **Appendix E-4**, and the results are given in **Appendix E-1, Table E.1-30**.

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 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.1-31**.

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) shower room model. The model is described in **Appendix E-1, Table E.1-32**.

### **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, 1989b). The particulate emission factors (PEFs) used to calculate inhalation daily intakes were calculated in accordance with the Supplemental Guidance for Developing SSLs for Superfund Sites (USEPA, 2002c), as provided in **Appendix E-1, Tables E.1-26 and E.1-27**.

Intake formulas, exposure parameters, and chemical-specific parameters are provided in **Appendix E-1, Tables E.1-15 through E.1-32**.

### 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, 1997b).

Toxicity criteria used to quantify non-carcinogenic hazards (risk reference doses - RfDs) and carcinogenic risks (e.g., cancer slope factors - CSFs) are presented in **Appendix E-1, Tables E.1-33 through E.1-36**.

Quantitative oral toxicity criteria were not available for lead. Lead was selected as a COPC in total soil at SWMU 51. 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 SWMU 51. 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 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-37a and E-38a**, respectively. The spreadsheets are provided as **Appendix E-1, Tables E-37b and E-38b** 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).

The potential risks associated with residential exposures to lead are addressed using the Integrated Exposure Uptake Biokinetic (IEUBK) Lead Model for Windows<sup>®</sup>, Version 1.0, Build 264 (USEPA, 1994b, 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-39**. Percentages below 5 percent are considered to be protective of human health. The corresponding input parameters and the distribution probability plot from the model are included with the table.

The toxic effects associated with chromium are dependent upon its valence state (USEPA, 1998). Two common forms of chromium are trivalent chromium (Cr III) and hexavalent chromium (Cr VI). Chromium III is the predominant form of chromium in nature and is the less toxic of the two forms. Hexavalent chromium is the more toxic form of chromium and is considered to be a Class A carcinogen via the route of inhalation. The speciation of hexavalent chromium (Cr VI) is not routinely performed during a sampling program due to the very short holding time and the unique stability issues associated with hexavalent chromium (i.e., it tends to change valence states very easily after sample collection). Unless there is convincing evidence that hexavalent chromium may be present at a site (such as its for control of scale in non-contact cooling water piping for a power plant or a chromium plating operation), it is generally not included in an analytical program. For SWMU 51, hexavalent chromium analyses were not performed for the environmental media samples.

It was assumed that the majority of the chromium that was detected at the site would be in the trivalent form. Hexavalent chromium is relatively unstable in the environment and is typically converted to trivalent chromium. As stated in Water-Related Environmental Fate of 129 Priority Pollutants (USEPA, 1979), hexavalent chromium or Cr (VI) is a moderately strong oxidizing agent and reacts with reducing materials to form trivalent chromium or Cr (III). 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)<sub>3</sub>. 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 samples taken at SWMU 51 ranged from 5.0 to 7.8 with an average of 6.15. The relationship between chromium concentrations versus pH, is shown in **Appendix E-5, Plot 1**. Three soil pH measurements (5.0, 5.9, and 5.9) represented acidic soil conditions and the total chromium concentrations were relatively low (16.6 to 39.1 mg/kg). One elevated chromium soil concentration (469 mg/kg) was associated with a neutral-to-alkaline soil pH (7.8). 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 the 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 content (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 1 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 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.1-40 through E.1-56**. The spreadsheets for the risk and hazard calculations are provided in **Appendix E-1, Tables E.1-57 through E.1-64** and summarized in **Table 6-2**. A refinement of the HIs based on target organs is conducted by calculating HIs on a target organ-specific basis. In addition, **Appendices E.1, Tables E.1-65 through E.1-72** summarize risks and hazards for risk/HI drivers (i.e., those COPCs contributing to a total risk greater than 1.E-04 or a total target organ hazard greater than 1).

As noted in *Section 6.1.1.1*, risks and hazards associated with cover soil and deep soil were calculated separately. The spreadsheets for the calculations are found in **Appendix E-6** and summarized in **Tables 6-3 and 6-4**, respectively.

#### **6.4.1 Lead Exposure Models**

The MDC for lead in total soil for SWMU 51 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 workers and the IEUBK model for the child resident scenario (USEPA, 2007d).

The ALM is used to evaluate risks of lead exposure to the fetus of pregnant female industrial workers, construction 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 (698 mg/kg). The assumptions and output of the modeling is presented in **Appendix E-1, Tables E.1-37a, E.1-37b, E.1-38a, and E.1-38b**. 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 (698 mg/kg). Because the future water supply for SWMU 51 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.1-39**. The corresponding input parameters and distribution probability plot are also provided with **Appendix E-1, Table E.1-39**. 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.

**Table 6-2**  
**Summary of Risks and Hazards**  
**SWMU 51**  
**Page 1 of 2**

| Timeframe/Receptor         | Risk         | HI            | Risk Drivers                                                                                                                    | Target Organ Segregation HI>1                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------|--------------|---------------|---------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Current maintenance worker | 9E-07        | 8E-02         | None                                                                                                                            | NA                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Future maintenance worker  | <b>3E-03</b> | <b>4.E+01</b> | Total Soil<br>TCDD-TE<br>2,4-DNT<br>2,6-DNT<br>Nitroglycerin<br>4-NT<br>2,4,6-TNT<br>As                                         | Blood (5.9) - Soil [2,4-DNT - Ing (2.5), and Derm (1.7)]<br>CNS (5.6) - Soil [2,4-DNT - Ing (2.5) and Derm (1.7)]<br>Liver (25.6) - Soil [2,4-DNT - Ing (2.5) and Derm (1.7); 2,4,6-TNT - Soil - Ing (16) and Derm (3.5)]                                                                                                                                                                                                 |
| Future industrial worker   | <b>1E-02</b> | <b>2E+02</b>  | Total Soil<br>TCDD-TE<br>2,4-DNT<br>2,6-DNT<br>Nitroglycerin<br>4-NT<br>2,4,6-TNT<br>As<br><u>Groundwater</u><br>PCE<br>TCDD-TE | Blood (26.7) - Soil [2,4-DNT - Ing (11) and Derm (7.7); 2,6-DNT - Ing (3.7) and Derm (2.4); 2-NT - Ing (1.2)]<br>Spleen (3.1) - Soil [1,3-DNB - Ing (1.9 and Derm (1.2)]<br>CNS (25) - Soil [2,4-DNT - Ing (11) and Derm (7.7); 2,6-DNT - Ing (3.7) and Derm (2.4)<br>Liver (115) - Soil [2,4-DNT - Ing (11) and Derm (7.7)]; 2,6-DNT - Ing (3.7) and Derm (2.4); 2,4,6-TNT - Ing (74) and Derm (16)]                     |
| Future excavation worker   | <b>1E-03</b> | <b>5E+02</b>  | Total Soil<br>TCDD-TE<br>2,4-DNT<br>2,6-DNT<br>Nitroglycerin<br>4-NT<br>2,4,6-TNT                                               | Spleen (9.0) - Soil [1,3-DNB - Ing (6.9) and Derm (2.1)]<br>CNS (80) - Soil [2,4-DNT - Ing (42) and Derm (13); 2,6-DNT - Ing (13) and Derm (4); Al - Inh (2.0); Mn - Inh (7.6)<br>Blood (77) - Soil [2,4-DNT - Ing (42) and Derm (13); 2,6-DNT - Ing (13) and Derm (4); 2-NT - Ing (4.2)]<br>Liver (371) - Soil [2,4-DNT - Ing (42) and Derm (13)]; 2,6 DNT - Ing (13) and Derm (4); 2,4,6-TNT - Ing (270) and Derm (26)] |
| Future adult resident      | NA           | <b>2.E+02</b> | NA                                                                                                                              | Blood (35) - Soil [2,4-DNT - Ing (18) and Derm (2.7); 2,6-DNT - Ing (5.7) and Derm (2.3); 2-NT - Ing (1.81)]<br>Spleen (4.1) - Soil [1,3-DNB - Ing (2.9) and Derm (1.2)]<br>CNS (33) - Soil [2,4-DNT - Ing (18) and Derm (7.2); 2,6-DNT - Ing (5.7) and Derm (2.3)]<br>Liver (163) - Soil [2,4-DNT (18) and Derm (7.2); 2,6-DNT - Ing (5.7) and Derm (2.3); 2,4,6-TNT - Ing (120) and Derm (15)]                          |

**Table 6-2**  
**Summary of Risks and Hazards**  
**SWMU 51**  
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| Timeframe/Receptor               | Risk         | HI            | Risk Drivers                                                                                                             | Target Organ Segregation HI>1                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------------------------------|--------------|---------------|--------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Future child resident            | <b>3E-02</b> | <b>2.E+03</b> | Total Soil<br>TCDD-TE<br>2,4-DNT<br>2,6-DNT<br>Nitroglycerin<br>4-NT<br>2,4,6-TNT<br>As<br>Groundwater<br>PCE<br>TCDD-TE | Blood (302) - Soil [2,4-DNT - Ing (170) and Derm (47); 2,6-DNT - Ing (53) and Derm (15); 2-NT - Ing (17) and Derm (1.4); Fe - Ing (1.9)]<br>Spleen (35) - Soil [1,3-DNB - Ing (27) and Derm (7.6)]<br>CNS (282) - Soil [2,4-DNT - Ing (170) and Derm (47); 2,6-DNT - Ing (53) and Derm (15)]<br>Liver (1,456) - Soil [2,4-DNT - Ing (170) and Derm (47); 2,6-DNT - Ing (53) and Derm (15); 2,4,6-TNT - Ing (1,100) and Derm (96); Fe - Ing (1.9)]<br>GI tract - Soil [Fe - Ing (1.9)] |
| Lifetime resident                | <b>5E-02</b> | NA            | Total Soil<br>TCDD-TE<br>2,4-DNT<br>2,6-DNT<br>Nitroglycerin<br>4-NT<br>2,4,6-TNT<br>As<br>Groundwater<br>PCE<br>TCDD-TE | NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Future adult resident (Off-Site) | NA           | 5.00E-03      | None                                                                                                                     | NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Future child resident (Off-Site) | <b>4E-04</b> | 1.00E-02      | Groundwater<br>PCE<br>TCDD-TE                                                                                            | NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Lifetime resident (Off-Site)     | <b>1E-03</b> | NA            | Groundwater<br>PCE<br>TCDD-TE                                                                                            | NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

NA = Not applicable.

HI = Hazard Index.

Bold = Exceeds USEPA Risk or Hazard Range.

Al = aluminum; As = arsenic; Fe = iron; Mn = manganese; 1,3-DNB = 1,3-dinitrobenzene; 2,4-DNT = 2,4-dinitrotoluene; 2,6-DNT = 2,6-dinitrotoluene; 2-NT = 2-nitrotoluene; PCE = tetrachloroethene; TCDD-TE = dioxin toxicity equivalent; 2,4,6-TNT = 2,4,6-trinitrotoluene. **[NOTE: As, Fe, Mn, and V are within background concentrations for total soil.]**  
 Ing = Ingestion; Inh - Inhalation; Derm = Dermal.

CNS = Central nervous system.

GI = Gastrointestinal.

**Table 6-3**  
**Summary of Risks and Hazards**  
**SWMU 51 - Cover Soil**

| Timeframe/Receptor        | Risk  | HI           | Risk Drivers             | Target Organ Segregation HI>1                                                                         |
|---------------------------|-------|--------------|--------------------------|-------------------------------------------------------------------------------------------------------|
| Future maintenance worker | 9E-07 | 1E-01        | None                     | None                                                                                                  |
| Future industrial worker  | 4E-06 | 5E-01        | As                       | None                                                                                                  |
| Future excavation worker  | 6E-07 | <b>1E+01</b> | None                     | CNS (HI = 10) - Soil [Mn - Inh (10)]<br>No target organ identified (HI = 2.2) - Soil [Al - Inh (2.2)] |
| Future adult resident     | NA    | 5E-01        | NA                       | None                                                                                                  |
| Future child resident     | 1E-05 | <b>4E+00</b> | 2,6-DNT<br>As            | CNS (HI = 1.6) - Soil [Mn - Ing and Derm (1.6)]<br>Kidney (HI = 1.4) - Soil [V - Ing and Derm (1.4)]  |
| Lifetime resident         | 2E-05 | NA           | 2,4-DNT<br>2,6-DNT<br>As | N/A                                                                                                   |

Note: NA = Not applicable.

HI = Hazard Index.

Bold = Exceeds USEPA Risk or Hazard Range.

Al = aluminum; As = arsenic; Fe = iron; Mn = manganese; V = vanadium; 2,4-DNT = 2,4-dinitrotoluene; 2,6-DNT = 2,6-dinitrotoluene; 2,4,6-TNT = 2,4,6-trinitrotoluene. **[NOTE: Al, As, Mn, and V are within background concentrations for cover soil.]**

Inh = Inhalation

CNS = Central nervous system

**Table 6-4**  
**Summary of Risks and Hazards**  
**SWMU 51 - Deep Soil**

| Timeframe/Receptor        | Risk  | HI           | Risk Drivers                                | Target Organ Segregation HI>1                                                                        |
|---------------------------|-------|--------------|---------------------------------------------|------------------------------------------------------------------------------------------------------|
| Future maintenance worker | 3E-06 | 9E-02        | 2,4-DNT                                     | None                                                                                                 |
| Future industrial worker  | 1E-05 | 4E-01        | 2,4-DNT<br>2,6-DNT<br>As                    | None                                                                                                 |
| Future excavation worker  | 2E-06 | <b>8E+00</b> | No individual COPCs resulted in risk >1E-06 | CNS (HI = 4.7) - Soil [Mn - Inh (4.4)]<br>No target organ identified (HI = 2.1) - Soil [Al-Inh(2.1)] |

NA = Not applicable.

HI = Hazard Index.

Bold = Exceeds USEPA Risk or Hazard Range.

Al = aluminum; As = arsenic; Mn = manganese; 2,4-DNT = 2,4-dinitrotoluene; 2,6-DNT = 2,6-dinitrotoluene; 2,4,6-TNT = 2,4,6-trinitrotoluene. **[NOTE: Al, As, and Mn are within background concentrations in deep soil.]**

Inh = Inhalation

CNS = Central nervous system

Default parameters were utilized for the ALM 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 (250 days).

Default parameters were used for the IEUBK model. The arithmetic mean for lead in total soil (698 mg/kg) was used in each of the models. The results of the lead assessments are provided below:

- Maintenance and Industrial Worker: 1.7% probability that fetal blood levels would exceed 10 g/dL (<5% therefore passes).
- Excavation Worker: 6.5% probability that fetal blood levels would exceed 10 g/dL (<5% therefore fails).
- Child resident: 32.2% probability that child blood levels would exceed 10 g/dL (<5% therefore fails).

SWMU 51 passes the lead exposure assessment for the maintenance worker and the industrial worker, but fails for the construction worker and child resident.

#### **6.4.2 Iron Margin of Exposure Evaluation**

Because iron concentrations in soil resulted in an HQ of 0.5 or higher for the child resident at SWMU 51, a “margin of exposure evaluation” was conducted for the site. This evaluation consists of a comparison of estimated intake of iron to the RDA and concentrations known to cause adverse health effects in children. The calculated intake of iron was 1.3 mg chemical/kg body weight per day (mg/kg-day) via the route of ingestion. This value was compared with amounts that are associated with an RDA of 10 mg/day (0.36 to 1.11 mg/kg-day) for children from 6 months to 10 years of age (USEPA, 1996b). The intake calculated for total soil at SWMU 51 was above the allowable range.

#### **6.4.3 Background**

Statistical evaluations were conducted to compare metals concentrations in soil at SWMU 51 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 the site’s 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 **Table 6-5** for surface and total soil. Separate background comparisons were performed for selected metals in the native cover material (cover soil) and deep soil.

**Table 6-5**  
**Summary of Site vs. Background Statistical Analyses**

| Inorganic<br>Constituent    | Data Distribution <sup>a</sup> |               | Site >                   | Basis <sup>b</sup>         |
|-----------------------------|--------------------------------|---------------|--------------------------|----------------------------|
|                             | SWMU-51                        | Background    | Background? <sup>b</sup> |                            |
| Surface Soil (0 - 0.5 feet) |                                |               |                          |                            |
| Aluminum                    | Normal                         | Not Normal    | Yes                      | Wilcoxon Mann Whitney Test |
| Antimony                    | Detects < 3 <sup>c</sup>       | All nondetect | No                       | Wilcoxon Mann Whitney Test |
| Arsenic                     | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Barium                      | Normal                         | Normal        | No                       | T-test                     |
| Beryllium                   | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Cadmium                     | Normal                         | Detects < 3   | No                       | Wilcoxon Mann Whitney Test |
| Calcium                     | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Chromium                    | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Cobalt                      | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Copper                      | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Iron                        | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Lead                        | Not Normal                     | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Magnesium                   | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Manganese                   | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Mercury                     | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Nickel                      | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Potassium                   | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Selenium                    | Detects < 3                    | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Thallium                    | Detects < 3                    | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Vanadium                    | Normal                         | Not Normal    | Yes                      | Wilcoxon Mann Whitney Test |
| Zinc                        | Normal                         | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Total Soil <sup>d</sup>     |                                |               |                          |                            |
| Aluminum                    | Normal                         | Not Normal    | Yes                      | Wilcoxon Mann Whitney Test |
| Antimony                    | Not Normal                     | All nondetect | No                       | Wilcoxon Mann Whitney Test |
| Arsenic                     | Not Normal                     | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Barium                      | Not COPC                       | Not Normal    | -- <sup>e</sup>          | --                         |
| Beryllium                   | Not COPC                       | Not Normal    | --                       | --                         |
| Cadmium                     | Not COPC                       | Not Normal    | --                       | --                         |
| Calcium                     | Not COPC                       | Not Normal    | --                       | --                         |
| Chromium                    | Not COPC                       | Normal        | --                       | --                         |
| Cobalt                      | Not Normal                     | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Copper                      | Not Normal                     | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Iron                        | Not Normal                     | Normal        | No                       | Wilcoxon Mann Whitney Test |
| Lead                        | Not Normal                     | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Magnesium                   | Not COPC                       | Not Normal    | --                       | --                         |
| Manganese                   | Not Normal                     | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Mercury                     | Not COPC                       | Not Normal    | --                       | --                         |
| Nickel                      | Not COPC                       | Not Normal    | --                       | --                         |
| Potassium                   | Not COPC                       | Not Normal    | --                       | --                         |
| Selenium                    | Not COPC                       | Detects < 3   | --                       | --                         |
| Thallium                    | Not Normal                     | Not Normal    | No                       | Wilcoxon Mann Whitney Test |
| Vanadium                    | Normal                         | Normal        | No                       | T-test                     |
| Zinc                        | Not COPC                       | Not Normal    | --                       | --                         |

<sup>a</sup> As determined by ProUCL version 4.0, NDs included (as DL/2), Shapiro-Wilks test, if available otherwise Lillefors test results used. Details in Appendix.

<sup>b</sup> Two sample (population) hypothesis testing, two-sided test, using ProUCL version 4.0.  
"Without ND" option used if 100% detects, otherwise "With ND" option employed.  
T-test used if both site and background data sets had normal distributions, otherwise WMW test used.  
95% confidence level selected. Details in Appendix.

<sup>c</sup> If detects < 3, data distribution could not be determined.

<sup>d</sup> Total soil = samples collected from surface to bottom of the waste layer, generally 0-15 feet bgs.

<sup>e</sup> No statistical results presented, as chemical not COPC.  
WMW Test = Wilcoxon Mann Whitney test.  
COPC = chemical of potential concern (for human health).

Based on the background evaluations presented in **Appendix E-7**, COPCs identified for SWMU 51 that exceed background include aluminum and vanadium for surface soil and aluminum for total soil. For cover soil, background comparisons were performed for aluminum, arsenic, manganese, and vanadium, and all four metals were found to be within background concentrations. For deep soil, background comparisons were performed for aluminum, arsenic, and manganese, and all three metals were found to be within background concentrations.

## **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 SWMU 51, 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 issue involves the amount of blank related (i.e., B-qualified) data in the data set. These data were retained at one-half the SQL in the HHRA if the proportion of B-qualified results in the data set were greater than 50 percent.

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, 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, 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 chemical in soil and groundwater; therefore, the site-related risks and hazards could be underestimated for the risk assessments due to inadequate detection limits.

The reporting limits for chemicals that were not detected in surface soil, total soil, and groundwater were compared with RBCs in **Appendix E-1, Tables E.1-3, E.1-5, and E.1-7**, respectively. As shown in **Appendix E-1, Table E.1-3**, reporting limits in surface soil exceeded RBCs for 5 of 134 constituents (4 percent). These constituents include NG, MCPA, MCPP, hexachlorobenzene, and n-nitroso-di-n-propylamine. With the exception of NG, these constituents have neither been disposed at SWMU 51 nor detected at the site. Although the maximum reporting limit for NG (6.1 mg/kg) exceeded the adjusted RBC of 0.78 mg/kg (i.e., RBC adjusted by one-tenth to account for cumulative effects from multiple chemicals), this concentration was below the unadjusted RBC for NG of 7.8 mg/kg. For 18 of 134 constituents (13 percent) in surface soil, there were no RBCs for comparison. These constituents include 2,2'-oxybis(2-chloropropane), PETN, dichloroprop, dimethylphthalate, 2-nitroaniline, 2-nitrophenol, 3-nitroaniline, 4-nitroaniline, 4-nitrophenol, acenaphthylene, bis(2-chloroethoxy)methane, di-octylphthalate, p-chloro-m-cresol, 2-hexanone, 4-bromophenyl phenylether, 4-chlorophenyl phenylether, 4-methyl-2-pentanone, and chloromethane. The majority of these chemicals are not likely to be associated with past practices at SWMU 51.

As shown in **Appendix E-1, Table E.1-5**, reporting limits in total soil exceeded RBCs for 33 of 110 constituents (30 percent). For 14 of 110 constituents (13 percent) in total soil, there were no RBCs for comparison. Some of these constituents could potentially be site-related. Because the data set for total soil included samples from the sludge layer, the elevated reporting limits are likely due to matrix effects.

As shown in **Appendix E-1, Table E.1-7**, reporting limits in groundwater exceeded RBCs for 58 of 164 constituents (35 percent). For 21 of 164 constituents (13 percent) in groundwater, there were no RBCs for comparison. Some of these constituents could potentially be site-related. It is assumed that groundwater exposures at SWMU 51 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 SWMU 51 groundwater will be used for residential purposes in the future.

These chemicals, if present in surface soil, total soil, and groundwater, could contribute additional risk and hazard at SWMU 51. Although risks and hazards associated with site may be

underestimated, however, the inclusion of these constituents as COPCs in the risk assessment would not be expected to change the overall conclusions of the risk assessment.

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 SWMU 51 are consistently higher or lower than background. However, the background data obtained may not fully characterize naturally-occurring metals level 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 RDAs 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.

### **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 occasionally.

The non-cancer hazard estimates for the inhalation of aluminum and manganese by the construction worker receptor are based on the construction worker PEF calculation. The construction worker evaluation was based on the default assumptions for the calculation, which assume that active excavation activities will occur for 250 days out of a year over 5-workday workweeks with 8-hour workdays. The default assumptions also included an estimate for the numbers and types of vehicles involved in the excavation process. Based on plans for removing the sludge layer at SWMU 51, however, the duration of the project is estimated to be six weeks. It is assumed that four vehicles with an estimated weight of 20 tons each would be used. In view of these plans, the inhalation cancer risk/non-cancer hazard estimates are overestimated in the HHRA. In addition, 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.

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 over estimate risks, depending on the degree of chemical transport to other media or the rate and extent a chemical degrades over time.

When calculating EPCs from sample data, “zero” was used to represent non-detect samples in the calculation of the 95% UCL of the mean. Approaches which substitute values for non-detected chemical concentrations are associated with uncertainty, because chemicals that were not detected at the specified sample MDL may be absent from the medium or may be present at a concentration below the sample MDL. Furthermore, only the detected concentrations in each data set are used to determine the distribution of the data. For data sets with non-detects, the

uncertainty associated with the distribution of the data could result in an over-estimation of the EPC.

The 95% UCL is used as the EPC for each medium if at least eight to ten samples are available. If the 95% UCL exceeds the maximum detected value or if fewer than five samples are available, the maximum is conservatively used as a default EPC. Using a value that is based on one sampling location (i.e., the maximum) has associated uncertainty and it adds a great deal of conservatism to the assessment. The 95% UCL was used as the EPC for each chemical in soil. Therefore, the cancer risk/non-cancer hazard estimates are not likely to be biased high. The EPCs for groundwater, however, were based on maximum values, which could result in an overestimation of risk or hazard.

The exposure parameters used to describe the extent, frequency, and duration of exposure is associated with uncertainty. 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), have shown that the USEPA default soil ingestion rate of 100 mg/day is likely to greatly overestimate adult exposures and risks. In addition, chemicals in soil are assumed 100% bioavailable; this assumes that ingested chemicals present in a soil matrix are absorbed through the gastrointestinal (GI) tract, which 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 not actual human epidemiological data to support the hypothesis that absorption of soil bound compounds under exposure conditions is a complete route of exposure. For example, the Public Health Statements from the Agency for Toxic Substances 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 SWMU 51 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 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 (**Appendix E-1, Table E.1-28**). 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 concentration of PCE in groundwater was assumed to be the constant dissolved concentration. Use of the maximum value may overestimate 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 under-estimation of chemical concentrations at SWMU 51. The depth to groundwater assumed for the calculations at SWMU 51 was based on the average depth to groundwater (41.5 ft or 1,265 cm). The shallowest depth to groundwater measured at SWMU 51 has been measured at 32.91 ft (or 1,003 cm). Because groundwater is relatively deep at SWMU 51, 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 (**Appendix E-1, Table E.1-30**). 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 SWMU 51 HHRA, the maximum concentration of PCE in groundwater was conservatively used as the input for the groundwater concentration in the model. Although homogeneous distribution is assumed, the maximum concentration is not likely to be representative of 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 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.

These assumptions are not likely to be met at SWMU 51 due to the presence of the sludge layer. For example, the soil and the soil properties are assumed to be homogeneous within any horizontal plane. In addition, the *User's Guide* states that a number of conditions preclude the use of the Johnson and Ettinger model (USEPA, 2004a). In EPA's spreadsheets, for example, the capillary fringe is assumed to be uncontaminated. At contaminated groundwater sites with large fluctuations in the water table elevation, however, the capillary fringe is likely to be contaminated. This condition would likely preclude the use of the Johnson and Ettinger model for SWMU 51. 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 SWMU 51, 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 with the shallowest depth to groundwater (1,003 cm). These assumptions contribute to a conservative estimate of the PCE concentration in building air.

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.1-31**). 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 PCE in SWMU 51 groundwater was used to estimate exposures to PCE 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 shallowest point of SWMU 51 is 32.91 ft. These values may not be representative of groundwater depth across the entire site.
- To be consistent with the other excavation/construction exposures in this HHRA, an exposure frequency of 250 days/year and ED of 1 year were assumed for a worker in the trench. The default value for exposure time 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 SWMU 51 for 4 hours each day for 1 year.

The Foster-Chrostowski (1987, 2003) shower room model was used to estimate the EPC of PCE in air due to volatilization from groundwater during showering and applied to an adult resident (**Appendix E-1, Table E.1-32**). 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 using upper bound 95% UCLs for CSFs (carcinogens), and safety factors for RfDs (non-carcinogens). The assumptions used here provide a rough but plausible estimate of the upper limit of risk; in other words, it is not likely that the true risk would be much more than the estimated risk, but it could very well be considerably lower, even approaching zero. More refined modeling in the area of dose response calculation (e.g., using maximum likelihood dose response values rather than the 95% UCL) would be expected to substantially lower the final risk.

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 risk 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.

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 et al., 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 et al., 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.1-33 through E.1-36**). 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 2-amino-4,6-dinitrotoluene, aluminum, 2,6-DNT, dibenz (a,h)anthracene, iron, PCE, thallium, vanadium, NG, and 4-nitrotoluene. Provisional inhalation toxicity values were used for aluminum and PCE. Toxicity values for copper, 2-nitrotoluene, and 2,3,7,8-TCDD toxicity equivalents were obtained from HEAST. The HEAST document, however, has not been updated since 1997. 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.1-33 through E.1-36**). 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, 2002e) recommends that toxicity values for subchronic exposures be used to calculate the HQs for this pathway. Although subchronic values for some chemicals are included in USEPA's database of Provisional Peer-Reviewed Toxicity Values, this web site cannot be accessed without authorization. Because the VDEQ compiles subchronic toxicity values, however, the web site for the VDEQ VRP was consulted for subchronic values (VDEQ, 2007). While toxicity values based on subchronic exposures were available for some COPCs at SWMU 51, the only chemical for which the subchronic value differed from the chronic value was 2,6-DNT ( $1.0 \times 10^{-2}$  mg/kg-day and  $1.0 \times 10^{-3}$  mg/kg-day, respectively). 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 this site 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.

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 SWMU 51. 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, 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. However, the suggested default value for exposure to an excavation worker via incidental ingestion is 100 mg/day (USEPA, 2007e).

Because chromium was analyzed and reported as total chromium, there is uncertainty regarding the species of chromium that exists at SWMU 51. 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 SWMU 51, chromium VI would not be expected to be present at the site. In addition, chromium VI is more unstable in nature.

Finally, the lifetime cancer risk for dibenz(a,h)anthracene has been recalculated in accordance with recent guidance from USEPA Region III concerning carcinogens that act via a mutagenic mode of action (USEPA, 2006b). For chemicals that USEPA has determined to be carcinogenic via a mutagenic mode of action, special adjustments are now applied to estimating cancer risks. These adjustments are age-dependent adjustment factors (ADAFs). Because a chemical-specific ADAF has not yet been developed for dibenz(a,h)anthracene, the following default ADAFs were used: 10 for age 0-2, 3 for age 2-6, and no adjustment for years 16 and older.

The following examples of the calculation is presented for ingestion of dibenz(a,h)anthracene in total soil:

#### *Age 0-2*

$$\frac{0.0445 \text{ mg / kg} \times 200 \text{ mg / day} \times 350 \text{ days / yr} \times 2 \text{ yr} \times 1 \times 10^{-6} \text{ kg / mg}}{365 \text{ days / yr} \times 70 \text{ yr} \times 15 \text{ kg}} \times \frac{7.3}{\text{mg / kg / day}} \times 10 = 1.2 \times 10^{-6}$$

#### *Age 2-6*

$$\frac{0.0445 \text{ mg / kg} \times 200 \text{ mg / day} \times 350 \text{ days / yr} \times 4 \text{ yr} \times 1 \times 10^{-6} \text{ kg / mg}}{365 \text{ days / yr} \times 70 \text{ yr} \times 15 \text{ kg}} \times \frac{7.3}{\text{mg / kg / day}} \times 3 = 2.4 \times 10^{-7}$$

#### *Age 6-16*

$$\frac{0.0445 \text{ mg / kg} \times 100 \text{ mg / day} \times 350 \text{ days / yr} \times 10 \text{ yr} \times 1 \times 10^{-6} \text{ kg / mg}}{365 \text{ days / yr} \times 70 \text{ yr} \times 70 \text{ kg}} \times \frac{7.3}{\text{mg / kg / day}} \times 3 = 1.9 \times 10^{-7}$$

#### *Age 16-30*

$$\frac{0.0445 \text{ mg / kg} \times 100 \text{ mg / day} \times 350 \text{ days / yr} \times 14 \text{ yr} \times 1 \times 10^{-6} \text{ kg / mg}}{365 \text{ days / yr} \times 70 \text{ yr} \times 70 \text{ kg}} \times \frac{7.3}{\text{mg / kg / day}} \times 1 = 8.9 \times 10^{-8}$$

#### *Total Ingestion Risk*

$$(1.2 \times 10^{-6}) + (2.4 \times 10^{-7}) + (1.9 \times 10^{-7}) + (8.9 \times 10^{-8}) = 1.71 \times 10^{-6}$$

The cancer risk calculated using ADAFs ( $1.7 \times 10^{-6}$ ) is higher than that calculated for the lifetime resident ( $5.1 \times 10^{-7}$ ) and the child resident ( $4.9 \times 10^{-7}$ ). While the new calculations result in a greater cumulative risk, the conclusions regarding the cancer risk associated with total soil do not change.

### 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 or 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 or 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, this approach 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*). For this HHRA, the cumulative risk estimates for the lifetime resident and child resident are greater than  $1 \times 10^{-2}$  (**Appendix E-1, Tables E.1-60 and E.1-61**). For the lifetime resident, the cumulative risks for 2,4-DNT and 2,6-DNT in total soil exceed  $1 \times 10^{-2}$ . However, the estimates for these COPCs are individually less than  $1 \times 10^{-2}$ . Using the alternate equation, the risk estimate for the lifetime resident is also greater than  $1 \times 10^{-2}$ . For the child residents, none of the risk estimates for individual COPCs exceed  $1 \times 10^{-2}$ .

## 6.6 HHRA Summary and Conclusions

This HHRA was performed to evaluate the potential human health effects associated with previous activities at SWMU 51. Receptors evaluated 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 was below the target risk range. The total HI was less than 1.

For the future maintenance worker, the total cancer risk associated with total soil ( $3\text{E-}03$ ) was above the target risk range, primarily due to 2,4-DNT, 2,6-DNT, dioxin/furans, NG, 4-nitrotoluene, 2,4,6-TNT, and arsenic. Arsenic has been determined to be within background concentrations for total soil. The total HI ( $\text{HI} = 4\text{E}+01$ ) was above 1, primarily due to 2,4-DNT, 2,6-DNT, NG, and 2,4,6-TNT. In addition, lead concentrations in total soil were below the criterion for blood lead levels. The total cancer risk associated with groundwater was below the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ . The total HI was less than 1. When recalculated by target organ, the following target organs exceeded an HI of 1: CNS (5.6), blood (5.9), and liver (25.6).

For future industrial worker exposures to surface soil, the total cancer risk associated with surface soil ( $4\text{E-}06$ ) was within the target risk range. The total HI was less than 1. The total cancer risk associated with exposures to total soil ( $1\text{E-}02$ ) was above the target risk range, primarily due to 2,4-DNT, 2,6-DNT, dioxins/furans, NG, 4-nitrotoluene, 2,4,6-TNT, and arsenic. Arsenic has been determined to be within background concentrations. The total HI ( $\text{HI} = 2\text{E}+02$ ) was above 1, primarily due to 1,3-DNB, 2,4-DNT, 2,6-DNT, NG, 2- and 4-nitrotoluene,

and 2,4,6-TNT. Site concentrations of lead in total soil were below the health protective criterion for lead. The total cancer risk associated with groundwater was below the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ . The total HI was less than 1. When recalculated by target organ, the following organs exceeded 1: spleen (3.1), CNS (25), blood (26.7), and liver (115).

For the future excavation worker, the total cancer risk associated with total soil ( $1\text{E-}03$ ) was above the target risk range, primarily due to 2,4-DNT, 2,6-DNT, dioxin/furans, NG, 4-nitrotoluene, and 2,4,6-TNT. The total HI ( $\text{HI} = 5\text{E}+02$ ) was above 1, primarily due to 1,3-DNB, 2,4-DNT, 2,6-DNT, NG, 2- and 4-nitrotoluene, 2,4,6-TNT, aluminum, and manganese.

Manganese has been determined to be within background for total soil. Site concentrations of lead in total soil were above the health protective criterion for lead. The total cancer risk associated with groundwater was below the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ . The total HI was less than 1. When recalculated by target organ, the following target organs were exceeded: spleen (9.0), CNS (80), blood (71), and liver (371).

For the future lifetime resident, the total cancer risks associated with total soil ( $5\text{E-}02$ ) were above the target risk range, primarily due to 2,4-DNT, 2,6-DNT, dioxin/furans, 2,4,6-TNT, NG, 4-nitrotoluene, and arsenic. Arsenic has been determined to be within background concentrations. For future adult residents, the total HI ( $\text{HI} = 2.0\text{E}+02$ ) was above 1, primarily due to 1,3-DNB, 2,4-DNT, 2,6-DNT, NG, 2- and 4-nitrotoluene, and 2,4,6-TNT. For the lifetime scenario, site concentrations were above the health protective criterion for lead. The total cancer risk associated with groundwater ( $1\text{E-}03$ ) was above the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ , due to PCE and dioxins/furans. For future adult resident exposures, the total HI was less than 1. When recalculated by target organ, the following target organs exceeded 1: spleen (4.1), CNS (33), blood (35), and liver (163).

For the future child resident, the total cancer risks associated with total soil ( $3\text{E-}02$ ) were above the target risk range, primarily due to 2,4-DNT, 2,6-DNT, dioxin/furans, NG, 4-nitrotoluene, 2,4,6-TNT, and arsenic. Arsenic has been determined to be within background concentrations. The total HI ( $\text{HI} = 2\text{E}+03$ ) was greater than 1, primarily due to 1,3-DNB, 2,4-DNT, 2,6-DNT, NG, 2- and 4-nitrotoluene, 2,4,6-TNT, iron, manganese, and vanadium. Iron, manganese, 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 ( $4\text{E-}04$ ) was above the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ , due to PCE and dioxins/furans. PCE, however, does not appear to originate from SWMU 51. It also should be noted that residential reuse is not anticipated and residential scenarios are used to evaluate clean closure options. The total HI was less than 1. When recalculated by target organ, the following target organs exceeded 1: spleen (35), CNS (282), blood (302), liver (1,456), and GI tract (1.9). The margin-of-exposure evaluation for iron indicated that the iron intake was above the allowable range. The target organs for iron are blood, liver, and the GI tract.

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 ( $1\text{E-}03$ ) was above the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$  due to PCE and dioxin/furans. For future adult resident exposures, the total HI ( $5\text{E-}03$ ) was less than 1.

For future child resident exposures to COPCs in off-site groundwater, the risk characterization results showed cancer risk associated with groundwater ( $4\text{E-}04$ ) was above the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ , due to PCE and dioxin/furans. The total HI was less than 1.

As discussed in *Section 6.1.1.1*, the soil samples at SWMU 51 included samples of the native cover material at the pit. In support of the CMS, analytical results from the cover soil samples were evaluated as a subset of the total soil data. Risks and hazards were calculated to determine whether the native cover material could be placed back into the pit after the sludge layer is removed.

For the future maintenance worker and excavation worker, total cancer risks associated with the cover soil were below the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ . For the future industrial worker, adult (lifetime) resident, and child resident, total cancer risks associated with the cover soil were within the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ .

The total HIs for the future maintenance worker, industrial worker, and adult resident were below the target HI of 1. The HI for the excavation worker was  $1\text{E}+01$  due to aluminum and manganese via inhalation. When recalculated by target organ, the HI for the CNS (10) exceeded 1. No target organ was identified for aluminum via the route of inhalation ( $\text{HI} = 2.2$ ). Aluminum and manganese have been determined to be within background concentrations for the cover soil. The HI for the child resident was  $4\text{E}+00$  due to manganese and vanadium. When recalculated by target organ, the HI for the CNS (1.6) and the HI for the kidney (1.4) slightly exceeded 1. Manganese and vanadium have been determined to be within background concentrations for the cover soil.

Soil samples were collected beneath the sludge layer at SWMU 51. With the exception of sample 51SB6C, these soil samples were collected from depths below 15 ft. As explained in *Section 6.1.1.1*, sample 51SB6C was collected at a depth of 9-11 ft, but was included in the deep soil data set because it was located below the sludge layer. Analyzed results for the deeper soil were evaluated separately. Although no exposures to the deeper soil are expected, risks and hazards were calculated to determine whether the deep soil can remain in place.

For all receptors, total cancer risk associated with deep soil were within the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ . The total HIs for the maintenance worker and industrial worker were below the target HI of 1. The HI for the excavation worker was  $8\text{E}+00$  due to aluminum and manganese via inhalation. When recalculated by target organ, the HI for the CNS (4.4) exceeded 1. No target organ was identified for aluminum via the route of inhalation ( $\text{HI} = 2.1$ ). Aluminum and manganese have been determined to be within background concentrations for deep soil. Because the deep soil is below 15 ft, no residential exposure to deep soil is anticipated.

Although sample 51SB6C was included in the deep soil data set, the analytical results for this sample were evaluated with respect to the residential screening criterion because this sample was collected at a depth of 9-11 ft (*Section 6.1.2*). It was determined that the majority of the detected concentrations were below the respective screening criterion. For those constituents with concentrations that exceeded screening criteria, however, risks and hazards for sample 51SB6C were calculated in proportion to risks and hazards for total soil, which includes depths to 15 ft. For the maintenance worker and excavation worker, total cancer risks associated with sample 51SB6C were below the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ . For the industrial worker, the lifetime resident, and the child resident, total cancer risks associated with sample 51SB6C were

within the target risk range of  $1\text{E-}06$  to  $1\text{E-}04$ . The total HIs for the maintenance worker, industrial worker, and adult resident were below the target HI of 1.

The HI for the excavation worker was  $5\text{E+}00$  due to aluminum and manganese via inhalation. When recalculated by target organ, the HI for the CNS (4.3) exceeded 1. No target organ was identified for aluminum via the route of inhalation ( $\text{HI} = 1.8$ ). Manganese has been determined to be within background concentrations in total soil. Although aluminum was not found to be within background for total soil, it is noted that this evaluation is based on a single sample. The concentration of aluminum for sample 51SB6C is 17,600 mg/kg. If this sampling location is left in place, it is highly unlikely that a residential receptor would be exclusively exposed to this single location.

The HI for the child resident was  $3\text{E+}00$  primarily due to vanadium via ingestion and dermal absorption. When recalculated by target organ, the HI for the kidney (1.1) exceeded 1. Vanadium has been determined to be within background concentrations in total soil.

## 7.0 ECOLOGICAL RISK ASSESSMENT

A SLERA was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at SWMU 51. 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 Master Work Plan* (URS, 2003), the *RFAAP Site Screening Process* (USEPA, 2001b), the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentzel 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, 1997c). Steps 1, 2 and 3a were completed as part of the SLERA. The addition of Step 3a focuses the outcome of the SLERA, streamlines the review process, and allows one assessment to function as the initial forum for ecological risk management decision making at the site.

The primary objective of the SLERA is to assess whether there is enough information to state that there is the potential for unacceptable risks to ecological receptors as a result of potential hazardous substance releases. Characterizing the ecological communities in the vicinity of SWMU 51, 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 SWMU 51.

Concentrations of chemicals were measured in surface soil, which was the only relevant environmental media at SWMU 51. Surface water was not present and groundwater does not discharge to the surface in the immediate vicinity of SWMU 51, 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 (1997c). Step 1 includes a screening-level problem formulation and ecological effects evaluation, and Step 2 includes a screening level preliminary exposure estimate and risk calculation. The SLERA is organized as follows: Site Characterization (*Section 7.1*); Identification of Chemicals of Potential Ecological Concern (COPECs) and Concentration Statistics (*Section 7.2*); Identification of Exposure Pathways and Potential Receptors for Analysis (*Section 7.3*); Identification of Assessment and Measurement Endpoints (*Section 7.4*); Exposure Estimation (*Section 7.5*); Effects Assessment (*Section 7.6*); Risk Characterization (*Section 7.7*); Uncertainty Analysis (*Section 7.8*); and, Results and Conclusions (*Section 7.9*).

## 7.1 Site Characterization

The SWMU 51 site characterization section includes a general discussion of SWMU 51, vegetative communities, a species inventory, and a discussion on threatened and endangered species.

SWMU 51 is located in the south-east section of the HSA, adjacent to SWMU 30 (Closed Asbestos Waste Site). SWMU 51 consists of a trench, approximately 140 ft long by 23 ft wide, which has been filled to natural grade with soil and is covered by grass and weeds. A barbed-wire fence surrounds SWMU 51 and is situated on a plateau ranging from approximately 1,820 to 1,840 ft msl. The plateau is generally flat to slightly sloping.

TNT neutralization sludge from the treatment of red water, a waste product generated during the production of TNT, was disposed of at SWMU 51 in the 1970s. The sludge contains 2,4,6-TNT, transformation products, and other associated explosive compounds. The source of the sludge was from the RFAAP Red Water Treatment Plant equalization/neutralization basin (listed as Unit 81a in USEPA, 1987). In addition to sludge disposal, an estimated 10 tons of red water ash was reportedly disposed of in the trench from 1968 to 1972. During this period, red water was concentrated by evaporation and the sludge was burned in rotary kilns located in the TNT manufacturing area (USATHAMA, 1976). The ash from the red water sludge produced from these kilns (red water ash) was disposed of in SWMUs 41 (Red Water Ash Landfill) and 51. There are no records after 1972 regarding activities at SWMU 51.

### 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 SWMU 51 during the Installation-wide biological survey of 1999. Five state-listed rare plants were observed at RFAAP during this survey: *Clematis coattails*, *Cystopteris 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, 1992b). 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**.

**Table 7-1**  
**Ecoregions of RFAAP**

| <b>Ecoregion</b>                       | <b>Land Surface Form</b>               | <b>Potential Natural Vegetation</b>                                                     | <b>Land Use</b>                                              |
|----------------------------------------|----------------------------------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------|
| 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 <sup>1</sup> , Appalachian oak, northern hardwoods <sup>2</sup> | Forest and woodland mostly ungrazed                          |

<sup>1</sup>maple, buckeye, beech, tuliptree, oak, linden

<sup>2</sup>maple, birch, beech, hemlock

SWMU 51 is a small rectangular disposal trench that was backfilled and is now vegetated. The vegetation consists primarily of herbaceous plants (e.g., nodding thistle, low grass, and small shrubs) surrounded by barbed wire fence (**Appendix F-1, Photos F-1 through F-9**). SWMU 51

is within the larger SWMU 30 which is also fenced. SWMU 30 appears to be mowed more frequently than SWMU 51. There are no storm drains, manholes, or catch basins in the area.

Based on previous site visits and site reconnaissance performed by an ecologist in June 2002, a photographic record was prepared (**Appendix F-1, Photos F-1 through F-9**). Prior to the reconnaissance, relevant information was obtained, including topographic maps, township, county, or other appropriate maps. This information was used to identify the location of potential ecological units such as streams, creeks, ponds, grasslands, forest, and wetlands on or near the site. Additionally, the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, which identifies the locations of threatened and endangered species at RFAAP, was reviewed. The location of known or potential contaminant sources affecting the site and the probable gradient of the pathway by which contaminants may be released to the surrounding environment were identified. The reconnaissance was used to evaluate more subtle clues of potential effects from contaminant releases.

#### **7.1.2 Surface Water**

There is no surface water or aquatic habitat at the site.

#### **7.1.3 Groundwater**

SWMU 51 is approximately  $\frac{3}{4}$  mile from the New River (relative to the direction of groundwater flow). Groundwater monitoring wells located downgradient of the site demonstrate that chemicals from the SWMU 51 area are not migrating via groundwater to the New River. There are also no other groundwater to surface water discharges in close proximity to SWMU 51; therefore, groundwater will not have an adverse impact on aquatic life or wildlife. It should be noted that although two new groundwater monitoring wells were installed a few hundred feet downgradient of the site (between the site and the New River), no site-related constituents were detected in these new wells (*Section 4.3*).

#### **7.1.4 Wetlands**

According to the information presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, and confirmed during the site reconnaissance, there are no designated wetlands at SWMU 51. There are also no wetlands close enough to the site that could potentially be impacted or receive surface water drainage from the site

#### **7.1.5 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 2002 site reconnaissance and using the photographs in **Appendix F-1**. As shown in **Appendix F-1, Photos F-1 through F-9**, SWMU 51 is almost entirely maintained vegetation, primarily nodding thistle, low grass, and small shrubs. Small herbaceous plants approximately 1.5 ft in height (**Appendix F-1, Photos F-5, F-7, and F-9**) cover about 40% of SWMU 51. This habitat can be expected to support different wildlife species assemblages and many species would be expected to spend some amount of time for foraging and resting activities, depending on the season.

Grassland communities at RFAAP comprise 4,379 acres, or about 63 percent of the 6,901-acre total [Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey].

During the site reconnaissance, the study area was examined for vegetative stress, including looking for plants displaying stunted growth, poor foliage growth, tissue discoloration, and a loss of leaf coverage. There were some minor areas of potentially stressed vegetation (**Appendix F-1, Photo F-6**), but this is thought to be naturally occurring and not due to chemical stressors.

### 7.1.6 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 five taxa found within 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                                                                                                          |
| Birds                   | 83                          | robin, swift, dove, sparrow, warbler, wren, hawk                                                                                                    |
| Mammals                 | 13                          | red fox, white-tailed deer, shrew, meadow vole                                                                                                      |

### 7.1.7 Threatened, Rare and Endangered Species Information

Threatened, rare, or endangered species found within the grassland community type at RFAAP include those presented in **Table 7-3** [Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey]. Given the grassland community type at the site, it is possible these species could also occur at the site; however, as mentioned in *Section 7.1.1*, no threatened, rare, or endangered species have been documented at SWMU 51.

**Table 7-3**  
**Threatened, Rare, and Endangered Species in RFAAP's Grassland Community**

| Common Name                | Scientific Name                 | Federal Status | State Status     |
|----------------------------|---------------------------------|----------------|------------------|
| Midland sedge              | <i>Carex mesochorea</i>         | not available  | Watchlist        |
| Shaggy false gromwell      | <i>Onosmodium hispidissimum</i> | not available  | Watchlist        |
| Regal fritillary butterfly | <i>Speyeria idalia</i>          | not available  | State threatened |
| Henslow's sparrow          | <i>Ammodramus henslowii</i>     | not available  | State threatened |
| Loggerhead shrike          | <i>Lanius ludovicianus</i>      | 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 SWMU 51.

## 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 SWMU 51 SLERA**

|        |                    |
|--------|--------------------|
| 51SB1A | 51SB8A             |
| 51SB2A | 51SB9A             |
| 51SB3A | 51SB10A            |
| 51SB4A | 51SB11A            |
| 51SB5A | TMSB1A (duplicate) |
| 51SB6A | TMSB8A (duplicate) |
| 51SB7A |                    |

### 7.2.1 Data Organization

Soil measurements are the only data available for SWMU 51. To assess potential ecological impacts, soil from 0-1 ft bgs have been considered, although actual SWMU 51 soil samples were all collected from 0-0.5 ft, except for VOCs that were collected from 0.5-1.0 ft. The 0-1 ft 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 one ft, 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 0-1 ft 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*).

**Table 7-5**  
**Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at SWMU 51**  
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|                               |
|-------------------------------|
| Scenario Timeframe: Current   |
| 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 |
|----------------|------------|-------------------------------------------|-----------------------------------|-----------------------------------|-------|-----------------------------------|---------------------|---------------------------|----------------------------|-------------------------------------|
| Surface Soil   | N/A        | 2,3,7,8-TCDD TE                           | 7.70E-07                          | 3.31E-06                          | mg/kg | 51SB5A                            | 5/5                 | N/A                       | Yes                        | DET                                 |
|                | 35822-46-9 | 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin | 2.00E-05                          | 3.80E-05                          | mg/kg | 51SB5A                            | 5/5                 | N/A                       | No                         | TEQ                                 |
|                | 67562-39-4 | 1,2,3,4,6,7,8-Heptachlorodibenzofuran     | 1.20E-06 J                        | 1.20E-06 J                        | mg/kg | 51SB3A                            | 1/5                 | 9.40E-07 - 9.90E-07       | No                         | TEQ                                 |
|                | N/A        | Total Heptachlorodibenzo-p-dioxin         | 4.20E-05                          | 7.10E-05                          | mg/kg | 51SB5A                            | 5/5                 | N/A                       | No                         | TEQ                                 |
|                | N/A        | Total Heptachlorodibenzofuran             | 1.20E-06 J                        | 1.20E-06 J                        | mg/kg | 51SB3A                            | 1/5                 | 9.40E-07 - 9.90E-07       | No                         | TEQ                                 |
|                | N/A        | Total Hexachlorodibenzo-p-dioxin          | 2.60E-06 J                        | 6.50E-06                          | mg/kg | 51SB5A                            | 5/5                 | N/A                       | No                         | TEQ                                 |
|                | N/A        | Total Pentachlorodibenzo-p-dioxin         | 2.60E-06 J                        | 2.60E-06 J                        | mg/kg | 51SB5A                            | 1/5                 | 9.40E-07 - 9.90E-07       | No                         | TEQ                                 |
|                | N/A        | Total Tetrachlorodibenzo-p-dioxin         | 2.60E-07 J                        | 2.50E-06                          | mg/kg | 51SB5A                            | 2/5                 | 1.90E-07 - 2.00E-07       | No                         | TEQ                                 |
|                | N/A        | Total Tetrachlorodibenzofuran             | 2.20E-07 J                        | 2.20E-07 J                        | mg/kg | 51SB6A                            | 1/5                 | 1.90E-07 - 2.00E-07       | No                         | TEQ                                 |
|                | 1746-01-6  | 2,3,7,8-Tetrachlorodibenzo-p-dioxin       | 2.40E-07                          | 2.40E-07                          | mg/kg | 51SB2A                            | 1/5                 | 1.90E-07 - 2.00E-07       | No                         | TEQ                                 |
|                | 3268-87-9  | Octachlorodibenzodioxin                   | 1.90E-03                          | 5.90E-03                          | mg/kg | 51SB5A                            | 5/5                 | N/A                       | No                         | TEQ                                 |
|                | 39001-02-0 | Octachlorodibenzofuran                    | 2.10E-06 J                        | 2.30E-06                          | mg/kg | 51SB6A                            | 2/5                 | 9.00E-07 - 2.00E-06       | No                         | TEQ                                 |
|                | 121-14-2   | 2,4-Dinitrotoluene                        | 9.00E-02                          | 2.50E+00                          | mg/kg | 51SB4A                            | 9/11                | 1.00E-01 - 1.00E-01       | Yes                        | DET                                 |
|                | 606-20-2   | 2,6-Dinitrotoluene                        | 7.00E-02 J                        | 1.70E+00 J                        | mg/kg | 51SB4A                            | 5/7                 | 1.00E-01 - 1.00E-01       | Yes                        | DET                                 |
|                | 91-57-6    | 2-Methylnaphthalene                       | 2.00E-02                          | 2.00E-02                          | mg/kg | 51SB10A                           | 1/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 99-65-0    | 1,3-Dinitrobenzene                        | 8.00E-02 J                        | 7.70E-01 J                        | mg/kg | 51SB2A                            | 4/11                | 1.00E-01 - 1.00E-01       | Yes                        | DET                                 |
|                | 88-72-2    | 2-Nitrotoluene                            | 1.40E-01 J                        | 1.10E+02                          | mg/kg | 51SB4A                            | 9/11                | 2.00E-01 - 2.00E-01       | Yes                        | DET                                 |
|                | 99-08-1    | 3-Nitrotoluene                            | 1.05E-01 J                        | 9.20E+00 J                        | mg/kg | 51SB4A                            | 8/11                | 2.00E-01 - 2.00E-01       | Yes                        | DET                                 |
|                | 99-99-0    | 4-Nitrotoluene                            | 4.45E-01 J                        | 6.20E+01                          | mg/kg | 51SB4A                            | 8/11                | 2.00E-01 - 2.00E-01       | Yes                        | DET                                 |
|                | 118-96-7   | 2,4,6-Trinitrotoluene                     | 4.00E-02 J                        | 1.30E+00                          | mg/kg | 51SB7A                            | 10/11               | 1.00E-01 - 1.00E-01       | Yes                        | DET                                 |
|                | 56-55-3    | Benzo(a)anthracene                        | 2.00E-02 J                        | 2.00E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 50-32-8    | Benzo(a)pyrene                            | 8.48E-03 J                        | 8.48E-03 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 205-99-2   | Benzo(b)fluoranthene                      | 2.90E-02 J                        | 2.90E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 191-24-2   | Benzo(g,h,i)perylene                      | 2.60E-02 J                        | 2.60E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 207-08-9   | Benzo(k)fluoranthene                      | 3.70E-02 J                        | 3.70E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 218-01-9   | Chrysene                                  | 3.95E-02 J                        | 3.95E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 53-70-3    | Dibenz(a,h)anthracene                     | 4.45E-02 J                        | 4.45E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 84-66-2    | Diethyl phthalate                         | 1.20E+00                          | 1.20E+00                          | mg/kg | 51SB7A                            | 1/11                | 3.90E-01 - 4.10E-01       | Yes                        | DET                                 |
|                | 206-44-0   | Fluoranthene                              | 1.10E-02 J                        | 2.70E-02                          | mg/kg | 51SB9A                            | 4/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 193-39-5   | Indeno(1,2,3-cd)pyrene                    | 3.15E-02 J                        | 3.15E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 98-95-3    | Nitrobenzene                              | 4.50E-02 J                        | 1.25E-01 J                        | mg/kg | 51SB1A                            | 4/11                | 1.00E-01 - 1.00E-01       | Yes                        | DET                                 |
|                | 85-01-8    | Phenanthrene                              | 9.95E-03 J                        | 3.00E-02                          | mg/kg | 51SB10A                           | 9/11                | 7.90E-03 - 7.90E-03       | Yes                        | DET                                 |
|                | 129-00-0   | Pyrene                                    | 7.90E-03                          | 1.35E-02 J                        | mg/kg | 51SB8A                            | 4/11                | 7.70E-03 - 8.10E-03       | Yes                        | DET                                 |
|                | 7429-90-5  | Aluminum                                  | 1.06E+04                          | 2.81E+04                          | mg/kg | 51SB4A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7440-36-0  | Antimony                                  | 2.50E-01 J                        | 6.40E-01                          | mg/kg | 51SB6A                            | 2/11                | 4.40E-01 - 8.20E-01       | Yes                        | DET                                 |

**Table 7-5**  
**Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at SWMU 51**  
**Page 2 of 2**

| 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   | 7440-38-2  | Arsenic   | 2.80E+00                          | 5.70E+00                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7440-39-3  | Barium    | 4.96E+01                          | 1.20E+02                          | mg/kg | 51SB9A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7440-41-7  | Beryllium | 4.10E-01                          | 8.00E-01                          | mg/kg | 51SB9A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7440-43-9  | Cadmium   | 1.30E-01 J                        | 3.60E-01 J                        | mg/kg | 51SB3A                            | 3/6                 | 3.95E-02 - 4.10E-02       | Yes                        | DET                                 |
|                | 7440-70-2  | Calcium   | 2.28E+02                          | 4.83E+02                          | mg/kg | 51SB7A                            | 8/8                 | N/A                       | Yes                        | DET                                 |
|                | 7440-47-3  | Chromium  | 1.72E+01                          | 3.46E+01                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7440-48-4  | Cobalt    | 3.30E+00                          | 1.39E+01                          | mg/kg | 51SB7A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7440-50-8  | Copper    | 4.70E+00                          | 1.74E+01                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7439-89-6  | Iron      | 1.15E+04                          | 3.16E+04                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7439-92-1  | Lead      | 1.10E+01                          | 3.41E+01                          | mg/kg | 51SB7A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7439-95-4  | Magnesium | 4.83E+02                          | 1.93E+03                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7439-96-5  | Manganese | 2.51E+02                          | 7.07E+02                          | mg/kg | 51SB9A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7439-97-6  | Mercury   | 2.40E-02 J                        | 1.00E-01                          | mg/kg | 51SB3A                            | 7/8                 | 1.60E-02 - 1.60E-02       | Yes                        | DET                                 |
|                | 7440-02-0  | Nickel    | 4.40E+00                          | 1.32E+01                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7440-09-7  | Potassium | 3.60E+02                          | 1.61E+03                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7782-49-2  | Selenium  | 6.05E-01 J                        | 6.05E-01 J                        | mg/kg | 51SB1A                            | 1/11                | 1.50E-01 - 4.40E-01       | Yes                        | DET                                 |
|                | 7440-28-0  | Thallium  | 6.50E-01 J                        | 1.10E+00 J                        | mg/kg | 51SB3A                            | 2/7                 | 3.55E-01 - 5.60E-01       | Yes                        | DET                                 |
|                | 7440-62-2  | Vanadium  | 2.75E+01                          | 6.41E+01                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                        | DET                                 |
|                | 7440-66-6  | Zinc      | 1.95E+01                          | 3.76E+01                          | mg/kg | 51SB5A                            | 11/11               | 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:

For 2,3,7,8-TCDD-TE, two values were calculated, the MAX and the RME (see text for further discussion)

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 SWMU 51**  
**Page 1 of 2**

|                               |
|-------------------------------|
| Scenario Timeframe: Current   |
| 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                           | 7.70E-07                          | 3.31E-06                          | mg/kg | 51SB5A                            | 5/5                 | N/A                       | Yes                    | IBC                                 |
|                | 35822-46-9 | 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin | 2.00E-05                          | 3.80E-05                          | mg/kg | 51SB5A                            | 5/5                 | N/A                       | No                     | TEQ                                 |
|                | 67562-39-4 | 1,2,3,4,6,7,8-Heptachlorodibenzofuran     | 1.20E-06 J                        | 1.20E-06 J                        | mg/kg | 51SB3A                            | 1/5                 | 9.40E-07 - 9.90E-07       | No                     | TEQ                                 |
|                | N/A        | Total Heptachlorodibenzo-p-dioxin         | 4.20E-05                          | 7.10E-05                          | mg/kg | 51SB5A                            | 5/5                 | N/A                       | No                     | TEQ                                 |
|                | N/A        | Total Heptachlorodibenzofuran             | 1.20E-06 J                        | 1.20E-06 J                        | mg/kg | 51SB3A                            | 1/5                 | 9.40E-07 - 9.90E-07       | No                     | TEQ                                 |
|                | N/A        | Total Hexachlorodibenzo-p-dioxin          | 2.60E-06 J                        | 6.50E-06                          | mg/kg | 51SB5A                            | 5/5                 | N/A                       | No                     | TEQ                                 |
|                | N/A        | Total Pentachlorodibenzo-p-dioxin         | 2.60E-06 J                        | 2.60E-06 J                        | mg/kg | 51SB5A                            | 1/5                 | 9.40E-07 - 9.90E-07       | No                     | TEQ                                 |
|                | N/A        | Total Tetrachlorodibenzo-p-dioxin         | 2.60E-07 J                        | 2.50E-06                          | mg/kg | 51SB5A                            | 2/5                 | 1.90E-07 - 2.00E-07       | No                     | TEQ                                 |
|                | N/A        | Total Tetrachlorodibenzofuran             | 2.20E-07 J                        | 2.20E-07 J                        | mg/kg | 51SB6A                            | 1/5                 | 1.90E-07 - 2.00E-07       | No                     | TEQ                                 |
|                | 1746-01-6  | 2,3,7,8-Tetrachlorodibenzo-p-dioxin       | 2.40E-07                          | 2.40E-07                          | mg/kg | 51SB2A                            | 1/5                 | 1.90E-07 - 2.00E-07       | No                     | TEQ                                 |
|                | 3268-87-9  | Octachlorodibenzodioxin                   | 1.90E-03                          | 5.90E-03                          | mg/kg | 51SB5A                            | 5/5                 | N/A                       | No                     | TEQ                                 |
|                | 39001-02-0 | Octachlorodibenzofuran                    | 2.10E-06 J                        | 2.30E-06                          | mg/kg | 51SB6A                            | 2/5                 | 9.50E-07 - 2.0E-06        | No                     | TEQ                                 |
|                | 121-14-2   | 2,4-Dinitrotoluene                        | 9.00E-02                          | 2.50E+00                          | mg/kg | 51SB4A                            | 9/11                | 1.00E-01 - 1.00E-01       | No                     | NIBC                                |
|                | 606-20-2   | 2,6-Dinitrotoluene                        | 7.00E-02 J                        | 1.70E+00 J                        | mg/kg | 51SB4A                            | 5/7                 | 1.00E-01 - 1.00E-01       | No                     | NIBC                                |
|                | 91-57-6    | 2-Methylnaphthalene                       | 2.00E-02                          | 2.00E-02                          | mg/kg | 51SB10A                           | 1/11                | 7.70E-03 - 8.10E-03       | No                     | NIBC                                |
|                | 99-65-0    | 1,3-Dinitrobenzene                        | 8.00E-02 J                        | 7.70E-01 J                        | mg/kg | 51SB2A                            | 4/11                | 1.00E-01 - 1.00E-01       | No                     | NIBC                                |
|                | 118-96-7   | 2,4,6-Trinitrotoluene                     | 4.00E-02 J                        | 1.30E+00                          | mg/kg | 51SB7A                            | 10/11               | 1.00E-01 - 1.00E-01       | No                     | NIBC                                |
|                | 88-72-2    | 2-Nitrotoluene                            | 1.40E-01 J                        | 1.10E+02                          | mg/kg | 51SB4A                            | 9/11                | 2.00E-01 - 2.00E-01       | No                     | NIBC                                |
|                | 99-08-1    | 3-Nitrotoluene                            | 1.05E-01 J                        | 9.20E+00 J                        | mg/kg | 51SB4A                            | 8/11                | 2.00E-01 - 2.00E-01       | No                     | NIBC                                |
|                | 99-99-0    | 4-Nitrotoluene                            | 4.45E-01 J                        | 6.20E+01                          | mg/kg | 51SB4A                            | 8/11                | 2.00E-01 - 2.00E-01       | No                     | NIBC                                |
|                | 56-55-3    | Benzo(a)anthracene                        | 2.00E-02 J                        | 2.00E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                    | IBC                                 |
|                | 50-32-8    | Benzo(a)pyrene                            | 8.48E-03 J                        | 8.48E-03 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                    | IBC                                 |
|                | 205-99-2   | Benzo(b)fluoranthene                      | 2.90E-02 J                        | 2.90E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                    | IBC                                 |
|                | 191-24-2   | Benzo(g,h,i)perylene                      | 2.60E-02 J                        | 2.60E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                    | IBC                                 |
|                | 207-08-9   | Benzo(k)fluoranthene                      | 3.70E-02 J                        | 3.70E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                    | IBC                                 |
|                | 218-01-9   | Chrysene                                  | 3.95E-02 J                        | 3.95E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                    | IBC                                 |
|                | 53-70-3    | Dibenz(a,h)anthracene                     | 4.45E-02 J                        | 4.45E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                    | IBC                                 |
|                | 84-66-2    | Diethyl phthalate                         | 1.20E+00                          | 1.20E+00                          | mg/kg | 51SB7A                            | 1/11                | 3.90E-01 - 4.10E-01       | No                     | NIBC                                |
|                | 206-44-0   | Fluoranthene                              | 1.10E-02 J                        | 2.70E-02                          | mg/kg | 51SB9A                            | 4/11                | 7.70E-03 - 8.10E-03       | Yes                    | IBC                                 |
|                | 193-39-5   | Indeno(1,2,3-cd)pyrene                    | 3.15E-02 J                        | 3.15E-02 J                        | mg/kg | 51SB8A                            | 1/11                | 7.70E-03 - 8.10E-03       | Yes                    | IBC                                 |
|                | 98-95-3    | Nitrobenzene                              | 4.50E-02 J                        | 1.25E-01 J                        | mg/kg | 51SB1A                            | 4/11                | 1.00E-01 - 1.00E-01       | No                     | NIBC                                |
|                | 85-01-8    | Phenanthrene                              | 9.95E-03 J                        | 3.00E-02                          | mg/kg | 51SB10A                           | 9/11                | 7.90E-03 - 7.90E-03       | Yes                    | IBC                                 |
|                | 129-00-0   | Pyrene                                    | 7.90E-03                          | 1.35E-02 J                        | mg/kg | 51SB8A                            | 4/11                | 7.70E-03 - 8.10E-03       | Yes                    | IBC                                 |
|                | 7429-90-5  | Aluminum                                  | 1.06E+04                          | 2.81E+04                          | mg/kg | 51SB4A                            | 11/11               | N/A                       | No                     | NIBC                                |
|                | 7440-36-0  | Antimony                                  | 2.50E-01 J                        | 6.40E-01                          | mg/kg | 51SB6A                            | 2/11                | 4.40E-01 - 8.20E-01       | No                     | NIBC                                |
|                | 7440-38-2  | Arsenic                                   | 2.80E+00                          | 5.70E+00                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                    | IBC                                 |
|                | 7440-39-3  | Barium                                    | 4.96E+01                          | 1.20E+02                          | mg/kg | 51SB9A                            | 11/11               | N/A                       | No                     | NIBC                                |
|                | 7440-41-7  | Beryllium                                 | 4.10E-01                          | 8.00E-01                          | mg/kg | 51SB9A                            | 11/11               | N/A                       | No                     | NIBC                                |
|                | 7440-43-9  | Cadmium                                   | 1.30E-01 J                        | 3.60E-01 J                        | mg/kg | 51SB3A                            | 3/6                 | 3.95E-02 - 4.10E-02       | Yes                    | IBC                                 |
|                | 7440-70-2  | Calcium                                   | 2.28E+02                          | 4.83E+02                          | mg/kg | 51SB7A                            | 8/8                 | N/A                       | No                     | NIBC                                |
|                | 7440-47-3  | Chromium                                  | 1.72E+01                          | 3.46E+01                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                    | IBC                                 |

**Table 7-6**  
**Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil**  
**Food Chain Exposure at SWMU 51**  
**Page 2 of 2**

| 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   | 7440-48-4  | Cobalt    | 3.30E+00                          | 1.39E+01                          | mg/kg | 51SB7A                            | 11/11               | N/A                       | No                     | NIBC                                |
|                | 7440-50-8  | Copper    | 4.70E+00                          | 1.74E+01                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                    | IBC                                 |
|                | 7439-89-6  | Iron      | 1.15E+04                          | 3.16E+04                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | No                     | NIBC                                |
|                | 7439-92-1  | Lead      | 1.10E+01                          | 3.41E+01                          | mg/kg | 51SB7A                            | 11/11               | N/A                       | Yes                    | IBC                                 |
|                | 7439-95-4  | Magnesium | 4.83E+02                          | 1.93E+03                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | No                     | NIBC                                |
|                | 7439-96-5  | Manganese | 2.51E+02                          | 7.07E+02                          | mg/kg | 51SB9A                            | 11/11               | N/A                       | No                     | NIBC                                |
|                | 7439-97-6  | Mercury   | 2.40E-02 J                        | 1.00E-01                          | mg/kg | 51SB3A                            | 7/8                 | 1.60E-02 - 1.60E-02       | Yes                    | IBC                                 |
|                | 7440-02-0  | Nickel    | 4.40E+00                          | 1.32E+01                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | Yes                    | IBC                                 |
|                | 7440-09-7  | Potassium | 3.60E+02                          | 1.61E+03                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | No                     | NIBC                                |
|                | 7782-49-2  | Selenium  | 6.05E-01 J                        | 6.05E-01 J                        | mg/kg | 51SB1A                            | 1/11                | 1.50E-01 - 4.40E-01       | Yes                    | IBC                                 |
|                | 7440-28-0  | Thallium  | 6.50E-01 J                        | 1.10E+00 J                        | mg/kg | 51SB3A                            | 2/7                 | 3.55E-01 - 5.60E-01       | No                     | NIBC                                |
|                | 7440-62-2  | Vanadium  | 2.75E+01                          | 6.41E+01                          | mg/kg | 51SB5A                            | 11/11               | N/A                       | No                     | NIBC                                |
|                | 7440-66-6  | Zinc      | 1.95E+01                          | 3.76E+01                          | mg/kg | 51SB5A                            | 11/11               | 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

For 2,3,7,8-TCDD-TE, two values were calculated, the MAX and the RME (see text for further discussion)

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 7-7**  
**Medium-Specific Exposure Point Concentration Summary for SWMU 51**  
**Page 1 of 2**

|                               |
|-------------------------------|
| Scenario Timeframe: Current   |
| Medium: Soil                  |
| Exposure Medium: Surface Soil |

| Exposure Point | Chemical<br>of<br>Potential<br>Concern | Units | Arithmetic<br>Mean<br>of<br>Detects | Multiple<br>Detection<br>Limits?<br>(Yes/No) <sup>1</sup> | 95% UCL<br>(Distribution) <sup>2</sup> | Maximum<br>Concentration | Exposure Point Concentration |       |                        |                        |
|----------------|----------------------------------------|-------|-------------------------------------|-----------------------------------------------------------|----------------------------------------|--------------------------|------------------------------|-------|------------------------|------------------------|
|                |                                        |       |                                     |                                                           |                                        |                          | Value                        | Units | Statistic <sup>3</sup> | Rationale <sup>4</sup> |
| Surface Soil   | 2,3,7,8-TCDD TE                        | mg/kg | 1.86E-06                            | No                                                        | 2.55E-06 (N)                           | 3.31E-06                 | 2.55E-06                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | 1,3-Dinitrobenzene                     | mg/kg | 3.08E-01                            | No                                                        | 3.43E-01 (N)                           | 7.70E-01                 | 3.43E-01                     | mg/kg | 95% KM-% Btstrp        | Test (4)               |
|                | 2,4,6-Trinitrotoluene                  | mg/kg | 2.76E-01                            | No                                                        | 7.47E-01 (G)                           | 1.30E+00                 | 7.47E-01                     | mg/kg | 95% KM-Cheby           | Test (6)               |
|                | 2,4-Dinitrotoluene                     | mg/kg | 8.06E-01                            | No                                                        | 1.99E+00 (NP)                          | 2.50E+00                 | 1.99E+00                     | mg/kg | 97.5% KM-Cheby         | Test (3)               |
|                | 2,6-Dinitrotoluene                     | mg/kg | 5.47E-01                            | No                                                        | 8.65E-01 (N)                           | 1.70E+00                 | 8.65E-01                     | mg/kg | 95% KM-t               | Test (4)               |
|                | 2-Methylnaphthalene <sup>5</sup>       | mg/kg | 5.40E-03                            | Yes                                                       | 7.06E-03 (NP)                          | 2.00E-02                 | 7.06E-03                     | mg/kg | 95% UCL-Bst            | Test (3)               |
|                | Benzo(a)anthracene <sup>5</sup>        | mg/kg | 5.40E-03                            | Yes                                                       | 7.12E-03 (NP)                          | 2.00E-02                 | 7.12E-03                     | mg/kg | 95% UCL-Bst            | Test (3)               |
|                | Benzo(a)pyrene <sup>5</sup>            | mg/kg | 4.35E-03                            | Yes                                                       | 5.37E-03 (NP)                          | 8.48E-03                 | 5.37E-03                     | mg/kg | 95% UCL-Bst            | Test (3)               |
|                | Benzo(b)fluoranthene <sup>5</sup>      | mg/kg | 6.22E-03                            | Yes                                                       | 8.49E-03 (NP)                          | 2.90E-02                 | 8.49E-03                     | mg/kg | 95% UCL-Bst            | Test (3)               |
|                | Benzo(g,h,i)perylene <sup>5</sup>      | mg/kg | 5.94E-03                            | Yes                                                       | 8.08E-03 (NP)                          | 2.60E-02                 | 8.08E-03                     | mg/kg | 95% UCL-Bst            | Test (3)               |
|                | Benzo(k)fluoranthene <sup>5</sup>      | mg/kg | 6.94E-03                            | Yes                                                       | 1.01E-02 (NP)                          | 3.70E-02                 | 1.01E-02                     | mg/kg | 95% UCL-Bst            | Test (3)               |
|                | Chrysene <sup>5</sup>                  | mg/kg | 7.17E-03                            | Yes                                                       | 1.05E-02 (NP)                          | 3.95E-02                 | 1.05E-02                     | mg/kg | 95% UCL-Bst            | Test (3)               |
|                | Dibenz(a,h)anthracene <sup>5</sup>     | mg/kg | 7.63E-03                            | Yes                                                       | 1.16E-02 (NP)                          | 4.45E-02                 | 1.16E-02                     | mg/kg | 95% UCL-Bst            | Test (3)               |
|                | Diethyl Phthalate <sup>5</sup>         | mg/kg | 2.89E-01                            | Yes                                                       | 3.87E-01 (NP)                          | 1.20E+00                 | 3.87E-01                     | mg/kg | 95% UCL-Bst            | Test (3)               |
|                | Fluoranthene                           | mg/kg | 1.74E-02                            | Yes                                                       | 1.92E-02 (N)                           | 2.70E-02                 | 1.92E-02                     | mg/kg | 95% KM-% Btstrp        | Test (1)               |
|                | Indeno(1,2,3-c,d)Pyrene <sup>5</sup>   | mg/kg | 6.44E-03                            | Yes                                                       | 9.07E-03 (NP)                          | 3.15E-02                 | 9.07E-03                     | mg/kg | 95% UCL-Bst            | Test (3)               |
|                | Nickel                                 | mg/kg | 8.11E+00                            | No                                                        | 9.69E+00 (N)                           | 1.32E+01                 | 9.69E+00                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Nitrobenzene                           | mg/kg | 8.75E-02                            | No                                                        | 1.05E-01 (N)                           | 1.25E-01                 | 1.05E-01                     | mg/kg | 95% KM-% Btstrp        | Test (4)               |
|                | o-Nitrotoluene                         | mg/kg | 2.37E+01                            | No                                                        | 6.27E+01 (G)                           | 1.10E+02                 | 6.27E+01                     | mg/kg | 95% KM-Cheby           | Test (6)               |
|                | m-Nitrotoluene                         | mg/kg | 2.17E+00                            | No                                                        | 5.17E+00 (G)                           | 9.20E+00                 | 5.17E+00                     | mg/kg | 95% KM-Cheby           | Test (6)               |
|                | p-Nitrotoluene                         | mg/kg | 1.40E+01                            | No                                                        | 3.44E+01 (G)                           | 6.20E+01                 | 3.44E+01                     | mg/kg | 95% KM-Cheby           | Test (6)               |
|                | Phenanthrene                           | mg/kg | 1.56E-02                            | No                                                        | 1.80E-02 (G)                           | 3.00E-02                 | 1.80E-02                     | mg/kg | 95% KM-BCA             | Test (6)               |
|                | Aluminum                               | mg/kg | 1.93E+04                            | No                                                        | 2.28E+04 (N)                           | 2.81E+04                 | 2.28E+04                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Antimony                               | mg/kg | 4.45E-01                            | Yes                                                       | 6.40E-01 (NP)                          | 6.40E-01                 | 6.40E-01                     | mg/kg | 95% KM-% Btstrp        | Test (1)               |
|                | Arsenic                                | mg/kg | 3.89E+00                            | No                                                        | 4.41E+00 (N)                           | 5.70E+00                 | 4.41E+00                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Barium                                 | mg/kg | 8.01E+01                            | No                                                        | 9.05E+01 (N)                           | 1.20E+02                 | 9.05E+01                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Beryllium                              | mg/kg | 5.70E-01                            | No                                                        | 6.56E-01 (N)                           | 8.00E-01                 | 6.56E-01                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Cadmium                                | mg/kg | 2.27E-01                            | Yes                                                       | 3.60E-01 (N)                           | 3.60E-01                 | 3.60E-01                     | mg/kg | 95% KM-% Btstrp        | Test (1)               |
|                | Calcium                                | mg/kg | 3.20E+02                            | No                                                        | 3.76E+02 (N)                           | 4.83E+02                 | 3.76E+02                     | mg/kg | 95% Student's-t        | Test (4)               |

**Table 7-7**  
**Medium-Specific Exposure Point Concentration Summary for SWMU 51**  
**Page 2 of 2**

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean of Detects | Multiple Detection Limits? (Yes/No) <sup>1</sup> | 95% UCL (Distribution) <sup>2</sup> | Maximum Concentration | Exposure Point Concentration |       |                        |                        |
|----------------|-------------------------------|-------|----------------------------|--------------------------------------------------|-------------------------------------|-----------------------|------------------------------|-------|------------------------|------------------------|
|                |                               |       |                            |                                                  |                                     |                       | Value                        | Units | Statistic <sup>3</sup> | Rationale <sup>4</sup> |
| Surface Soil   | Chromium                      | mg/kg | 2.55E+01                   | No                                               | 2.82E+01 (N)                        | 3.46E+01              | 2.82E+01                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Cobalt                        | mg/kg | 7.51E+00                   | No                                               | 9.17E+00 (N)                        | 1.39E+01              | 9.17E+00                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Copper                        | mg/kg | 1.00E+01                   | No                                               | 1.22E+01 (N)                        | 1.74E+01              | 1.22E+01                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Iron                          | mg/kg | 2.34E+04                   | No                                               | 2.74E+04 (N)                        | 3.16E+04              | 2.74E+04                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Lead                          | mg/kg | 1.66E+01                   | No                                               | 2.03E+01 (NP)                       | 3.41E+01              | 2.03E+01                     | mg/kg | 95% Modified-t         | Test (3)               |
|                | Magnesium                     | mg/kg | 9.30E+02                   | No                                               | 1.16E+03 (N)                        | 1.93E+03              | 1.16E+03                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Manganese                     | mg/kg | 4.43E+02                   | No                                               | 5.30E+02 (N)                        | 7.07E+02              | 5.30E+02                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Mercury                       | mg/kg | 5.65E-02                   | No                                               | 7.35E-02 (N)                        | 1.00E-01              | 7.35E-02                     | mg/kg | 95% KM-t               | Test (4)               |
|                | Potassium                     | mg/kg | 8.25E+02                   | No                                               | 1.04E+03 (N)                        | 1.61E+03              | 1.04E+03                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Pyrene                        | mg/kg | 1.06E-02                   | Yes                                              | 1.15E-02 (N)                        | 1.35E-02              | 1.15E-02                     | mg/kg | 95% KM-% Btstrp        | Test (1)               |
|                | Selenium <sup>5</sup>         | mg/kg | 1.72E-01                   | Yes                                              | 2.64E-01 (L)                        | 6.05E-01              | 2.64E-01                     | mg/kg | 95% UCL-T              | Test (5)               |
|                | Thallium                      | mg/kg | 8.75E-01                   | Yes                                              | 1.10E+01 (NP)                       | 1.10E+00              | 1.10E+00                     | mg/kg | 95% KM-% Btstrp        | Test (1)               |
|                | Vanadium                      | mg/kg | 4.94E+01                   | No                                               | 5.63E+01 (N)                        | 6.41E+01              | 5.63E+01                     | mg/kg | 95% Student's-t        | Test (4)               |
|                | Zinc                          | mg/kg | 2.98E+01                   | No                                               | 3.31E+01 (N)                        | 3.76E+01              | 3.31E+01                     | mg/kg | 95% Student's-t        | Test (4)               |

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

<sup>2</sup> 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.

<sup>3</sup> 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) 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).

<sup>4</sup> 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.

<sup>5</sup> 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).

### 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) (Van den Berg et al., 2005; USEPA, 1989a, 1994c; WHO, 1998). Dioxin-like compounds (PCDDs and PCDFs) are present in the environmental media as complex mixtures. PCDDs and PCDFs consist of a family of approximately 75 and 135 congeners, respectively. To simplify the task of screening PCDDs/PCDFs for evaluation in this risk assessment, these compounds were evaluated with respect to a single member of this class of compounds. The concentration of each congener was evaluated on the basis of its concentration relative to that of 2,3,7,8-TCDD, which has been shown to be the most potent congener of the class of PCDDs/PCDFs. For this SLERA the higher of the TEFs for mammals and birds was used, as a conservative approach (Van den Berg et al., 2006; WHO, 1998). The toxicity equivalent 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 SWMU 51 surface soil revealed one sample with a soil pH of 5.0, so aluminum was selected as a COPEC for both food chain and direct contact exposure, given the site's slightly acidic soil conditions.

### 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.

Forty-three COPECs (21 inorganic and 22 organic COPECs) have been selected for surface soil direct contact exposure (**Table 7-5**).

Twenty-one COPECs (9 inorganic and 12 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 *HHRA 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 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. 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

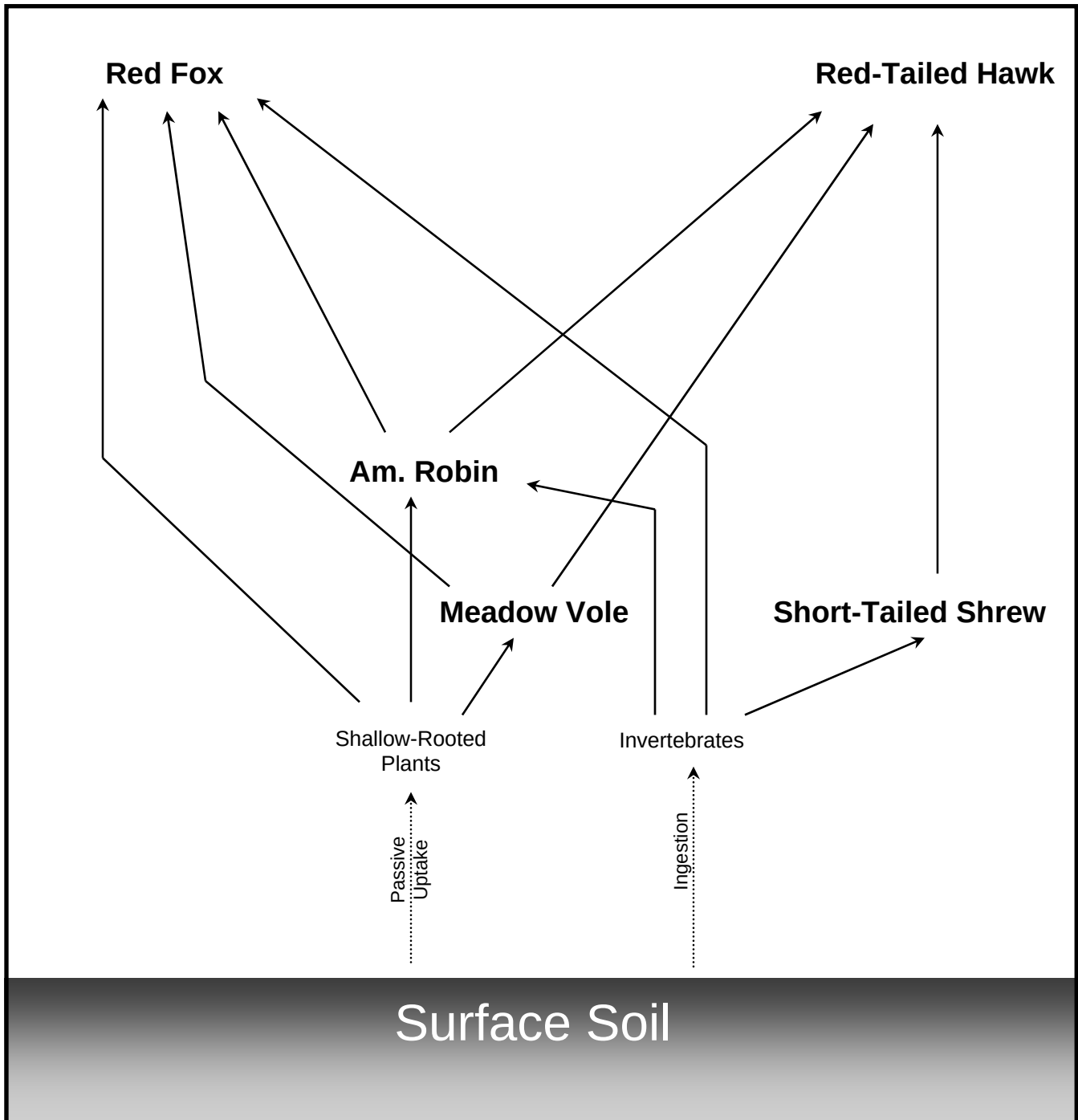
Five representative receptor species that are expected or possible in the area of SWMU 51 (Section 7.1) were selected as indicator species for the potential effects of COPECs. These indicator species represent two classes of vertebrate wildlife (mammals and birds) and a range of both body size and food 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 7.1.5), 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**).

**Figure 7-1**  
**Simplified Terrestrial Food Web**  
**Conceptual Site Exposure Model (CSEM)**



**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; 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 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, 1997c) states: “For the screening-level ecological risk assessment, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments. Adverse effects on populations can be inferred from measures related to impaired reproduction, growth, and survival. Adverse effects on communities can be inferred from changes in community structure or function. Adverse effects on habitats can be inferred from changes in composition and characteristics that reduce the habitats’ ability to support plant and animal populations and communities.”

The selected assessment endpoints for SWMU 51 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 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 species are ecologically linked for terrestrial invertebrates, small prey items, 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, 1997c).

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 fauna consume contaminated biota. Direct exposure routes include dermal contact, absorption, inhalation, and ingestion. Examples of direct exposure include animals incidentally ingesting contaminated soil; and, plants absorbing contaminants by uptake from contaminated soil. 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 SWMU 51 is assumed to be approximately 5.0, based on results from one surface soil sample. For purposes of the SLERAs, bioavailability is conservatively assumed to be 100 percent.

For terrestrial 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 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 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-3 through F-13**. For the SLERAs, conservative Tier 1 exposures are based on maximum dietary intake, maximum incidental soil intake, minimum body weight, 100 percent site exposure [i.e., area use factor (AUF) set equal to unity], and the use of COPEC MDCs as EPCs. Less conservative Tier 2 exposures are based on average dietary and incidental soil intake, average body weight, calculated AUF based on site area and home range of the receptor species, and COPEC EPCs set equal to 95% UCLs. The SWMU 51 site area was estimated to be 0.13 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  $k^{\text{th}}$  food type (mg/kg dry weight)
- $F_k$  = the fraction of the  $k^{\text{th}}$  food type that is contaminated
- $I_k$  = the ingestion rate of the  $k^{\text{th}}$  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.

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 (2007f), 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:

$$\text{Log BAF / BCF} = -0.578 \times \text{Log } K_{ow} + 1.588$$

where:

Log K<sub>ow</sub> = 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<sub>ow</sub> from the literature was used (as plant uptake is inversely related to K<sub>ow</sub>). For the Tier 2 approach, a more accurate (average) log K<sub>ow</sub> value from the Syracuse Research Corporation (SRC) website (<http://esc.syrres.com>) was used. SRC's interactive website estimates log K<sub>ow</sub> 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 the Tier 1 approach (for TCDD) to 0.0039 for the Tier 2 approach (for TCDD) (**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 (2007f). 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 (2007f) and Sample et al. (1998b). Tier 2 values are based on regression equations (USEPA, 2007f) or upperbound 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 no observable adverse effect level (NOAEL) or lowest observable adverse effect level (LOAEL) values using recommended Tri-Service (Wentsel et al., 1996) uncertainty factors].

### 7.6.2 Development of TRVs

TRVs were selected from available data for use in the SWMU 51 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<sub>50</sub> 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. Ecological 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 7.1.5*), there were some minor areas of potentially stressed vegetation (**Appendix F-1, Photo F-6**), but these areas are likely naturally occurring and not due to chemical stressors. 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

The potential wildlife risks associated with SWMU 51 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 325 (see following paragraphs), segregation of COPECs by mode of toxicological action was not necessary.

Tier 1 and Tier 2 individual COPEC EEQs and HIs (summed EEQs) for terrestrial receptors at SWMU 51 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 6 to 325 for the five receptor species, using TRVs based on either NOAEL or LOAEL values. The red fox and short-tailed shrew were predicted to be the most impacted, followed by the red-tailed hawk, the American robin, and the meadow vole, respectively. Inorganic constituents including arsenic, selenium and zinc; and the organic constituent TCDD, 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, plant, small mammal, and incidental soil ingestion.

More realistic Tier 2 total EEQs were slightly elevated, especially values based on NOAEL TRVs, which ranged from less than one to 4. 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 and only the LOAEL based Tier 2 total EEQ for the meadow vole was equal to one when rounded to one significant figure (although no individual EEQ exceeded one for the meadow vole). LOAEL EEQs were less than one for the short-tailed shrew, American robin, red-tailed hawk, and red fox (**Table 7-8**).

**Meadow Vole.** The total EEQ for the NOAEL TRV and LOAEL TRVs exceeded one (4.2 and 1.3, respectively). One COPEC had an individual NOAEL based EEQ that exceeded one (EEQ in parenthesis): arsenic (1.9). No COPECs had individual LOAEL based EEQs that exceeded one. The primary exposure pathway was the ingestion of plants and incidental ingestion of soil.

**Short-tailed Shrew.** The total EEQs for the NOAEL TRV exceeded one (4.5). Two COPECs had individual NOAEL based EEQs that exceeded one (EEQ in parenthesis): arsenic (1.5) and TCDD (1.4). No COPECs had individual LOAEL based EEQs that exceeded one. The primary exposure pathway was the ingestion of invertebrates.

**American Robin.** The total EEQs for the NOAEL TRV exceeded one (2.6). One COPEC had an individual NOAEL based EEQ that exceeded one (EEQ in parenthesis): zinc (1.5). No COPECs had individual LOAEL based EEQs that exceeded one. The primary exposure pathway was the ingestion of invertebrates.

### 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**.

**Table 7-8**  
**Wildlife EEQ Hazard Summary for SWMU 51**

| Receptor                        | Tier 1 <sup>a</sup>                              |                 | Tier 2 <sup>b</sup>                                          |                 |
|---------------------------------|--------------------------------------------------|-----------------|--------------------------------------------------------------|-----------------|
|                                 | NOAEL-Based EEQ                                  | LOAEL-Based EEQ | NOAEL-Based EEQ                                              | LOAEL-Based EEQ |
| Meadow vole                     | 16                                               | 5.5             | 4.2                                                          | 1.3             |
| Hazard Driver(s) <sup>c</sup> : | <u>Arsenic</u> - plant and soil ingestion        |                 | <u>Arsenic</u> - plant and soil ingestion                    |                 |
| Short-tailed shrew              | 325                                              | 41              | 4.5                                                          | 0.8             |
| Hazard Driver(s) <sup>c</sup> : | <u>TCDD</u> - terrestrial invertebrate ingestion |                 | <u>Arsenic and TCDD</u> - terrestrial invertebrate ingestion |                 |
| American robin                  | 58                                               | 17              | 2.6                                                          | 0.7             |
| Hazard Driver(s) <sup>c</sup> : | <u>Zinc</u> - terrestrial invertebrate ingestion |                 | <u>Zinc</u> - terrestrial invertebrate ingestion             |                 |
| Red-tailed hawk                 | 85                                               | 41              | 0.004                                                        | 0.002           |
| Hazard Driver(s) <sup>c</sup> : | <u>Selenium</u> - small mammal ingestion         |                 | --                                                           |                 |
| Red fox                         | 292                                              | 170             | 0.007                                                        | 0.004           |
| Hazard Driver(s) <sup>c</sup> : | <u>Selenium</u> - small mammal ingestion         |                 | --                                                           |                 |

<sup>a</sup> Tier 1 = Max EEQ using max EPC, max BAF/BCF, max intake rates, min BW and FHR =1.

<sup>b</sup> Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg intake rates, avg BW and calculated FHR  $\leq 1$ .

<sup>c</sup> 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

**Table 7-9**  
**Direct Toxicity Evaluation for Surface Soil at SWMU 51**  
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| 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 SQiRT 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 | Comment                                                    |
|------------------------|---------------------|-----------------------|------------------------------|-----------------------|---------------------------------------------------|--------------------------------------------------|-------------------------------------------------------|----------------------|----------------|---------------------------------------|-----------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------|------------------------------------------------------------|
| TCDD TE - RME          | 5 / 5               | 3.31E-06              | 2.55E-06                     | 7.70E-07              | 1.00E-02                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| 1,3-Dinitrobenzene     | 4 / 11              | 7.70E-01              | 4.26E-01                     | 8.00E-02              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | NVA                                     | NVA                                            |                                                                                 |                                                            |
| 2,4,6-Trinitrotoluene  | 10 / 11             | 1.30E+00              | 5.15E-01                     | 4.00E-02              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | NVA                                     | NVA                                            |                                                                                 |                                                            |
| 2,4-Dinitrotoluene     | 9 / 11              | 2.50E+00              | 1.98E+00                     | 9.00E-02              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | NVA                                     | NVA                                            |                                                                                 |                                                            |
| 2,6-Dinitrotoluene     | 5 / 7               | 1.70E+00              | 1.35E+00                     | 5.50E-02              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | NVA                                     | NVA                                            |                                                                                 |                                                            |
| 2-Methylnaphthalene    | 1 / 11              | 2.00E-02              | 8.29E-03                     | 2.00E-02              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | NVA                                     | NVA                                            |                                                                                 |                                                            |
| Aluminum               | 11 / 11             | 2.81E+04              | 2.28E+04                     | 1.06E+04              | 1.00E+00                                          | Yes                                              | pH < 5.5; Plant tox (OHMTADS)                         | NVA                  | NVA            | NVA                                   | 5.00E+01                                | NVA                                            | 2 / 2                                                                           | pH close to 5.5                                            |
| Antimony               | 2 / 11              | 6.40E-01              | 3.86E-01                     | 2.50E-01              | 2.70E-01                                          | Yes                                              | Mammal tox                                            | NVA                  | 2.00E+01       | 7.80E+01                              | 5.00E+00                                | NVA                                            | 0 / 3                                                                           | No exceedences                                             |
| Arsenic                | 11 / 11             | 5.70E+00              | 4.41E+00                     | 2.80E+00              | 2.80E+01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Barium                 | 11 / 11             | 1.20E+02              | 9.05E+01                     | 4.96E+01              | 3.30E+02                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Benzo(a)anthracene     | 1 / 11              | 2.00E-02              | 8.28E-03                     | 2.00E-02              | 1.00E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Benzo(a)pyrene         | 1 / 11              | 8.48E-03              | 5.17E-03                     | 8.48E-03              | 1.00E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Benzo(b)fluoranthene   | 1 / 11              | 2.90E-02              | 1.61E-02                     | 2.90E-02              | 1.00E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Benzo(g,h,i)perylene   | 1 / 11              | 2.60E-02              | 1.47E-02                     | 2.60E-02              | 1.00E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Benzo(k)fluoranthene   | 1 / 11              | 3.70E-02              | 2.00E-02                     | 3.70E-02              | 1.00E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Beryllium              | 11 / 11             | 8.00E-01              | 6.56E-01                     | 4.10E-01              | 2.10E+01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Cadmium                | 3 / 6               | 3.60E-01              | 2.35E-01                     | 1.30E-01              | 3.60E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Calcium                | 8 / 8               | 4.83E+02              | 3.76E+02                     | 2.28E+02              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | NVA                                     | NVA                                            |                                                                                 |                                                            |
| Chromium (Cr III tox)  | 11 / 11             | 3.46E+01              | 2.82E+01                     | 1.72E+01              | 2.60E+01                                          | Yes                                              | Bird tox (Cr III)                                     | NVA                  | 6.40E+01       | NVA                                   | 1.00E+00                                | 4.00E-01                                       | 2 / 3                                                                           | EcoSSL says data insufficient to derive direct contact SSL |
| Chromium (Cr VI tox)   | 11 / 11             | 3.46E+01              | 2.82E+01                     | 1.72E+01              | 8.10E+01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Chrysene               | 1 / 11              | 3.95E-02              | 2.13E-02                     | 3.95E-02              | 1.00E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Cobalt                 | 11 / 11             | 1.39E+01              | 9.17E+00                     | 3.30E+00              | 1.30E+01                                          | Yes                                              | Plant tox                                             | NVA                  | 4.00E+01       | 1.30E+01                              | 2.00E+01                                | NVA                                            | 1 / 3                                                                           | Plant tox                                                  |
| Copper                 | 11 / 11             | 1.74E+01              | 1.22E+01                     | 4.70E+00              | 2.80E+01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Dibenz(a,h)anthracene  | 1 / 11              | 4.45E-02              | 2.37E-02                     | 4.45E-02              | 1.00E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Diethyl phthalate      | 1 / 11              | 1.20E+00              | 6.86E-01                     | 1.20E+00              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | 1.00E+02                                | NVA                                            | 0 / 1                                                                           | No exceedences                                             |
| Fluoranthene           | 4 / 11              | 2.70E-02              | 1.90E-02                     | 1.10E-02              | 1.00E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Indeno(1,2,3-cd)pyrene | 1 / 11              | 3.15E-02              | 1.74E-02                     | 3.15E-02              | 1.00E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Iron                   | 11 / 11             | 3.16E+04              | 2.74E+04                     | 1.15E+04              | 5 ≤ pH ≤ 8                                        | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Lead                   | 11 / 11             | 3.41E+01              | 2.03E+01                     | 1.10E+01              | 1.10E+01                                          | Yes                                              | Bird tox                                              | NVA                  | 7.00E+01       | 1.20E+02                              | 5.00E+01                                | 5.00E+02                                       | 0 / 4                                                                           | No exceedences                                             |
| Magnesium              | 11 / 11             | 1.93E+03              | 1.16E+03                     | 4.83E+02              | 4.40E+03                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Manganese              | 11 / 11             | 7.07E+02              | 5.30E+02                     | 2.51E+02              | 2.20E+02                                          | Yes                                              | Plant tox                                             | NVA                  | NVA            | 2.20E+02                              | 5.00E+02                                | NVA                                            | 2 / 2                                                                           | Plant tox                                                  |
| Mercury                | 7 / 8               | 1.00E-01              | 7.30E-02                     | 2.40E-02              | 5.80E-02                                          | Yes                                              | No reference                                          | NVA                  | 6.60E+00       | NVA                                   | 3.00E-01                                | 1.00E-01                                       | 1 / 4                                                                           | No reference for BTAG                                      |
| 2-Nitrotoluene         | 8 / 11              | 9.20E+00              | 3.95E+00                     | 1.40E-01              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | NVA                                     | NVA                                            |                                                                                 |                                                            |
| 3-Nitrotoluene         | 9 / 11              | 1.10E+02              | 7.53E+01                     | 1.05E-01              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | NVA                                     | NVA                                            |                                                                                 |                                                            |
| 4-Nitrotoluene         | 8 / 11              | 6.20E+01              | 3.74E+01                     | 4.45E-01              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | NVA                                     | NVA                                            |                                                                                 |                                                            |
| Nickel                 | 11 / 11             | 1.32E+01              | 9.69E+00                     | 4.40E+00              | 3.80E+01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Nitrobenzene           | 4 / 11              | 1.25E-01              | 7.88E-02                     | 4.50E-02              | NVA                                               | NVA                                              |                                                       | NVA                  | NVA            | NVA                                   | NVA                                     | 4.00E+01                                       | 0 / 1                                                                           | No exceedences                                             |
| PAHs - LMW (8)         | 1 / 11              | 5.00E-02              | 2.60E-02                     | 3.00E-02              | 2.9E+01                                           | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| PAHs - HMW (8)         | 1 / 11              | 2.80E-01              | 1.60E-01                     | 2.60E-01              | 1.1E+00                                           | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Phenanthrene           | 9 / 11              | 3.00E-02              | 1.74E-02                     | 9.95E-03              | 1.00E-01                                          | No                                               |                                                       |                      |                |                                       |                                         |                                                |                                                                                 |                                                            |

**Table 7-9**  
**Direct Toxicity Evaluation for Surface Soil at SWMU 51**  
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| Chemical (1) | Detection Frequency | Maximum Concentration | Exposure Point Concentration | Minimum Concentration | BTAG or USEPA EcoSSL Screening Toxicity Value (2) | Retain COPEC as Max Cone > 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 | Comment                                                    |
|--------------|---------------------|-----------------------|------------------------------|-----------------------|---------------------------------------------------|--------------------------------------------------|-------------------------------------------------------|-----------------------|----------------|---------------------------------------|-----------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------|------------------------------------------------------------|
| Potassium    | 11 / 11             | 1.61E+03              | 1.04E+03                     | 3.60E+02              | NVA                                               | NVA                                              |                                                       | NVA                   | NVA            | NVA                                   | NVA                                     | NVA                                            |                                                                                 |                                                            |
| Pyrene       | 4 / 11              | 1.35E-02              | 1.11E-02                     | 7.90E-03              | 1.00E-01                                          | No                                               |                                                       |                       |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Selenium     | 1 / 11              | 6.05E-01              | 2.58E-01                     | 6.05E-01              | 1.80E+00                                          | No                                               |                                                       |                       |                |                                       |                                         |                                                |                                                                                 |                                                            |
| Thallium     | 2 / 7               | 1.10E+00              | 8.81E-01                     | 6.50E-01              | 1.00E-03                                          | Yes                                              | Plant tox (no ref)                                    | NVA                   | 1.00E+00       | NVA                                   | 1.00E+00                                | NVA                                            | 3 / 3                                                                           |                                                            |
| Vanadium     | 11 / 11             | 6.41E+01              | 5.63E+01                     | 2.75E+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         | 11 / 11             | 3.76E+01              | 3.31E+01                     | 1.95E+01              | 1.00E+01                                          | Yes                                              | Plant tox (OHMTADS)                                   | NVA                   | 2.00E+02       | NVA                                   | 5.00E+01                                | 2.00E+02                                       | 1 / 4                                                                           | Plant tox                                                  |

All values presented in mg/kg.

NVA = No Value Available

Surface soil pH of SWMU 51 is 5.0 based on one geochemical sample collected at SWMU-51.

(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 (Buckman, 1999).

(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 low molecular weight PAHs (LMW) and high molecular weight PAHs (HMW).

LMW and HMW PAHs based on the number of ring structures (less than 4 rings = LMW; 4 or more rings = HMW).

### 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 EcoSSL (USEPA, 2005b), 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 (NVA), the value was also carried forward for comparison to other available screening values (see list below). Based on the results of this first step, 10 COPECs were selected based on an EcoSSL or BTAG exceedance while 12 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 22 chemicals was compared with up to five individual soil screening values that are referenced on the USEPA Region 3 BTAG website for direct contact toxicity, listed as follows (in addition to the BTAG screening value, if one was available):

- NOAA Screening Quick Reference Table (SQuiRT) values (Buckman, 1999).
- Canadian Council of Ministers of the Environment (CCME) Environmental Quality Guideline values (CCME, 2003).
- EcoSSLs for invertebrate or plant toxicity (USEPA, 2005b).
- 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 aluminum MDC exceeded the two available benchmarks; however, the soil pH at SWMU 51 is 5.0. USEPA (USEPA, 2005b) recommends that aluminum should only be identified as a COPEC in soil with a pH of less than 5.5. However, Section 7.3 of the EcoSSL guidance (USEPA, 2005b) also indicates that at a pH of 5.0 and higher, soluble aluminum does not occur and toxicity associated with aluminum is not expected. It should also be noted that deeper soil at SWMU 51 were less acidic (e.g., pH = 7.8 at 13 to 15 ft bgs), and it is possible that additional surface soil samples would find that soil has a pH that is greater than 5.5. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 51.
- The chromium MDC exceeded two of the three available benchmarks for trivalent chromium; 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 SWMU 51.
- The cobalt MDC exceeded one of the three available benchmarks; however, this 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 SWMU 51.
- 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 SWMU 51.

- The mercury MDC exceeded one of the four available benchmarks; 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 SWMU 51.
- The thallium MDC exceeded the three available benchmarks; however, there is no reference available to determine the basis or appropriateness of the BTAG value. The other two direct contact screening values were from the CCME (for residential, agricultural, parkland, commercial, and industrial land uses) and from ORNL (for potential plant toxicity). As discussed in *Section 7.7.1*, plant toxicity is not an overriding concern for the site. If the 95% UCL EPC for thallium is used, no exceedance is found. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 51.
- The vanadium MDC exceeded one of the two available benchmarks; 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 SWMU 51.
- The zinc MDC exceeded one of the four available benchmarks; however, this 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 SWMU 51.
- None of other COPECs selected in the first screening step had any benchmark exceedances.

These results suggest that direct contact toxicity for COPECs in soil are not a concern. 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 no inorganic COPEC drivers with EEQs greater than one for the food chain assessment, therefore no background comparison was necessary. COPEC hazard drivers for the direct contact assessment, although not considered significant, were: aluminum, chromium, cobalt, manganese, mercury, thallium, vanadium, and zinc. Inorganic COPECs that were not statistically different based on appropriate statistical tests are considered background related (see *HHRA Section 6.4.3* for details). As summarized in **Table 7-10**, aluminum and vanadium direct contact COPECs in SWMU 51 surface soil are the only constituents considered to be potentially site related and not attributed to background.

**Table 7-10**  
**Background Comparison for Surface Soil at SWMU 51**

| <b>Soil COPEC</b> | <b>Wilcoxon Mann<br/>Whitney Test<br/>Site &gt; Background?</b> | <b>Considered to be<br/>Background?</b> |
|-------------------|-----------------------------------------------------------------|-----------------------------------------|
| Aluminum          | Yes                                                             | No                                      |
| Chromium          | No                                                              | Yes                                     |
| Cobalt            | No                                                              | Yes                                     |
| Manganese         | ---                                                             | Yes                                     |
| Mercury           | No                                                              | Yes                                     |
| Thallium          | No                                                              | Yes                                     |
| Vanadium          | Yes                                                             | No                                      |
| Zinc              | No                                                              | Yes                                     |

## 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 (2007f) 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

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.

There were 135 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**.

Twenty six of the 135 non-detect constituents had maximum detection limits that exceeded either one or both of the screening criteria. This finding is not unexpected, given the conservative and numerically low screening values.

The uncertainty analysis is presented in **Table 7-11** and lists some of the major assumptions made for the SLERA; the direction of bias caused by each assumption (i.e., if the uncertainty results in an overestimate or underestimate of risk); the likely magnitude of impact (quantitative [percent difference], or qualitative [high, medium, low, or unknown]); if possible, a description of recommendations for minimizing the identified uncertainties if the SLERA progresses to higher level assessment phases; and the ease of implementing the recommendation (USEPA, 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 percent bioavailable.
- Using some laboratory-derived or empirically-estimated partitioning and transfer factors to predict COPEC concentrations in plants, invertebrates, and/or prey species.
- Use of the HQ method to estimate risks to populations or communities.

## **7.9 SLERA Results and Conclusions**

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting SWMU 51. 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 NOAEL based food chain assessment results suggest potential adverse impacts to terrestrial wildlife (driver in parenthesis) such as the meadow vole (arsenic), short-tailed shrew (arsenic and TCDD) and American robin (zinc) via terrestrial invertebrate ingestion. However, more realistic LOAEL based food chain assessment results suggest there is no potential adverse impacts as no individual chemical had an EEQ greater than or equal to one.

The direct contact assessment results for soil invertebrates suggest that a reduction in wildlife food supply is not likely due to COPECs in surface soil, and the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 51.

Migration of COPECs in groundwater to surface water and sediment of the New River was determined unlikely due to the distance of this receptor area from the site and therefore was not deemed to be an ecological concern.

**Table 7-11**  
**Uncertainty Analysis**

| <b>Component</b>                                                                                                   | <b>Bias</b>         | <b>Magnitude</b> | <b>Ways to Minimize Uncertainty</b>                                                                                 | <b>Additional Comments</b>                                                                           |
|--------------------------------------------------------------------------------------------------------------------|---------------------|------------------|---------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| 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 <sub>50</sub> 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<br>2) obtain species-specific NOAEL data | 1) May not be accepted by Agency<br>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 HQ 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                                                                      |

Based on the results of the SLERA conducted at SWMU 51, on the fact that no wildlife rare, threatened, or endangered species have been confirmed at the SWMU 51 study area, and the very small size of the SWMU (0.31 acres), further action to address ecological concerns are not warranted for surface soil.

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 chapter identifies the corrective measures objectives (CMOs) for the contaminants of interest (COIs) identified by the risk assessments and provides remediation volume estimates based on the CMOs and analytical results. CMOs are cleanup objectives that are developed during the RFI/CMS to protect human health and the environment. They consist of medium-specific goals for protecting human health and the environment. CMOs provide the basis for the identification, detailed analysis, and selection of corrective measures alternatives.

### **8.1 Summary of Chemicals of Interest**

The SLERA concluded that remedial measures to address ecological concerns are not warranted for soil. However, the residual risk to ecological receptors was calculated to evaluate whether remediation for human health concerns would be protective of the environment or significantly reduce ecological risks.

The HHRA (*Section 6.0*) identified ten COIs (1,3-DNB, 2,4-DNT, 2,6-DNT, NG, 2- and 4-nitrotoluene, 2,4,6-TNT, dioxins/furans as TCDD TE, aluminum, and lead) under both an industrial and residential future-use scenario for total soil at SWMU 51. In addition, arsenic, manganese, iron, and vanadium were determined to be associated with unacceptable risk in the HHRA; however, these compounds were within background ranges, so are not further considered.

In addition, the HHRA further evaluated the risks associated with both the native/cover material and deeper soil at SWMU 51. This evaluation was performed to determine whether further evaluation of these media was warranted, or whether the unacceptable risks were limited to the sludge/grossly contaminated soil layer. For the native/cover material, the HI exceeded 1 for the excavation worker and adult and child residents due to aluminum, manganese, and/or vanadium. However, these metals have been determined to be within background concentrations. Therefore, no COIs were selected for the native/cover material. For the deeper soil, the HI exceeded 1 for the excavation worker due to aluminum and manganese. Aluminum and manganese have been determined to be within background concentrations. Because the deep soil is below 15 ft, no residential exposure to deep soil is anticipated.

Therefore, based on the results from the HHRA and SLERA, it is concluded that the COIs are limited to the sludge material and grossly contaminated soil beneath the sludge material. This layer is primarily located from 13-18 ft bgs. Further, as discussed in *Section 5.2.2*, migration of COIs from SWMU 51 to groundwater has not occurred. Therefore, the sludge layer and contaminated soil beneath the sludge were determined to be the media of interest for SWMU 51. The COIs identified within this layer, based on the results of the human health (*Section 6.0*) and ecological (*Section 7.0*) risk evaluations, are 1,3-DNB, 2,4-DNT, 2,6-DNT, NG, 2- and 4-nitrotoluene, 2,4,6-TNT, dioxins/furans, aluminum, and lead.

### **8.2 Remedial Goals**

Guidance on the receptors to be evaluated for the industrial and residential exposure scenarios was obtained from the VDEQ VRP risk assessment guidance document (VDEQ, 2007). VRP considers subsurface as well as surface soil to be potentially accessible for risk assessment purposes. During construction or excavation activities, subsurface soil could be brought to the surface and become available for exposure. If subsurface contaminants are at greater depths than

reasonably expected to be reached during a construction or utility project, those samples may be eliminated from the risk assessment. As a general default, VRP assumes that contamination down to 15 ft could be encountered and should be included in the risk assessment. The sludge material extends below the 15-foot exposure level. Further, no COIs were selected for the soil beneath the sludge and grossly contaminated soil by the HHRA. In addition, contamination of groundwater has not occurred due to contamination present in soil at SWMU 51 (see *Section 5.2.2*).

Risk-based remedial goals (RGs) were calculated for use down to 15 ft bgs based on the lower of a carcinogenic risk of  $10^{-5}$  or an apportioned total HI of 1. The calculated RGs for each risk assessment scenario are presented in the **Appendix G, Table 1 (cancer) and Appendix G, Table 2 (noncancer)** below and will be referred to as “shallow RGs.” **Table 8-1** shows the lowest value from the cancer and noncancer calculations and selects the lower of the two values. The lowest value for each chemical was selected for cancer and non-cancer risk and the lower of these two values was selected as the final shallow RG. **Appendix G** describes the RG calculation process. Fifteen feet was selected as the cutoff depth based on exposure depths used in standard risk assessment scenarios.

**Table 8-1**  
**Shallow Soil Remedial Goals**

| <b>Chemical</b>       | <b>Selected Cancer RG<br/>(TR = <math>10^{-5}</math>)</b> | <b>Selected NC Hazard<br/>(HI=1)</b> | <b>Selected RG<br/>(0-15 ft bgs interval)</b> |
|-----------------------|-----------------------------------------------------------|--------------------------------------|-----------------------------------------------|
| 1,3-Dinitrobenzene    | na                                                        | 0.8                                  | <b>0.8</b>                                    |
| 2,4-Dinitrotoluene    | 1.2                                                       | 15.4                                 | <b>1.2</b>                                    |
| 2,6-Dinitrotoluene    | 1.2                                                       | 7.7                                  | <b>1.2</b>                                    |
| Dioxins (TCDD TE)     | na <sup>a</sup>                                           | na <sup>a</sup>                      | <b>0.001</b>                                  |
| Lead                  | na <sup>a</sup>                                           | na <sup>a</sup>                      | <b>400</b>                                    |
| Nitroglycerin         | 47.7                                                      | 0.76                                 | <b>0.8</b>                                    |
| 2-Nitrotoluene        | na                                                        | 91                                   | <b>91.0</b>                                   |
| 4-Nitrotoluene        | 51.0                                                      | 31                                   | <b>30.8</b>                                   |
| 2,4,6-Trinitrotoluene | 31.9                                                      | 4.4                                  | <b>4.4</b>                                    |
| Aluminum              | na                                                        | 1180                                 | <b>40041<sup>b</sup></b>                      |
| Arsenic               | bkgd                                                      | na                                   | <b>15.8</b>                                   |
| Iron                  | na                                                        | bkgd                                 | <b>50962</b>                                  |
| Manganese             | na                                                        | bkgd                                 | <b>2543</b>                                   |
| Vanadium              | na                                                        | bkgd                                 | <b>108</b>                                    |

Bkgd = Within Background TR = Target Cumulative Risk

NA = Not Applicable

<sup>a</sup> RGs based on published EPA values

<sup>b</sup> Aluminum background level is higher than calculated RG

All values are presented in milligrams per kilogram (mg/kg).

At depths below 15 ft bgs, RGs were selected according to **Table 8-2** and will be referred to as “deep RGs.” Residential RBCs, Industrial RBCs, metals 95% background UTLs, maximum concentrations in the deep soil grouping and minimum concentrations in the sludge sample grouping were considered. The rationale for each deep RG is presented below. These deep RGs are non-risk based and are intended to demonstrate that, at depths greater than 15 ft, the sludge layer and grossly contaminated soil have been removed.

- For 1,3,5-DNB 2-NT and 4-NT, the residential RBC was selected since the r-RBC was higher than the minimum sludge concentration. The r-RBC is considered a conservative value given the depth of the samples and the absence of explosives related constituents in groundwater.
- For aluminum, the 95% background UTL was selected since this was higher than the minimum sludge concentration, the maximum deep concentration and the r-RBC.
- For 2,4,6-TNT, 2,4-DNT and 2,6-DNT, the midpoint between the minimum sludge concentration and the maximum deep soil concentration was selected since the minimum sludge concentration was greater than the maximum deep soil concentration and concentrations were fairly close. As discussed during the February 2008 EPA/VDEQ/RFAAP partnering meeting, the trench sludge and grossly contaminated soil are below the exposure depth for residential scenarios (typically 15 ft; although 20 ft was used for SWMU 51 to be more conservative). These deep RGs were selected to ensure that the trench sludge and grossly contaminated soil immediately below the sludge have been removed. Excavation will continue until COI concentrations in the confirmation samples are less than the RGs.
- For NG, a value of 10 times the deep soil maximum was used. There was a single detection of NG in the sludge (3300 mg/kg) out of 8 samples and a single detection of NG in the deep soil (6.7 mg/kg) out of 13 samples. Due to the low frequency of detection [Frequency of Detection (FOD) = 0.125 in the sludge and FOD = 0.077 in the deep soil] and the large range between the two detections, 10 times the deep soil concentration is more protective than the midpoint.
- For lead, the USEPA interim lead cleanup goal for un-restricted re-use of 400 mg/kg was selected.
- For dioxin/furans as TE, the residential value (1 µg/kg) from OSWER directive 9200.4-26 (*Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites*, April 2008) was selected.

Confirmation samples will be collected from the side walls and bottom of the excavation after visual signs of sludge have been removed, and concentrations will be compared to the shallow RGs at depths less than 15 ft bgs and to the deep RGs at depths greater than 15 ft bgs to confirm that the sludge and grossly contaminated soil have been removed. Excavation will continue until confirmation sample concentrations are below the RGs.

### 8.3 Site-Specific CMOs

The site-specific CMO for SWMU 51 is to eliminate the potential threats to human health and the environment that exist from the sludge material and/or grossly contaminated soil under the sludge material, as well as eliminate the threat for a potential future release of contaminants from the sludge material to groundwater.

**Table 8-2**  
**Deep Soil Remedial Goals**

| Analyte                       | Residential<br>RBC | Industrial/<br>Commercial<br>RBC | RFAAP<br>Background | Maximum Deep<br>Soil<br>Concentration | Minimum<br>Sludge<br>Concentration | Selected RG | RG Source                              |
|-------------------------------|--------------------|----------------------------------|---------------------|---------------------------------------|------------------------------------|-------------|----------------------------------------|
| <b>Explosives (mg/kg)</b>     |                    |                                  |                     |                                       |                                    |             |                                        |
| 1,3-Dinitrobenzene            | 7.8                | 100                              | na                  | 0.32                                  | 0.1                                | 7.8         | r-RBC                                  |
| 2,4,6-Trinitrotoluene         | 21                 | 95                               | na                  | 22                                    | 64                                 | 43          | Avg of Min Sludge and Max Deep Soil    |
| 2,4-Dinitrotoluene            | 0.95               | 4.2                              | na                  | 42                                    | 79                                 | 60.5        | Avg of Min Sludge and Max Deep Soil    |
| 2,6-Dinitrotoluene            | 0.95               | 4.2                              | na                  | 11                                    | 17                                 | 14          | Avg of Min Sludge and Max Deep Soil    |
| 2-Nitrotoluene                | 780                | 10000                            | na                  | 93                                    | 100                                | 10000       | r-RBC                                  |
| 4-Nitrotoluene                | 310                | 1800                             | na                  | 45                                    | 60                                 | 310         | r-RBC                                  |
| Nitroglycerin                 | 7.8                | 100                              | na                  | 6.7                                   | 3300                               | 67          | 10X Max deep soil                      |
| <b>Metals (mg/kg)</b>         |                    |                                  |                     |                                       |                                    |             |                                        |
| Aluminum                      | 78000              | 1000000                          | 40041               | 27700                                 | 8620                               | 40041       | Background                             |
| Lead                          | 400                | 800                              | 26.8                | 18.3                                  | 10.4                               | 400         | USEPA Interim Lead Clean-up Goal       |
| <b>Dioxins/Furans (ng/kg)</b> |                    |                                  |                     |                                       |                                    |             |                                        |
| 2,3,7,8-TCDD TE               | 4.3                | 19                               | na                  |                                       |                                    | 1000 ug/kg  | OSWER Directive 9200.4-26 (USEPA 1998) |

Notes: Red font in the RBC column indicates a carcinogen.  
2,4,6-TNT reverts to carcinogenic value when unadjusted.  
DNT mix RBC value was used.

## 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 SWMU 51, no technologies involving treatment were evaluated in detail. The first limitation to utilizing treatment technologies is that technologies capable of treating the contaminants present in the sludge (i.e., lead, aluminum, explosives, 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 lead in soil, but does not address the explosives or dioxins/furans. Therefore, technologies that require extensive on-site management/testing are not implementable.

The following three corrective measure alternatives were developed for SWMU 51 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 Sludge and Grossly Contaminated Soil and Off-site Disposal.

A detailed description of these 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, groundwater monitoring, and periodic reviews. The various components of this alternative are discussed below.

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.

**Long-Term Monitoring of Site Conditions.** Long-term monitoring of groundwater would be conducted to evaluate the potential migration of contaminants into groundwater. A long-term sampling plan would be developed for SWMU 51 by the Army, USEPA, and VDEQ, to monitor the levels of contaminants in the groundwater. This would include the semiannual monitoring of

**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 <sup>1</sup>  |                            |            |        |              |
| 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 <sup>2</sup>    | Sample                     | \$1029     | 28     | \$14,316     |
| Sample Labor, Preparation, Reporting | Episode                    | \$8,000    | 2      | \$16,000     |
| Subtotal                             |                            |            |        | \$30,316.00  |
|                                      | SUBTOTAL (ANNUALLY)        |            |        | \$37,316.00  |
|                                      | CONTINGENCY @ 30%          |            |        | \$11,194.80  |
|                                      | TOTAL ANNUAL O&M COSTS     |            |        | \$48,510.80  |
| PRESENT WORTH (30 YEARS AT 5%)       |                            |            |        | \$754,009.90 |

<sup>1</sup> Costs assigned on a annual basis

<sup>2</sup> Two sampling events per year with analysis for lead, aluminum, explosives, and dioxins/furans (11 samples + 2 dups + 1 rinse blank)

groundwater collected from 11 existing monitoring wells displayed on **Figure 2-12**. The wells and the rationale as to their selection is as follows:

- 51MW1 (downgradient and slightly crossgradient to the west).
- 51MW2 (downgradient).
- 59MW01 (downgradient).
- 48MW1 (downgradient).
- 48MW2 (downgradient).
- 48MW3 (downgradient).
- 49MW01 (downgradient).
- 48MW06 (downgradient and slightly crossgradient to the west).
- 48MW07 (downgradient and slightly crossgradient to the west).
- 16-4 (upgradient/ crossgradient to the east).
- C1 (upgradient).

The wells would be sampled twice a year for lead, aluminum, explosives, and dioxins/furans. A monitoring plan would be developed which would detail the sampling of these wells. Eleven groundwater samples and two duplicate samples 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 will be required.

**Periodic Reviews.** Although this alternative does not allow for unrestricted use and exposure, available data would be analyzed as part of the periodic review process to assess whether additional remedial actions or site controls are required.

### **9.3 Alternative Three – Excavation of Sludge and Grossly Contaminated Soil and Off-site Disposal with Land Use Controls and No Long-Term Monitoring**

This alternative involves excavation of sludge and grossly contaminated soil (see *Section 8.0*). The results of the SWMU 51 soil investigations indicate that the trench sludge material consisted of a black, paste-like sludge material that was very evident when encountered. It is a very sticky substance that exhibits a sweet odor. Therefore, identification and removal of the sludge material and grossly contaminated soil will be based on visual observations during excavation. Remedial Goals, as defined in *Section 8.2*, will be used to verify the concentrations of the COIs in confirmation samples after removal of the trench sludge and grossly contaminated soil. The estimated area to be excavated is presented on **Figure 2-3** as the trench boundary. Excavated materials will be shipped to an off-site landfill for disposal. The Hazardous Remediation Waste Management Requirements (HWIR) pertaining to land disposal of contaminated media would pertain to this site. The sludge present in the SWMU 51 disposal pit is a wastewater treatment sludge from the manufacturing and processing of explosives, and therefore, meets the definition of a RCRA source-specific waste (K044 listed waste). However, this listing is based on a determination that these wastes are reactive. On 16 May 2001, the EPA issued the final HWIR rule that allows more wastes to take advantage of exclusions from hazardous waste regulation. With the new changes, all wastes listed solely for the characteristics of ignitability, corrosivity, and/or reactivity (ICR) are not considered hazardous wastes if they no longer exhibit any of these

characteristics. The EPA states that when a waste has been listed solely for ICR characteristics, and that waste does not exhibit any hazardous characteristics at the point of generation, then that waste is not subject to Land Disposal Restrictions (LDR) standards. However, if the characteristic is removed after the point of generation, the waste is still subject to all applicable LDR requirements in 40 CFR 268. As the K044 listed wastes are listed solely for the characteristic of reactivity, these exclusions apply. Therefore, if sampling during the excavation determines that the waste is no longer reactive, the soil will not be considered to be a K044 waste and will be disposed as either a hazardous, non-listed waste or a non-hazardous waste based on the RCRA waste characteristics. As the soil does not contain greater than 10% explosives, it is not likely that the soil will be determined to be reactive so it is not likely to be classified as a K044 waste. The hazardous waste determination would therefore be based on the Toxicity Characteristic Leachate Procedure (TCLP) sample results. If the TCLP results indicate that the soil is a toxic waste (i.e., TCLP result greater than the 40 CFR 261.30(b) standards) it will be disposed per RCRA Subtitle C requirements. For cost-estimating purposes in this RFI/CMS, it was assumed that the sludge meets the definition of hazardous waste and will be disposed in a RCRA Subtitle C landfill.

The estimated volume of the materials to be excavated is 662 yd<sup>3</sup>. The density of the waste material was assumed to be 1.4 tons/yd<sup>3</sup>; therefore, the total quantity of waste material to be excavated will be approximately 927 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. As described in *Sections 4.1 and 8.1*, soil above and surrounding the sludge has been determined to be clean fill and/or native material. Therefore, this soil would be removed and stored during waste excavation and used as fill material.

This alternative entails removing all waste materials from the site. As COIs were not selected for the soil beneath the waste, clean closure will be achieved and land use controls will not be required.

The components of the excavation of sludge and grossly contaminated soil and off-site disposal alternative used for costing purposes are detailed below. The costs for this alternative are presented as **Table 9-2**.

**Reporting/Design Work Plans.** The contractor will prepare site-specific work plans prior to excavation activities that will include a QA planning component, health and safety component, Work Plan, and field procedures. The work plans will be reviewed and approved by the USEPA and VDEQ prior to removal activities.

After the corrective measures have been completed and the final inspection approved by the USEPA and VDEQ, a Corrective Measures Summary Report will be completed. Writing and compilation of the information for the report will occur throughout the duration of the remedial action. The report will include site drawings, sample data, copies of manifests, and a detailed narrative of the corrective measures.

**Site Set-up.** Site set-up for the excavation will consist of setting up a decontamination station, mobilization of equipment and personnel, and setting up staging areas. It should be noted that mobilization costs are included with the excavation costs in **Table 9-2**. The water needs of the

**Table 9-2**  
**Cost for Alternative Three: Excavation of Sludge and Grossly Contaminated Soil**  
**and Off-site Disposal**

| ITEM                                                                         | UNITS    | UNIT COST   | NUMBER | TOTAL               |
|------------------------------------------------------------------------------|----------|-------------|--------|---------------------|
| <b>CAPITAL COSTS<sup>1</sup></b>                                             |          |             |        |                     |
| <b>Reporting/Workplans</b>                                                   |          |             |        |                     |
| Health and Safety Plan                                                       | Report   | \$10,000.00 | 1      | \$10,000.00         |
| Quality Assurance Project Plan                                               | Report   | \$10,000.00 | 1      | \$10,000.00         |
| Work Plan                                                                    | Report   | \$15,000.00 | 1      | \$15,000.00         |
| Corrective Measures Summary Report                                           | Report   | \$20,000.00 | 1      | \$20,000.00         |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$55,000.00</b>  |
| <b>Site Set-Up</b>                                                           |          |             |        |                     |
| 1000-gallon Storage Tank                                                     | Lump Sum | \$500.00    | 5      | \$2,500.00          |
| 55-gallon drums                                                              | Each     | \$86.74     | 100    | \$8,674.00          |
| Decontamination Pad                                                          | Site     | \$1,500.00  | 1      | \$1,500.00          |
| Poly Sheeting                                                                | Roll     | \$145.73    | 4      | \$582.92            |
| Silt Fence w/ Stakes 3' x 800'                                               | Roll     | \$28.24     | 32     | \$903.68            |
| Safety Fence 4' x 800'                                                       | Roll     | \$66.81     | 32     | \$2,137.92          |
| Geotextile, Mirafi Filterweave 700                                           | SF       | \$0.29      | 3200   | \$928.00            |
| Lumber 4"x6", 12ft                                                           | Each     | \$24.50     | 160    | \$3,920.00          |
| Decon Soap                                                                   | Gallon   | \$22.50     | 5      | \$112.50            |
| Misc Supplies (brushes, shovels, etc)                                        | Lump Sum | \$250.00    | 1      | \$250.00            |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$21,509.02</b>  |
| <b>Contamination Delineation</b>                                             |          |             |        |                     |
| Direct Push Rig (Geoprobe)                                                   | Day      | \$1,500.00  | 3      | \$4,500.00          |
| Oversight (Geologist)                                                        | Hour     | \$65.00     | 30     | \$1,950.00          |
| Per Diem                                                                     | Day      | \$131.00    | 4      | \$524.00            |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$6,974.00</b>   |
| <b>Health and Safety</b>                                                     |          |             |        |                     |
| Site Health and Safety Officer                                               | Hour     | \$90.00     | 200    | \$18,000.00         |
| Safety Supplies (tyvex, gloves, etc.)                                        | Lump Sum | \$500.00    | 1      | \$500.00            |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$18,500.00</b>  |
| <b>Excavation</b>                                                            |          |             |        |                     |
| QC Personnel (1)                                                             | Hour     | \$70.00     | 200    | \$14,000.00         |
| Field Supervisor (1)                                                         | Hour     | \$60.00     | 200    | \$12,000.00         |
| Field Technician (2)                                                         | Hour     | \$37.75     | 400    | \$15,100.00         |
| Equipment Operators (2)                                                      | Hour     | \$50.00     | 400    | \$20,000.00         |
| Project Manager (1)                                                          | Hour     | \$124.75    | 120    | \$14,970.00         |
| Per Diem <sup>2</sup>                                                        | Day      | \$131.00    | 150    | \$26,986.00         |
| Project Business Administrator                                               | Hour     | \$81.00     | 40     | \$3,240.00          |
| Truck (3)                                                                    | Month    | \$1,175     | 3      | \$3,525.00          |
| Excavator - Cat 330 or equivalent (includes mob/demob)                       | Month    | \$9,350.00  | 1      | \$9,350.00          |
| Pressure Washer (includes mob/demob)                                         | Month    | \$600.00    | 1      | \$600.00            |
| Roller - Vibratory Compactor (includes mob/demob)                            | Week     | \$875.00    | 1      | \$875.00            |
| Water Truck, 2000 gallon (includes mob/demob)                                | Month    | \$2,480.00  | 1      | \$2,480.00          |
| 4" Dry-Prime Pump with Generator                                             | Month    | \$1,965.00  | 1      | \$1,965.00          |
| FOGM (total work hrs * 2.5)                                                  | Hour     | \$23.40     | 206    | \$4,680.00          |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$129,771.00</b> |
| <b>Waste Characterization &amp; Confirmation Sampling</b>                    |          |             |        |                     |
| Off-Site Lab Analytical (TCLP metals, RCRA Char, Explosives, Dioxins/Furans) | Sample   | \$1,533.00  | 50     | \$76,650.00         |
| Decon Water Sample (RCRA Waste Characterization)                             | Sample   | \$1,410.00  | 1      | \$1,410.00          |
| <b>Subtotal</b>                                                              |          |             |        | <b>\$78,060.00</b>  |

**Table 9-2 (Continued)**  
**Cost for Alternative Three: Excavation of Sludge and Grossly Contaminated Soil**  
**and Off-site Disposal**

| ITEM                                    | UNITS    | UNIT COST  | NUMBER | TOTAL               |
|-----------------------------------------|----------|------------|--------|---------------------|
| <b>CAPITAL COSTS<sup>1</sup></b>        |          |            |        |                     |
| <b>Waste Transportation/Disposal</b>    |          |            |        |                     |
| Hazardous Waste Transportation/Disposal | Ton      | \$ 173.53  | 927    | \$160,862.31        |
| <b>Subtotal</b>                         |          |            |        | <b>\$160,862.31</b> |
| <b>Site Restoration</b>                 |          |            |        |                     |
| D5 Bulldozer (includes mob/demob)       | Month    | \$3,800.00 | 1      | \$3,800.00          |
| Clean Fill                              | CY       | \$25.00    | 1256   | \$31,400.00         |
| Seeding, Vegetative Cover               | Acre     | \$3,528.00 | 1.0    | \$3,528.00          |
| Survey Equipment/Team                   | Lump Sum | \$1,500.00 | 1.0    | \$1,500.00          |
| <b>Subtotal</b>                         |          |            |        | <b>\$40,228.00</b>  |
| <b>CAPITAL COSTS<sup>1</sup></b>        |          |            |        |                     |
| <b>SUBTOTAL</b>                         |          |            |        | <b>\$450,275.33</b> |
| SUPERVISION AND ADMIN @ 8%              |          |            |        | \$36,022.03         |
| CONTINGENCY @ 30%                       |          |            |        | \$135,082.60        |
| <b>TOTAL CAPITAL COSTS</b>              |          |            |        | <b>\$675,030.96</b> |
| <b>O&amp;M COSTS</b>                    |          |            |        |                     |
| <b>None</b>                             |          |            |        |                     |
| <b>SUBTOTAL (ANNUALLY)</b>              |          |            |        | <b>\$0.00</b>       |
| CONTINGENCY @ 30%                       |          |            |        | \$0.00              |
| <b>TOTAL ANNUAL O&amp;M COSTS</b>       |          |            |        | <b>\$0.00</b>       |
| <b>PRESENT WORTH (30 YEARS AT 5%)</b>   |          |            |        | <b>\$675,030.00</b> |

<sup>1</sup> The estimated length of time is as follows: delineation 3 days, mobilization/site set-up 2 days, excavation 12 days, site restoration 3 days, decon/demob 3 days

<sup>2</sup> Per diem costs for 28 days for H&S and QC officers, site super, field techs, and equipment operators, 10 days for PM

process are for decontamination; therefore, water will be trucked to the site and stored in a 500-gallon tank. The cost elements for preparing the work zone are presented below:

- The equipment decontamination station will be constructed with material such as high-density polyethylene for containment purposes. This decontamination station should be bermed to ensure containment of decontamination liquids.
- A 500-gallon tank will be used throughout the duration of the corrective measure activities to store water for use in the decontamination station.
- A silt fence will be constructed for erosion control and a safety fence will be constructed around the perimeter of the work site to prevent unauthorized personnel and wildlife from entering the work zone.

**Contamination Delineation.** The area to be excavated will be delineated prior to mobilization of the excavation personnel. For the purpose of this study, it is assumed that 30 soil borings would be completed to delineate the areal extent and depth to the top of the waste. The soil would be continuously evaluated using visual observations for sludge and grossly contaminated soil. Details on boring locations will be developed during the work planning phase.

**Health and Safety.** Health and safety measures will be taken to protect on-site workers during excavation activities. For cost-estimating purposes, modified Level D 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 CAT 330 or equivalent excavator (trackhoe) will be used to excavate the contaminated area into a stockpile. Clean/native soil from above and around the sludge will be removed and stored along one side of the trench. Sloping or benching will be performed as required to prevent cave-in from occurring as the excavation proceeds. Contaminated soil will be directly loaded into dump trucks and transported from the site. It is assumed that the excavation will proceed at a maximum rate of 10-12 trucks per day (22 tons/truck). The estimated length of time for the excavation is 12 working days. A water truck will be required on site during excavation activities for dust suppression purposes. Personnel assumed for this alternative include one QC Engineer, one field supervisor, two field technicians, two equipment operators, and one project manager.

**Waste Characterization & Confirmation Sampling.** For the purposes of this document, analysis for the following waste characteristics is assumed for composite samples collected from excavated soil prior to excavation. The receiving facility requires that one composite sample be collected from the waste materials per 1,000 tons. For the purposes of this CMS, it is assumed that two composite samples will be collected from the delineated waste materials to assess whether the soil is a hazardous waste prior to excavation. In addition, investigative-derived materials will be sampled prior to disposal for RCRA waste characteristics. It is also assumed that confirmation samples will be collected to ensure that trench sludge and grossly contaminated soil has been removed. For the purposes of this document, it is assumed that 45 samples will be sufficient to ensure removal. The Interim Measures Work Plan will provide more detail on the number and location of samples, as well as the chemical analysis for each sample.

| Test                              | Media | Method           |                   | Price* |
|-----------------------------------|-------|------------------|-------------------|--------|
|                                   |       | Preparation      | Analysis          |        |
| Corrosivity, pH, 3 day TAT        | Solid | NA               | SW846 9045D       | \$13   |
| Flash Pt. Ignitability, 3 day TAT | Solid | NA               | SW846 1010        | \$26   |
| Reactivity, 3 day TAT             | Solid | SW846 Chap 7.3   | SW846 Chap 7.3    | \$91   |
| Dioxins/furans, 7 day TAT         | Solid | SW846 8290       | SW846 8290        | \$1050 |
| Explosives, 7 day TAT             | Solid | SW846 3550B      | SW846 8330B       | \$260  |
| TCLP Metals, 3 day TAT            | Solid | SW846 1311/3010A | SW846 6010B/7470A | \$133  |
| Total Cost                        |       |                  |                   | \$1573 |

\* Based on laboratory alliance (2007) and 30% markup for 7-day turnaround time (TAT).

**Waste Transportation and Disposal.** Corrective measure activities are expected to generate approximately 1,236 tons of hazardous soil and 1,000 gallons of decontamination water. Excavated soil is anticipated to be classified as hazardous waste, so will be disposed in a RCRA Subtitle C 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 hazardous waste will be transported to EQ – Belleville Michigan facility 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 clean materials from the top of the excavation will be placed back in the trench using a D5 bulldozer. Additional soil will be added such that the trench matches the surrounding grade. Approximately 6 inches of topsoil will then be applied and the area will be graded. Erosion control measures will be implemented and excavation areas will be seeded. Upon completion of site restoration operations, the contractor will remove the temporary facilities from the area.

Prior to adding the soil, all clean/native fill will be sampled at a rate of 1 composite sample per 1,000 cubic yards. Four aliquots from separate areas will be composited into each sample. The samples will be analyzed for TAL metals, TCL VOCs, TCL SVOCs, pesticides/PCBs, and explosives. Results will be compared to residential RBCs and RFAAP 95% UTL background levels to ensure that the fill is acceptable. If the native fill does not pass the screening, additional fill will be brought on site from an off-site source and will be analyzed in the same manner.

After the site restoration activities are completed, Shaw will demobilize all equipment off site.

**Land Use Controls.** SWMU 51 is located in an active magazine area and several other SWMUs are in the immediate vicinity, making any development of this area extremely unlikely. In addition, RFAAP is revising its policy to enhance the use of management controls in conjunction with physical controls that can further limit access to this portion of the installation.

***Long-Term Monitoring.*** Based on the analysis of groundwater data at the site and the distribution of COIs in the soil; and, per agreements with the USEPA and VDEQ, no long-term monitoring is required at this site.

## **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 percent to minus 30 percent). Actual cost of each alternative is dependent on the final scope, schedule, market conditions, and other variables. Development of the cost for each alternative included:

- Engineering level design of final remedy.
- Capital cost.
- Installation cost.
- Institutional controls costs (if applicable).

### **10.2 Effectiveness**

#### **10.2.1 Overall Protection of Human Health and the Environment**

No risks to ecological receptors were determined for SWMU 51; therefore, all alternatives provide protection to the environment. However, Alternative One does not meet this criterion as no measures are taken to prevent human contact with contaminated soil and sludge. Alternative

Two provides some protection of human health as measures are taken to prevent contact with contaminated soil and sludge. For Alternative Three, sludge and grossly contaminated soil will be removed from the site, thereby providing protection of human health and the environment.

### **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. Alternative Three will eliminate contaminants from the site, 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 NEPA requirements is presented in **Appendix H**.

### **10.2.3 Long-term Effectiveness and Permanence**

Alternative One does not provide long-term effectiveness or permanence because elevated contaminant concentrations will remain in place and no active controls will be taken to reduce exposure. Alternative Two does not provide long-term effectiveness and permanence because the waste materials would remain in place; however, human contact with the contaminants would be reduced through the implementation of institutional controls. For Alternative Three, all contaminated sludge and grossly contaminated soil would be removed from the site, thereby providing long-term effectiveness and permanence.

### **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. Alternative Three 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 Alternative Three 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 and Three 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 and Three are expected to be routine. Permitting will not be required for the activities described under Alternatives Two or Three.

### 10.3.3 Availability of Services and Materials

Alternatives Two and Three 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 and Three are presented in **Tables 9-1 and 9-2**, respectively. Costs for each of the alternatives are summarized in **Table 10-1**.

**Table 10-1**  
**Summary of Costs**  
**SWMU 51 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<br>(Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring) | \$8,280            | \$48,511                                    | \$745,729                                    | \$754,009          |
| 4 – Excavation of Sludge and Grossly Contaminated Soil and Off-site Disposal                                 | \$675,030          | \$0                                         | \$0                                          | \$675,030          |

## 11.0 RANKING OF CORRECTIVE MEASURES ALTERNATIVES

The three corrective measures alternatives presented in *Section 9.0* and evaluated in *Section 10.0* are assessed in this section using a numerical ranking system. The alternatives are ranked according to the criteria discussed in *Section 10.0* that include effectiveness, implementability, and cost. Each selection criterion for each alternative was ranked 1 through 5. A score of 5 indicates the most favorable alternative. A score of 1 indicates the least favorable alternative.

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 Three, Excavation of Sludge and Grossly Contaminated Soil and Off-site Disposal is the selected corrective measure alternative for SWMU 51.

**Table 11-1**  
**Ranking Assessment of Corrective Measures Alternatives**

| Alternative                                                                                                           | Effectiveness                                                                                                                                                                                                                                         | Implementability                                                                                                                                               | Cost (30-yr Present Worth) | Total Score |
|-----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------|
| Alternative 1 – No Further Action                                                                                     | Not effective in preventing unacceptable risks to human health or the environment as contaminated sludge and soil remain.                                                                                                                             | This alternative does not entail activities to be implemented. Therefore, an assessment of implementability is not applicable.                                 | \$0                        |             |
|                                                                                                                       | 3<br>3X 1                                                                                                                                                                                                                                             | 10<br>2X 5                                                                                                                                                     | 5<br>1X 5                  | 18          |
| Alternative 2 – Institutional Controls (Industrial/Commercial Use Scenario Land Use Controls, Groundwater Monitoring) | Contaminated sludge and soil would remain at the site. Risks to human health are reduced by implementing land use controls. No unacceptable risks to ecological receptors were determined to be associated with this site.                            | Relatively simple to implement. Uses commercially-available processes from readily available sources. Administrative implementability expected to be achieved. | \$754,009                  |             |
|                                                                                                                       | 6<br>3X 2                                                                                                                                                                                                                                             | 10<br>2X 5                                                                                                                                                     | 3<br>1X 3                  | 19          |
| Alternative 3 – Excavation of Sludge and Grossly Contaminated Soil and Off-site Disposal                              | Contaminated sludge and soil 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. | Relatively simple to implement. Uses commercially-available processes from readily available sources. Administrative implementability expected to be achieved. | \$675,030                  |             |
|                                                                                                                       | 15<br>3X 5                                                                                                                                                                                                                                            | 10<br>2X 5                                                                                                                                                     | 4<br>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 SWMU 51 RFI/CMS identified ten COIs (1,3-DNB, 2,4-DNT, 2,6-DNT, NG, 2- and 4-nitrotoluene, 2,4,6-TNT, dioxins/furans as TCDD TE, aluminum, and lead) as being a potential concern to human health and the environment (see *Section 8.0*). The CMO for the SWMU 51 study area is to eliminate the potential threats to human health and the environment that exist from the sludge material and/or grossly contaminated soil under the sludge material, as well as eliminate the threat for a potential future release of contaminants from the sludge material to groundwater. This objective is considered protective of human health and the environment in the study area because there are no current exposures to contaminated sludge or soil and contamination has been determined to not be migrating off site. Three 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 Sludge and Grossly Contaminated Soil and Off-site Disposal.

Alternative Three, which entails excavation and off-site disposal as the primary remediation process, was found to achieve the CMO. Therefore, Alternative Three was selected as the final alternative for SWMU 51 because it is implementable and provides a greater level of protection to human health and the environment not provided by the other alternatives. In addition, Alternative Three is the sole alternative that facilitates clean closure. By achieving clean closure, Alternative Three accomplishes the Army's goal for the Installation Restoration Program and its funding source the Environmental Restoration, Army account. In addition, Alternative Three has a lower cost and meets CMOs, which Alternative Two does not. This alternative 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 sludge material.
- Excavation of the delineated sludge as well as any grossly contaminated soil present under the sludge.
- Transportation and off-site disposal of soil.
- Confirmation sampling to ensure that trench sludge and grossly contaminated soil has been removed, with remaining COI concentrations below the RGs.
- Site restoration activities.

Implementation of this alternative will eliminate contaminated soil 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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