RADFORD ARMY AMMUNITION PLANT, VIRGINIA

SWMU 43
RCRA Facility Investigation 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

January 2011

received
2-1-11
11-14

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

January 28, 2011

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

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

Re: Radford Army Ammunition Plant, Va.
Review of Army's Final RCRA Facility Investigation Report for
Solid Waste Management Unit 43

Dear Mr. McKenna and Ms. Holt:

The U.S. Environmental Protection Agency (EPA) and Virginia Department of Environmental Quality (VDEQ) have reviewed the U.S. Army's (Army's) January 2011 Final RCRA Facility Investigation Report for Solid Waste Management Unit 43, located at the Radford Army Ammunition Plant (RFAAP) in Radford, Virginia. Based upon our review, the report is approved, and in accordance with Part II. (E) (5) of RFAAP's Corrective Action Permit, it can now be considered final.

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

Sincerely,

William Geiger
RCRA Project Manager
Office of Remediation (3LC20)

cc: James Cutler, VDEQ

ATK

ATK Armament Systems
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January 20, 2011

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 23219

Subject: With Certification, SWMU 43RCRA Facility Investigation, Final Document, January 2011
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 14, 2011. Also enclosed is the 14 January 2011 transmittal email.

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

Sincerely,

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

c: Karen Sismour
Virginia Department of Environmental Quality
629 East Main Street
Richmond, VA 23219

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

11-815-15
JMcKenna

Rich Mendoza
US Army Environmental Center
11711 North IH 35, Suite 110
Attn: Richard Mendoza (C-23)
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Tom Meyer
Corps of Engineers, Baltimore District
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bc:
Env. File
J. McKenna, ACO Staff
Rob Davie-ACO Staff
P.W. Holt
J. J. Redder
Env. File

Coordination: JMcKenna
J. McKenna

M. A. Miano

11-815-15
JMcKenna

Concerning the following:

Radford Army Ammunition Plant
SWMU 43
RCRA Facility Investigation
Final Document, January 2011

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: Antonio Munera
PRINTED NAME: Antonio Munera
TITLE: LTC, CM
Commanding

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

11-815-15
JMcKenna

Greene, Anne

From: McKenna, Jim
Sent: Friday, January 14, 2011 1:54 PM
To: Greene, Anne; Cutler,Jim; dennis.druck@us.army.mil; Geiger.William@epamail.epa.gov; Redder, Jerome; Lohman,Elizabeth; Mendoza, Rich; Meyer, Tom NAB02; Parks, Jeffrey N; Sismour,Karen; Timothy.Leahy@shawgrp.com
Cc: Flint, Jeremy
Subject: Final SWMU 43 RFI Report (UNCLASSIFIED)
Attachments: SWMU 43 RFI response to comments email correspondence.pdf

Importance: High

Classification: UNCLASSIFIED
Caveats: FOUO

All:

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

Attached is email correspondence related to the comments and responses on the draft SWMU 43 RFI Report. Note per our July 21, 2010 partnering meeting to further address Comment #3, it was agreed that RFAAP would perform an additional round of ground water sampling and if this new groundwater data was within 1 order of magnitude of the 2007 round, then no further action was required beyond institutional control. Also it was agreed that the new groundwater data will be presented in the final RFI Report but would not need to be incorporated into the risk assessment.
The re-sampling effort did occur and was well within this range and is presented in the final RFI report.

Thank you for your support of the Radford Army Ammunition Plant Installation Restoration Program.

Jim McKenna

Jim McKenna	1Z63V8840198018113
Mr. Richard Mendoza	1Z63V8840198978943
Mr. Tom Meyer	1Z63V8840195918129
Mr. Dennis Druck	1Z63V8840197819732
Mr. James Cutler	1Z63V8840197562170
Ms. Elizabeth Lohman	1Z63V8840197511788
Ms. Susan Ryan	1Z63V8840195611754
Mr. William Geiger	1Z63V8840198494162

Classification: UNCLASSIFIED

Caveats: FOUO

Classification: UNCLASSIFIED
Caveats: FOUO

om: Geiger.William@epamail.epa.gov
nt: Monday, June 21, 2010 3:11 PM
: McKenna, Jim J Mr CIV USA AMC
Cc: Parks, Jeffrey N; jeremy.flint@atk.com; jerome.redder@atk.com; jlcutler@deq.virginia.gov; Cramer.Mike@epamail.epa.gov; Mendoza, Richard R Mr CIV USA IMCOM; Timothy.Leahy@shawgrp.com; Meyer, Tom NAB02
Subject: RE: SWMU 43 RFI Comments (UNCLASSIFIED)

Jim, EPA and VDEQ have reviewed RAAP's responses to our comments on the SWMU 43 RFI. We approve of all of them, with the exception of Comment #3.

It is understood that groundwater use restrictions are in place installation-wide. While this provides protection of human health it does not address EPA/Virginia's goal of protecting beneficial use of groundwater. Waste remains in place at this site and monitoring would be required to demonstrate that MCLs are not exceeded in the future. PCE has already been detected and SWMU 43 represents the likely source, as RAAP has pointed out in their response to Comment #2.

William A. Geiger
Remedial Project Manager
Office of Remediation (3LC20)
U.S. Environmental Protection Agency
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one: 215.814.3413
iger.William@epa.gov

From: "McKenna, Jim J Mr CIV USA AMC" <jim.mckenna@us.army.mil>
To: William Geiger/R3/USEPA/US@EPA
Cc: "Parks, Jeffrey N" <Jeffrey.Parks@shawgrp.com>, <jerome.redder@atk.com>, <jlcutler@deq.virginia.gov>, "Mendoza, Richard R Mr CIV USA IMCOM" <richard.r.mendoza@us.army.mil>, <Timothy.Leahy@shawgrp.com>, "Meyer, Tom NAB02" <Tom.Meyer@nab02.usace.army.mil>, Mike Cramer/R3/USEPA/US@EPA, <jeremy.flint@atk.com>
Date: 05/10/2010 11:04 AM
Subject: RE: SWMU 43 RFI Comments (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: FOUO <<RTCs SWMU 43_rev05052010.doc>>

Will and everyone, attached are RFAAP responses to the comments.
nks, Jim

-----Original Message-----
From: Geiger.William@epamail.epa.gov

[mailto:Geiger.William@epamail.epa.gov <mailto:Geiger.William@epamail.epa.gov>]
Sent: Thursday, April 08, 2010 3:35 PM
To: McKenna, Jim J Mr CIV USA AMC
c: diane.wisbeck@arcadis-us.com; jim spencer; Parks, Jeffrey N; jerome.redder@atk.com;
cutler@deq.virginia.gov; Mendoza, Richard R Mr CIV USA IMCOM; Timothy.Leahy@shawgrp.com;
ina_MacGillivray@URSCorp.com; Meyer, Tom NAB02; Cramer.Mike@epamail.epa.gov

Subject: SWMU 43 RFI Comments

Jim, attached are EPA/VDEQ comments for the Nov '09 SWMU 43 RFI Report.

William A. Geiger
Remedial Project Manager
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Phone: 215.814.3413
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Classification: UNCLASSIFIED
veats: FOUO

[attachment "RTCs SWMU 43_rev05052010.doc" deleted by William Geiger/R3/USEPA/US]

Response to EPA Comments on the
Final SWMU 43 RCRA Facility Investigation Report
Radford Army Ammunition Plant (RFAAP), Virginia
November 2009 Final

Comments from Mr. William Geiger, Remediation Project Manager,
United States Environmental Protection Agency Region III,
and Mr. Jim Cutler, Virginia Department of Environmental Quality

General Comments

Comment 1.

Comment: Based on the results of the investigation and subsequent risk evaluations, the RCRA Facility Investigation (RFI) for Solid Waste Management Unit (SWMU) 43 recommends in Section 8.4, Controls, that institutional controls (ICs) be implemented at the site. Specifically, the RFI states that the site will be "incorporated into a plant management manual to ensure long-term protection of human health and the environment. The management manual provides for advance notice, assessment and approval of intrusive work that may occur within the plan with a general digging prohibition at sites such as this" (Page 8-4). Since elevated risks at the site are associated with exposure to contaminated groundwater, implementation of ICs at the site will need to incorporate groundwater use restrictions in addition to the general digging prohibition that is described. Please revise the RFI to incorporate a groundwater use restriction into the IC, and describe the mechanism for its implementation.

Response: The text will be revised as requested, by adding in media-specific restrictions for groundwater in order to prohibit groundwater extraction or usage from the site. An explanation of the mechanism for its implementation will also be added.

Comment 2.

Comment: Tetrachloroethylene (PCE) and/or metals were detected in groundwater above applicable screening criteria in upgradient monitoring wells 43MW1 and 43MW2. The RFI suggests that the constituents detected in these two wells may not be associated with or originate from SWMU 43. However, the RFI does not discuss a potential source of these contaminants. Figure 1-1, SWMU 43, shows several other SWMUs in the vicinity of SWMU 43, but none appear to be south/southeast of the site, in what would be considered upgradient of SWMU 43. Please revise the RFI to identify the probable source of the PCE and metals contaminants detected in the SWMU 43 upgradient wells, and provide an update on any investigations that may be addressing the contamination.

Response: A reanalysis of the groundwater data shows that SWMU 43 is the likely source of these constituents. The single upgradient detection was extremely low and is attributed to dispersion in the groundwater. The upgradient detection is likely due to the relatively low gradient in the flat floodplain terrace adjacent to the New River. The text will be revised to state that SWMU 43 is the source of the low concentration of PCE and metals found upgradient. References to an upgradient source will be removed from the text.

Comment 3.

Comment: Continued groundwater monitoring has not been proposed as part of the long-term monitoring of the site, and justification for this approach has not been provided. Several constituents were detected above screening criteria in groundwater, and PCE and arsenic were identified as risk drivers in the human health risk assessment (although arsenic was subsequently found to be within background). Additionally, Figure 2-4, Geologic Cross-Section A-A', appears to show that the groundwater table is in contact with the landfill waste, which will be left in place. Furthermore, several constituents were detected in soil above the soil screening levels (SSLs) for migration to groundwater. Based on these factors, it appears that future groundwater monitoring may be warranted. Revise the RFI to provide justification for not proposing long-term groundwater monitoring at SWMU 43 in light of the above-noted factors, or alternatively, propose a long-term groundwater monitoring program at the site.

Response: Because PCE concentrations in groundwater were well below the MCL, and the risk pathway for groundwater exposure will be eliminated by the implementation of media-specific institutional controls, as agreed to in Response to Comment #1, Long Term Monitoring of the site is not necessary.

Comment 4.

Comment: Page 6-16 of the *Master Work Plan Addendum 19: SWMU 48, SWMU 49, SWMU 50, SWMU 59, SWMU 41, Area O, FLFA, SWMU 43, Area P (Work Plan Addendum 19)*, dated July 2007, stated that "Surface water/sediment in the ditch that bisects the site and in the adjacent New River is potentially impacted by runoff from the landfill or discharge of site groundwater." However, it does not appear that the surface media in the ditch that bisects the site was sampled as part of the 2007 investigation. Although sampling in the ditch was not initially proposed in the EPA-approved Work Plan Addendum 19, revise the RFI to address whether this sampling is now warranted based on the results of the 2007 investigation.

Response: The text will be revised to explain that sediment sampling is not necessary due to the low number of surface soil exceedences within the landfill cells on either side that would be expected to contribute sediment to the ditch. Surface water was not observed in the ditch during our site field work and; therefore, was not collected.

Comment 5.

Comment: While most of the exposure factors used in the human health risk assessment (HHRA) have been appropriately obtained from applicable guidance documents, several exposure factors were used without sufficient justification. Please revise the HHRA to address the following:

- The exposure frequency (EF) selected for a maintenance worker is 50 days a year, based on a best professional judgment that maintenance activities would occur one day a week, with two weeks of vacation a year. To support the use of this EF, please clarify what type(s) of maintenance activities are anticipated (mowing, etc.). Additionally, Section 6.2.1 indicates that part of the site has a gravel parking area, currently used to store office and equipment trailers. Please clarify whether the 50 day/yr EF is sufficiently conservative for workers who may frequent this parking area.

- The EF selected for an excavation worker is 125 days a year, which according to the Appendix E tables, is a value from EPA's 2002 *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24 (SSL Guidance). However, the default EF for a construction worker listed in the SSL Guidance is 250 days/year (Exhibit 5-1). Revise the HHRA to use the default EF of 250 days/year or provide additional justification for using an EF of 125 days/year.

- The ingestion rate of produce was extracted from the 1997 *Exposure Factors Handbook*, Volume I (EPA/600/P-95/002Fa), with the same value (18.6 g/d) being used for both the adult and child receptor. Please note that EPA's *Child-Specific Exposure Factors Handbook*, Final Report, dated 2008, (EPA/600/R-06/096F) includes produce ingestion rates specific to the child receptor. Revise the HHRA to use a child-specific produce ingestion rate.

Response: There are currently no routine activities occurring at SWMU 43. To address occasional exposures due to grounds-keeping activities, such as mowing the grass or maintaining the storage areas, the maintenance worker scenario is based on a worker who visits the site once per week for 50 weeks during the year. These exposure parameters are consistent with the exposure parameters that have been applied at other sites at RFAAP over several years. Text will be added to Section 6.2.1 to further clarify the typical activities assumed for the maintenance worker.

There is no current construction at SWMU 43. Given the size of SWMU 43 (approximately 3 acres) and its location on the river bank, extensive construction would not be expected at this site. Assuming five-day work weeks, the EF of 125 days/year represents a six-month construction period, which would seem reasonable for a site of this size and location. Text will be added to Section 6.2.1 to clarify this assumption. In addition, this EF is consistent with the EF values used for similar sites at RFAAP over several years.

The *Child-Specific Exposure Factors Handbook* will be reviewed to determine whether the child-specific ingestion rate for fruits and vegetables would be more conservative than the values used in the HHRA for SWMU 43. In the event that the ingestion rate is more conservative, the HHRA will be revised accordingly. Conversely, if the ingestion rate for the adult is sufficiently protective of the child, the calculations will not be revised because there would be no change in the conclusions. The potential impacts on the HHRA due to differences between the ingestion rates would then be discussed in the uncertainty section.

Comment 6.

Comment: The RFI report does not sufficiently and fully describe the hydrologic setting at the site. Section 2.5 provides a short description but does not mention the occurrence of the two sampled seeps (43SP-1 and 43SP-2) as surface water, which represents potential groundwater release points. Figure 2-6 also presents 'water features' which appear to be stormwater channels around SWMU 43, even though these features are not discussed in the text. Please revise the RFI to describe the hydrologic connectivity between the groundwater resource, the seeps and the New River, as well as the potential stormwater channels shown in Figure 2-6.

Response: The text will be revised and expanded to explain that the two seeps are ephemeral and are only present during periods of high groundwater flow. Both seeps were dry during field activities and were not sampled. Due to the ephemeral nature of the seeps, they are not a good indication of groundwater quality in the area. With the exception of the large ditch through the between the two landfill cells, the drainage features shown on Figure 2-6 are storm water drainage ditches and are not expected to have an effect on the overall flow regime. During unusually wet periods when groundwater is extremely high, the ditches may act to cut off some flow from further upgradient. The large ditch between the two cells appears to affect the groundwater elevations on the "downstream" side of the ditch. Although the flow paths are primarily towards the New River, there appears to be some "drag" in the direction of flow in the New River. The ditch cuts off this drag effect and on the downstream side, resulting in lower water levels in the wells on that side of the ditch. This information will be added to the text.

Comment 7.

Comment: The RFI report does not follow standard US EPA guidance to present the measurement endpoints. The document provides brief descriptions of what the endpoints should contain, yet does not identify in a clear, concise manner the endpoints chosen for the site.

Please revise Section 7.1.4.2 to more clearly present the measurement endpoints selected for the site. Please refer to these guidance documents:

US Environmental Protection Agency (EPA), 1996. ECO Update: Ecological Significance and Selection of Candidate Assessment Endpoints. Publication 9345.0-11FSI, EPA 540/F-95/037. Volume 3, Number 1. January, 1996.

US Environmental Protection Agency (EPA), 2003. Generic Ecological Risk Assessment Endpoints (GEAEs) for Ecological Risk Assessment, Risk Assessment Forum, Washington DC. EPA/630/P-02/004F http://cfpub.epa.gov/ncea/CFM/recordisplay.cfm?deid=55131

Response: A summary table showing the assessment endpoint, measurement endpoint, receptor, and the type of information provided by the evaluation will be added to *Section 7.1.4.2.*

Comment 8.

Comment: The SLERA conducts an assessment of the potential risk attributable to sediment exposure using groundwater partition models. This is a conservative and appropriate pathway to include in the SLERA in the absence of measured sediment analytical data from the New River. However, the RFI report should accurately describe how this pathway was evaluated earlier on in the text. For example, the fifth paragraph in Section 7.1 (p. 7-1) states that concentrations of chemicals were "measured" in sediment, even though the sediment exposure concentrations were modeled. Please revise the text accordingly.

Response: The text will be revised in Section 7.1 to clarify that sediment was not measured.

Comment 9.

Comment: The SLERA conclusions (Section 7.2.8, second paragraph) indicate that risk to receptors does not exist from food chain exposure, but rather a potential for 'reduction in wildlife food supply'. The statement suggests that a phytotoxic threshold was exceeded, thereby eliminating forage, and limiting food chain exposure. This conclusion does not support earlier statements indicating that the plant community was (qualitatively) similar to other areas. The conclusions in this Section (as well as the Executive Summary and Conclusions sections) should be revised for consistency with earlier statements in the RFI report.

Response: Plants were not quantitatively evaluated in the SLERA as plants as receptors do not typically warrant a detailed examination of effects. Also, an inadequate plant toxicity database exists for many chemicals, and because of the disturbed nature of the site, potential risks to plants are not deemed a reason to recommend further action. The text will be revised to clarify that although there is a potential reduction in wildlife food supply due to exceedance of direct contact screening values, the overall health of the plant community at the site was comparable to the plant communities in the surrounding areas.

Specific Comments

Comment 1.

Comment: Section 2.4, Site Geology, Page 2-4:

Geologic cross-sections were prepared for the site using data collected during installation of monitoring wells and soil borings. However, it appears that boring logs for only the monitoring wells have been included in Appendix B. Boring logs for the ten borings installed in 2007 have not been provided; therefore, the generalizations presented in the geologic cross-sections cannot be verified. Please revise the RFI to include the boring logs for those borings that were installed during the 2007 investigation.

Response: The boring logs will be added to the report. Shallow soil sampling geoprobe samples are not that helpful in x-section

Comment 2.

Comment: Section 2.5, Site Hydrogeology, Page 2-4:

This section does not discuss hydraulic conductivities or anticipated groundwater flow rates for the site. If these data are available for SWMU 43 or other sites in the vicinity, this information should be provided to aid in the understanding of the conceptual site model. Please revise the RFI to include this information.

Response: The text will be revised as requested. Additional information from permeability testing conducted in similar wells (river terrace, set in unconsolidated sediment) in the Horseshoe Area as part of the draft 2005 *Current Conditions Report.*

Comment 3.

Comment: Figures 2-4 and 2-5:

Please add sample depths to the cross sections to provide a better picture of how the landfill was sampled.

Response: The figures will be revised as requested.

Comment 4.

Comment: Figure 2-6, SWMU 43, Potentiometric Surface Map:

Figure 2-6 appears to show a much higher groundwater elevation in the eastern section of the landfill than in the western section. The RFI does not address this observation. Please revise the RFI to address what may be causing the 4-5 foot difference in groundwater elevations between the eastern and western portions of the landfill.

Response: The text will be revised as requested. The text will explain that there is a ditch, which leads to the New River, in between the Eastern and Western sections of the landfill. The groundwater slightly upgradient of the site's ditch is higher in elevation due to the drag from the current in the New River. The ditch cuts off this drag effect and resulting in the lower water levels seen in the downgradient, eastern cell

Comment 5.

Comment: Section 3.1.1:

Figure 3 from the geophysics report showing the interpretation of waste location should be included in this section to compliment Figure 3-2 which depicts the soil sample results.

Response: This figure will be added to the report as Figure 3-3 and the text will be revised to refer to this figure.

Comment 6.

Comment: Table 4-1, Analytes Detected in SWMU 43 Soil Samples – 2007 RFI:

This table identifies the laboratory qualifier "Q" for several of the dioxin results, but the meaning of this qualifier has not been defined in the legend. Please revise Table 4-1 to define the meaning of the "Q" qualifier.

Response: The table's legend will be revised as requested, to define Q.

Comment 7.

Comment: Section 4.1.4, Soil Screening Level Comparison, Page 4-27:

Four total dioxins/furans were detected above their migration to groundwater SSL, and the RFI concludes that "the low frequency of detection suggests that these compounds are not a concern in soil at SWMU 43." While this may be probable for the other chemicals detected above SSLs, dioxins were only analyzed in a small number of samples (six samples) at only two locations. Furthermore, dioxins were not analyzed in groundwater so potential impacts to this medium are unknown. Please revise the RFI to address this apparent data gap. Additionally, revise the RFI to acknowledge the limited number of soil samples that were analyzed for dioxins/furans when discussing frequency of detection.

Response: The text will be revised to explain that dioxins/furans were only detected above residential screening levels in Total dioxins/furans, and not in any individual dioxin/furan congener, and that is why they were not deemed a concern. Dioxins/furans are very strongly sorbed in soils and are therefore unlikely to be detected in groundwater, which is why the groundwater samples were not analyzed for them.

Comment 8.

Comment: Section 6.0, Human Health Risk Assessment (HHRA), Page 6-1:

The first sentence of this section states that the HHRA evaluates potential adverse effects "associated with exposure to site-related chemicals in soil, surface water, sediment, and groundwater." However, sediment samples were not collected at SWMU 43, and are, therefore, not evaluated in the HHRA. Please revise the first sentence of Section 6.0 to remove reference to sediment since this medium was not evaluated at SWMU 43.

Response: The reference to sediment will be deleted from this sentence.

Comment 9.

Comment: Section 6.1.1.3, Surface Water, Page 6-4:

Data from surface water samples collected in 1991 were used for the Chemical of Potential Concern (COPC) screening process. Given the age of the data (18 years old), the HHRA should indicate whether these data were validated, and whether they are considered appropriate for use in a risk assessment. Please revise the HHRA to address these concerns.

Response: The surface water samples were collected in October 1991 and are validated. Although additional samples were proposed to be collected at the previous seep locations for this investigation, the seeps were dry during the field sampling event due to drought conditions. The uncertainty associated with the use of older data is discussed in the uncertainty section (Section 6.5.1).

Comment 10.

Comment: Section 6.1.1.4, Groundwater, Page 6-4:

The HHRA does not clarify whether the metals results in groundwater are representative of the total or dissolved fraction. Please revise the HHRA to indicate whether total or dissolved metals results are used in the HHRA and discuss any associated uncertainties in using these data within the uncertainty analysis.

Response: The metals results represent concentrations of total metals as analyzed in unfiltered groundwater samples. Evaluation of unfiltered data is considered to be conservative and is consistent with Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (USEPA, 1989). Use of these data may be uncertain because several of these samples were turbid due to length of time between sampling events and not representative of water that potential receptors are likely to drink. Text will be added to Section 6.5.1 to acknowledge the potential uncertainties associated with using unfiltered data.

Comment 11.

Comment: Section 6.1.2, Identification of COPCs, Page 6-4:

The third paragraph states, "Analytes for which no screening criteria exist were also selected as COPCs." This approach was followed for some chemicals but not others. It appears that screening criteria for surrogate chemicals may have been used for some chemicals for which screening criteria are not available (i.e., the screening value for pyrene was used for benzo(g,h,i)perylene). This approach is generally acceptable; however, the HHRA should discuss the use of surrogate chemicals in the COPC selection process, and clarify why the selected surrogates are considered appropriate. Please revise Section 6.1.2 to acknowledge the use of surrogates in the COPC selection process and to discuss the structure activity relationship between chemicals lacking toxicity criteria and any identified surrogates.

Response: The surrogates used in this HHRA were consistent with those selected as surrogates in the Virginia Department of Environmental Quality's (VDEQ's) risk assessment guidance (VDEQ, 2009). A brief discussion regarding the use of surrogates for chemicals lacking toxicity values will be briefly discussed in Section 6.1.2.

Comment 12.

Comment: Table 6-2: Summary of Chemicals of Potential Concern at SWMU 43:

Table 6-2 does not include tetrachloroethylene (PCE) even though this chemical was identified as a COPC for groundwater (Appendix E.1, Table E.1-8). Please revise Table 6-2 to identify PCE as a COPC for groundwater.

Response: Table 6-2 will be revised to include PCE as a COPC in groundwater.

Comment 13.

Comment: Section 6.2.1, Conceptual Site Model/Receptor Characterization, Page 6-6:

The sixth paragraph states that "maintenance workers, industrial workers, and excavation workers were evaluated for exposures to surface soil and total soil at SWMU 43." However, only the maintenance worker and industrial worker appear to have been evaluated for exposure to surface soil. The excavation worker was evaluated for exposure to total soil only (Appendix E.1, Tables E.1-48 and E.1-49). Evaluating the excavation worker for exposure to total soil only is appropriate as mixing of soil is expected during excavation activities, however, the HHRA should clearly state this. Please revise Section 6.2.1 to indicate that the excavation worker was evaluated for exposure to total soil only.

Response: The text will be revised to clarify that the excavation worker was evaluated for exposures to total soil only.

Comment 14.

Comment: Section 6.2.1, Conceptual Site Model/Receptor Characterization, Page 6-9:

An adult recreational user of the New River was evaluated for exposure to surface water, but the child recreational user and/or the adolescent recreational user were not evaluated. Sufficient justification for excluding these potential receptors has not been provided. Furthermore, RFAAP previously indicated that off-site adult and child receptors would be evaluated for exposure to groundwater, but again, only the off-site adult recreational user was evaluated (Attachment 9 of the Draft Notes from the RFAAP EPA/VDEQ Partnering Meeting, November 18, 2009, SWMU 43 – Sanitary Landfill No. 2 slide presentation). Please revise the HHRA to evaluate a child and/or adolescent recreational user's exposure to surface water, or provide sufficient justification for excluding these receptors from the evaluation. Additionally, clarify why an off-site child receptor was not evaluated even though this approach was discussed during the November 18, 2009 partnering meeting.

Response: Because the child receptors evaluated in this HHRA are assumed to be six years of age and under, it was considered highly unlikely that children in this age group would be wading or swimming in the New River, due to the depth and current of the river. The adolescent recreational user will be added to the HHRA. Exposure parameters will be obtained from *The Child-Specific Exposure Factors Handbook* (EPA, 2008) or the *Exposure Factors Handbook* (EPA, 1997), as appropriate. This additional scenario is not expected to change the overall conclusions of the HHRA. Because the site is adjacent to the New River and groundwater flow is in that direction, there is no place downgradient for a well. The onsite and offsite groundwater usage would then be identical and the offsite adult and child residential exposure scenario would be identical to the onsite residential scenarios. A note will be added to the text of the onsite residential scenarios to explain why the downgradient receptor is not possible. The recreational users were substituted as the next most likely downgradient receptor. (also see RTC to comment 17 below)

Comment 15.

Comment: Section 6.2.2, Identification of Exposure Pathways, Page 6-9:

An adult recreational user was evaluated in the HHRA, but this potential receptor is not identified in Section 6.2.2. Please revise Section 6.2.2 to identify the adult recreational user as a potential receptor.

Response: The text will be revised in Section 6.2.2 to include the adult recreational user.

Comment 16.

Comment: Section 6.4.2, Background, Page 6-15:

The last sentence indicates that aluminum, arsenic, cobalt, iron, and vanadium contributed to the total soil hazard index (HI) for the child resident, but "these constituents are within background." This section does not mention that manganese also contributed to an HI greater than 1 for the child resident, and, according to Table 6-5, Background Comparison for Total Soil at SWMU 43, manganese concentrations at the site are not consistent with background concentrations. Please revise the HHRA to discuss manganese concentrations in site soils and what impact this may have on the HHRA conclusions.

Response: For the child resident, manganese in soil is shown as a contributor to the HI (Table 6.-3) because the hazard quotients for ingestion (0.32) and dermal absorption (0.22) are above an HI of 0.1. However, the total HI for manganese in total soil is 0.5. The text in Section 6.4.2 will be revised to acknowledge that manganese concentrations in soil are above the background range, but that manganese in soil does not exceed an HI of 1.

Comment 17.

Comment: Section 6.6, HHRA Summary and Conclusions, Page 6-29:

This section states that off-site adult and child residents were evaluated for potential exposures to groundwater, but this scenario does not appear to have been evaluated in the HHRA. Additionally, an off-site adult recreational user was evaluated, but this receptor is not mentioned. Please revise the HHRA to address these discrepancies.

Response: Because it was found that groundwater at SWMU 43 flows toward the New River, off-site residential exposure due to migration of groundwater downgradient of SWMU 43 was no longer a relevant pathway. Recreational users were evaluated as the most likely potential future receptors downgradient of SWMU 43. This explanation will be added to the text. The results for the adult recreational user are presented at the in the last paragraph of Section 6.6. (also see RTC to comment 14 above)

Comment 18.

Comment: Section 7.1.2, Data Organization, Pages 7-6 and 7-7:

This section (and others, such as Section 7.1.8, 'Approach for the Evaluation of Direct Contact Toxicity', Page 7-20) indicates that only surface soil, sediment and surface water data were evaluated in the SLERA. However, Section 7.1 (page 7-1) includes groundwater. Section 7.2.1 (page 7-28) indicates that 'surface soil, surface water and groundwater' samples were used in the SLERA (sediments are not mentioned). Also, the RFI does not define and describe 'surface water' as the seep water linked to the groundwater resource. Please revise Section 7 in the RFI report, where appropriate, to ensure that the types of measured and modeled exposure media evaluated in the SLERA are consistently presented.

Response: The text will be revised where appropriate to clarify how measured (surface soil and surface water) and modeled (sediment) media were evaluated in the SLERA. The hydrologic link between groundwater and surface water will be included and the difference between the modeled (groundwater to New River) and measured (seeps) media will be clarified

Comment 19.

Comment: Section 7.1.3, Identification of Exposure Pathways and Potential Receptors for Analysis, Pages 7-7 and 7-8:

The text in this section describes the exposure pathway component of the conceptual site model. This should include the hydrologic linkage between site groundwater and the seeps considered as surface water exposure points. This information should be consistently described throughout the document and presented in this section in particular for clearer understanding of this potential pathway. Please revise the text accordingly.

Response: Please see the response to Comment 18.

Comment 20.

Comment: Section 7.1.4.2, Measurement Endpoints, Pages 7-14 and 7-15:

This section provides only cursory information on the measurement endpoints, and does not include the 'aquatic receptor' endpoints. Section 7.1.3.2 'Aquatic Receptors' identifies two food chain receptors (the great blue heron and the mink) evaluated in the SLERA, even though these species are omitted from the endpoint process. Please revise this section accordingly to link all of the measurement endpoints to their associated assessment endpoints. This information can best be summarized in table format.

Response: Agreed. Also, please see the response to General Comment 7.

Comment 21.

Comment: Section 7.1.8.2, Surface Water, Page 7-21:

This section (similar to the comment provided for Section 7.1.3) should clarify which receptors are evaluated using the process described in the text. It is apparent that the New River itself was not studied; therefore this approach appears to apply to incidental aquatic receptors that occur in the seep locations. Please revise this section to clearly describe the exposure setting and receptors evaluated using this surface water screening process.

Response: A more detailed description of the evaluation process used for exposure of aquatic receptors to surface water via groundwater seeps will be included in this section and throughout the SLERA.

Comment 22.

Comment: Section 7.1.11 General Uncertainty Analysis, Pages 7-25 to 7-27:

The uncertainty analysis is presented *before* the screening-level risk characterization is complete. It is recommended to combine this section with Section 7.2.7 (Uncertainty Analysis) in order to develop one, comprehensive uncertainty analysis at the end of the SLERA. Table 7-4 (page 7-27) is quite useful and should be further expanded to include other major sources of uncertainty and their impact on the risk evaluation (e.g., using generic direct-contact screening benchmarks, limitations associated with using two old seep samples to assess current surface water quality, assessing aquatic exposures to surface water and sediment in the New River based on modeled exposures). Please consider revising the text accordingly.

Response: Section 7.1.11 is a general uncertainty analysis and applies to the SLERA approach used, and is appropriate in the SLERA Approach section (Section 7.1). Section 7.2.7, on the other hand, includes detailed site-specific and chemical-specific sources of SLERA uncertainty, and is appropriate in Section 7.2. As requested, additional site-specific sources of uncertainty will be added to Section 7.2.7.

Comment 23.

Comment: Table 7-13, Direct Toxicity Evaluation for Surface Soil at SWMU 43:

The maximum concentrations listed for cobalt, copper, iron, lead, mercury, nickel, selenium and zinc do not match the descriptive statistics provided earlier (refer to Table 4-2, Summary of Analytes Detected in SWMU 43 Soil Samples). Please review the data to correct any errors, and verify that the appropriate concentrations are presented as the exposure point concentrations (EPCs).

Response: It will be confirmed that the correct version of Table 7-13 was included in the report. Table 4-2 lists all soil samples (surface and subsurface) for SWMU 43; however, only surface soil samples were evaluated for the SLERA. The maximum soil concentrations for the COPECs listed above were located in deeper soil samples; therefore they do not match the maximum surface soil concentrations presented in Table 7-13.

Comment 24.

Comment: Section 7.2.4.2, Surface Water, Page 7-45:

As previously pointed out in the comments above, this section also presents a confusing interpretation of the surface water setting. This section indicates that 'organisms inhabiting the streams near SWMU 43' would be potentially, adversely affected by (aluminum, barium, and iron). Yet, previous discussions state that no surface water features are associated with SWMU 43 outside of the adjacent New River. Please revise the RFI report to consistently present the surface water setting at and around the site.

Response: See response to Comment 21.

Comment 25.

Comment: Section 8.1, Contaminant Assessment, Page 8-1:

The first sentence of this section states, "The contamination assessment indicated that [volatile organic compounds] VOCs, non [polynuclear aromatic hydrocarbon] PAH [semi-volatile organic compounds] SVOCs, pesticides, herbicides, and metals are not a concern in soil at SWMU 43 since they were not greater than [screening levels] SLs in any soil samples." Metals should not be included in this statement since both arsenic and mercury were detected above SLs in soil samples. Please revise the above-referenced sentence to exclude metals.

Response: The text will be revised as requested.

Comment 26.

Comment: Section 8.5, Conclusion, Page 8-5:

This page indicates that the main drivers of risk/hazard in groundwater are arsenic and PCE. However, manganese should also be recognized as a risk/hazard driver. The HQ for ingestion of manganese in groundwater by a future child resident (2.2) exceeds 1. Additionally, the background assessment determined that manganese concentrations in total soil were not consistent with background. Therefore, manganese should also be recognized as a constituent that is contributing to a cumulative HI greater than 1 for the future child resident.

Response: Agreed. Manganese will be listed as a risk/hazard driver along with arsenic and PCE.

Minor Comments

Comment 1.

Comment: Section 7.1.2,

Methodologies for the Identification of COPECs and Concentration Statistics (Page 7-6): The last sentence in the first paragraph is repeated verbatim in the last sentence of the second paragraph. Please revise this section in order to remove the redundancy.

Response: The redundant text will be revised as requested.

Leahy, Timothy

From:	McKenna, Jim J Mr CIV USA AMC [jim.mckenna@us.army.mil]
Sent:	Monday, May 10, 2010 10:55 AM
To:	Geiger.William@epamail.epa.gov
Cc:	Parks, Jeffrey; jerome.redder@atk.com; jlcutler@deq.virginia.gov; Mendoza, Richard R Mr CIV USA IMCOM; Leahy, Timothy; Meyer, Tom NAB02; Cramer.Mike@epamail.epa.gov; jeremy.flint@atk.com
Subject:	RE: SWMU 43 RFI Comments (UNCLASSIFIED)
Attachments:	RTCs SWMU 43_rev05052010.doc
Importance:	High

Classification: UNCLASSIFIED
Caveats: FOUO <<RTCs SWMU 43_rev05052010.doc>>

Will and everyone, attached are RFAAP responses to the comments.
Thanks, Jim

-----Original Message-----
From: Geiger.William@epamail.epa.gov
[mailto:Geiger.William@epamail.epa.gov]
Sent: Thursday, April 08, 2010 3:35 PM
To: McKenna, Jim J Mr CIV USA AMC
Cc: diane.wisbeck@arcadis-us.com; jim spencer; Parks, Jeffrey N; jerome.redder@atk.com; jlcutler@deq.virginia.gov; Mendoza, Richard R Mr CIV USA IMCOM; Timothy.Leahy@shawgrp.com; Tina_MacGillivray@URSCorp.com; Meyer, Tom NAB02; Cramer.Mike@epamail.epa.gov

Subject: SWMU 43 RFI Comments

Jim, attached are EPA/VDEQ comments for the Nov '09 SWMU 43 RFI Report.

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Classification: UNCLASSIFIED
Caveats: FOUO

Response to EPA Comments on the
Final SWMU 43 RCRA Facility Investigation Report
Radford Army Ammunition Plant (RFAAP), Virginia
November 2009 Final

Comments from Mr. William Geiger, Remediation Project Manager,
United States Environmental Protection Agency Region III,
and Mr. Jim Cutler, Virginia Department of Environmental Quality

General Comments

Comment 1.

Comment: Based on the results of the investigation and subsequent risk evaluations, the RCRA Facility Investigation (RFI) for Solid Waste Management Unit (SWMU) 43 recommends in Section 8.4, Controls, that institutional controls (ICs) be implemented at the site. Specifically, the RFI states that the site will be "incorporated into a plant management manual to ensure long-term protection of human health and the environment. The management manual provides for advance notice, assessment and approval of intrusive work that may occur within the plan with a general digging prohibition at sites such as this" (Page 8-4). Since elevated risks at the site are associated with exposure to contaminated groundwater, implementation of ICs at the site will need to incorporate groundwater use restrictions in addition to the general digging prohibition that is described. Please revise the RFI to incorporate a groundwater use restriction into the IC, and describe the mechanism for its implementation.

Response: The text will be revised as requested, by adding in media-specific restrictions for groundwater in order to prohibit groundwater extraction or usage from the site. An explanation of the mechanism for its implementation will also be added.

Comment 2.

Comment: Tetrachloroethylene (PCE) and/or metals were detected in groundwater above applicable screening criteria in upgradient monitoring wells 43MW1 and 43MW2. The RFI suggests that the constituents detected in these two wells may not be associated with or originate from SWMU 43. However, the RFI does not discuss a potential source of these contaminants. Figure 1-1, SWMU 43, shows several other SWMUs in the vicinity of SWMU 43, but none appear to be south/southeast of the site, in what would be considered upgradient of SWMU 43. Please revise the RFI to identify the probable source of the PCE and metals contaminants detected in the SWMU 43 upgradient wells, and provide an update on any investigations that may be addressing the contamination.

Response: A reanalysis of the groundwater data shows that SWMU 43 is the likely source of these constituents. The single upgradient detection was extremely low and is attributed to dispersion in the groundwater. The upgradient detection is likely due to the relatively low gradient in the flat floodplain terrace adjacent to the New River. The text will be revised to state that SWMU 43 is the source of the low concentration of PCE and metals found upgradient. References to an upgradient source will be removed from the text.

Comment 3.

Comment: Continued groundwater monitoring has not been proposed as part of the long-term monitoring of the site, and justification for this approach has not been provided. Several constituents were detected above screening criteria in groundwater, and PCE and arsenic were identified as risk drivers in the human health risk assessment (although arsenic was subsequently found to be within background). Additionally, Figure 2-4, Geologic Cross-Section A-A', appears to show that the groundwater table is in contact with the landfill waste, which will be left in place. Furthermore, several constituents were detected in soil above the soil screening levels (SSLs) for migration to groundwater. Based on these factors, it appears that future groundwater monitoring may be warranted. Revise the RFI to provide justification for not proposing long-term groundwater monitoring at SWMU 43 in light of the above-noted factors, or alternatively, propose a long-term groundwater monitoring program at the site.

Response: Because PCE concentrations in groundwater were well below the MCL, and the risk pathway for groundwater exposure will be eliminated by the implementation of media-specific institutional controls, as agreed to in Response to Comment #1, Long Term Monitoring of the site is not necessary.

Comment 4.

Comment: Page 6-16 of the *Master Work Plan Addendum 19: SWMU 48, SWMU 49, SWMU 50, SWMU 59, SWMU 41, Area O, FLFA, SWMU 43, Area P (Work Plan Addendum 19)*, dated July 2007, stated that "Surface water/sediment in the ditch that bisects the site and in the adjacent New River is potentially impacted by runoff from the landfill or discharge of site groundwater." However, it does not appear that the surface media in the ditch that bisects the site was sampled as part of the 2007 investigation. Although sampling in the ditch was not initially proposed in the EPA-approved Work Plan Addendum 19, revise the RFI to address whether this sampling is now warranted based on the results of the 2007 investigation.

Response: The text will be revised to explain that sediment sampling is not necessary due to the low number of surface soil exceedences within the landfill cells on either side that would be expected to contribute sediment to the ditch. Surface water was not observed in the ditch during our site field work and; therefore, was not collected.

Comment 5.

Comment: While most of the exposure factors used in the human health risk assessment (HHRA) have been appropriately obtained from applicable guidance documents, several exposure factors were used without sufficient justification. Please revise the HHRA to address the following:

- The exposure frequency (EF) selected for a maintenance worker is 50 days a year, based on a best professional judgment that maintenance activities would occur one day a week, with two weeks of vacation a year. To support the use of this EF, please clarify what type(s) of maintenance activities are anticipated (mowing, etc.). Additionally, Section 6.2.1 indicates that part of the site has a gravel parking area, currently used to store office and equipment trailers. Please clarify whether the 50 day/yr EF is sufficiently conservative for workers who may frequent this parking area.

- The EF selected for an excavation worker is 125 days a year, which according to the Appendix E tables, is a value from EPA's 2002 *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24 (SSL Guidance). However, the default EF for a construction worker listed in the SSL Guidance is 250 days/year (Exhibit 5-1). Revise the HHRA to use the default EF of 250 days/year or provide additional justification for using an EF of 125 days/year.

- The ingestion rate of produce was extracted from the 1997 *Exposure Factors Handbook*, Volume I (EPA/600/P-95/002Fa), with the same value (18.6 g/d) being used for both the adult and child receptor. Please note that EPA's *Child-Specific Exposure Factors Handbook*, Final Report, dated 2008, (EPA/600/R-06/096F) includes produce ingestion rates specific to the child receptor. Revise the HHRA to use a child-specific produce ingestion rate.

Response: There are currently no routine activities occurring at SWMU 43. To address occasional exposures due to grounds-keeping activities, such as mowing the grass or maintaining the storage areas, the maintenance worker scenario is based on a worker who visits the site once per week for 50 weeks during the year. These exposure parameters are consistent with the exposure parameters that have been applied at other sites at RFAAP over several years. Text will be added to Section 6.2.1 to further clarify the typical activities assumed for the maintenance worker.

There is no current construction at SWMU 43. Given the size of SWMU 43 (approximately 3 acres) and its location on the river bank, extensive construction would not be expected at this site. Assuming five-day work weeks, the EF of 125 days/year represents a six-month construction period, which would seem reasonable for a site of this size and location. Text will be added to Section 6.2.1 to clarify this assumption. In addition, this EF is consistent with the EF values used for similar sites at RFAAP over several years.

The *Child-Specific Exposure Factors Handbook* will be reviewed to determine whether the child-specific ingestion rate for fruits and vegetables would be more conservative than the values used in the HHRA for SWMU 43. In the event that the ingestion rate is more conservative, the HHRA will be revised accordingly. Conversely, if the ingestion rate for the adult is sufficiently protective of the child, the calculations will not be revised because there would be no change in the conclusions. The potential impacts on the HHRA due to differences between the ingestion rates would then be discussed in the uncertainty section.

Comment 6.

Comment: The RFI report does not sufficiently and fully describe the hydrologic setting at the site. Section 2.5 provides a short description but does not mention the occurrence of the two sampled seeps (43SP-1 and 43SP-2) as surface water, which represents potential groundwater release points. Figure 2-6 also presents 'water features' which appear to be stormwater channels around SWMU 43, even though these features are not discussed in the text. Please revise the RFI to describe the hydrologic connectivity between the groundwater resource, the seeps and the New River, as well as the potential stormwater channels shown in Figure 2-6.

Response: The text will be revised and expanded to explain that the two seeps are ephemeral and are only present during periods of high groundwater flow. Both seeps were dry during field activities and were not sampled. Due to the ephemeral nature of the seeps, they are not a good indication of groundwater quality in the area. With the exception of the large ditch through the between the two landfill cells, the drainage features shown on Figure 2-6 are storm water drainage ditches and are not expected to have an effect on the overall flow regime. During unusually wet periods when groundwater is extremely high, the ditches may act to cut off some flow from further upgradient. The large ditch between the two cells appears to affect the groundwater elevations on the "downstream" side of the ditch. Although the flow paths are primarily towards the New River, there appears to be some "drag" in the direction of flow in the New River. The ditch cuts off this drag effect and on the downstream side, resulting in lower water levels in the wells on that side of the ditch. This information will be added to the text.

Comment 7.

Comment: The RFI report does not follow standard US EPA guidance to present the measurement endpoints. The document provides brief descriptions of what the endpoints should contain, yet does not identify in a clear, concise manner the endpoints chosen for the site.

Please revise Section 7.1.4.2 to more clearly present the measurement endpoints selected for the site. Please refer to these guidance documents:

US Environmental Protection Agency (EPA), 1996. ECO Update: Ecological Significance and Selection of Candidate Assessment Endpoints. Publication 9345.0-11FSI, EPA 540/F-95/037. Volume 3, Number 1. January, 1996.

US Environmental Protection Agency (EPA), 2003. Generic Ecological Risk Assessment Endpoints (GEAEs) for Ecological Risk Assessment, Risk Assessment Forum, Washington DC. EPA/630/P-02/004F http://cfpub.epa.gov/ncea/CFM/recordisplay.cfm?deid=55131

Response: A summary table showing the assessment endpoint, measurement endpoint, receptor, and the type of information provided by the evaluation will be added to *Section 7.1.4.2.*

Comment 8.

Comment: The SLERA conducts an assessment of the potential risk attributable to sediment exposure using groundwater partition models. This is a conservative and appropriate pathway to include in the SLERA in the absence of measured sediment analytical data from the New River. However, the RFI report should accurately describe how this pathway was evaluated earlier on in the text. For example, the fifth paragraph in Section 7.1 (p. 7-1) states that concentrations of chemicals were "measured" in sediment, even though the sediment exposure concentrations were modeled. Please revise the text accordingly.

Response: The text will be revised in Section 7.1 to clarify that sediment was not measured.

Comment 9.

Comment: The SLERA conclusions (Section 7.2.8, second paragraph) indicate that risk to receptors does not exist from food chain exposure, but rather a potential for 'reduction in wildlife food supply'. The statement suggests that a phytotoxic threshold was exceeded, thereby eliminating forage, and limiting food chain exposure. This conclusion does not support earlier statements indicating that the plant community was (qualitatively) similar to other areas. The conclusions in this Section (as well as the Executive Summary and Conclusions sections) should be revised for consistency with earlier statements in the RFI report.

Response: Plants were not quantitatively evaluated in the SLERA as plants as receptors do not typically warrant a detailed examination of effects. Also, an inadequate plant toxicity database exists for many chemicals, and because of the disturbed nature of the site, potential risks to plants are not deemed a reason to recommend further action. The text will be revised to clarify that although there is a potential reduction in wildlife food supply due to exceedance of direct contact screening values, the overall health of the plant community at the site was comparable to the plant communities in the surrounding areas.

Specific Comments

Comment 1.

Comment: Section 2.4, Site Geology, Page 2-4:

Geologic cross-sections were prepared for the site using data collected during installation of monitoring wells and soil borings. However, it appears that boring logs for only the monitoring wells have been included in Appendix B. Boring logs for the ten borings installed in 2007 have not been provided; therefore, the generalizations presented in the geologic cross-sections cannot be verified. Please revise the RFI to include the boring logs for those borings that were installed during the 2007 investigation.

Response: The boring logs will be added to the report. Shallow soil sampling geoprobe samples are not that helpful in x-section

Comment 2.

Comment: Section 2.5, Site Hydrogeology, Page 2-4:

This section does not discuss hydraulic conductivities or anticipated groundwater flow rates for the site. If these data are available for SWMU 43 or other sites in the vicinity, this information should be provided to aid in the understanding of the conceptual site model. Please revise the RFI to include this information.

Response: The text will be revised as requested. Additional information from permeability testing conducted in similar wells (river terrace, set in unconsolidated sediment) in the Horseshoe Area as part of the draft 2005 *Current Conditions Report.*

Comment 3.

Comment: Figures 2-4 and 2-5:

Please add sample depths to the cross sections to provide a better picture of how the landfill was sampled.

Response: The figures will be revised as requested.

Comment 4.

Comment: Figure 2-6, SWMU 43, Potentiometric Surface Map:

Figure 2-6 appears to show a much higher groundwater elevation in the eastern section of the landfill than in the western section. The RFI does not address this observation. Please revise the RFI to address what may be causing the 4-5 foot difference in groundwater elevations between the eastern and western portions of the landfill.

Response: The text will be revised as requested. The text will explain that there is a ditch, which leads to the New River, in between the Eastern and Western sections of the landfill. The groundwater slightly upgradient of the site's ditch is higher in elevation due to the drag from the current in the New River. The ditch cuts off this drag effect and resulting in the lower water levels seen in the downgradient, eastern cell

Comment 5.

Comment: Section 3.1.1**:**

Figure 3 from the geophysics report showing the interpretation of waste location should be included in this section to compliment Figure 3-2 which depicts the soil sample results.

Response: This figure will be added to the report as Figure 3-3 and the text will be revised to refer to this figure.

Comment 6.

Comment: Table 4-1, Analytes Detected in SWMU 43 Soil Samples – 2007 RFI:

This table identifies the laboratory qualifier "Q" for several of the dioxin results, but the meaning of this qualifier has not been defined in the legend. Please revise Table 4-1 to define the meaning of the "Q" qualifier.

Response: The table's legend will be revised as requested, to define Q.

Comment 7.

Comment: Section 4.1.4, Soil Screening Level Comparison, Page 4-27:

Four total dioxins/furans were detected above their migration to groundwater SSL, and the RFI concludes that "the low frequency of detection suggests that these compounds are not a concern in soil at SWMU 43." While this may be probable for the other chemicals detected above SSLs, dioxins were only analyzed in a small number of samples (six samples) at only two locations. Furthermore, dioxins were not analyzed in groundwater so potential impacts to this medium are unknown. Please revise the RFI to address this apparent data gap. Additionally, revise the RFI to acknowledge the limited number of soil samples that were analyzed for dioxins/furans when discussing frequency of detection.

Response: The text will be revised to explain that dioxins/furans were only detected above residential screening levels in Total dioxins/furans, and not in any individual dioxin/furan congener, and that is why they were not deemed a concern. Dioxins/furans are very strongly sorbed in soils and are therefore unlikely to be detected in groundwater, which is why the groundwater samples were not analyzed for them.

Comment 8.

Comment: Section 6.0, Human Health Risk Assessment (HHRA), Page 6-1:

The first sentence of this section states that the HHRA evaluates potential adverse effects "associated with exposure to site-related chemicals in soil, surface water, sediment, and groundwater." However, sediment samples were not collected at SWMU 43, and are, therefore, not evaluated in the HHRA. Please revise the first sentence of Section 6.0 to remove reference to sediment since this medium was not evaluated at SWMU 43.

Response: The reference to sediment will be deleted from this sentence.

Comment 9.

Comment: Section 6.1.1.3, Surface Water, Page 6-4:

Data from surface water samples collected in 1991 were used for the Chemical of Potential Concern (COPC) screening process. Given the age of the data (18 years old), the HHRA should indicate whether these data were validated, and whether they are considered appropriate for use in a risk assessment. Please revise the HHRA to address these concerns.

Response: The surface water samples were collected in October 1991 and are validated. Although additional samples were proposed to be collected at the previous seep locations for this investigation, the seeps were dry during the field sampling event due to drought conditions. The uncertainty associated with the use of older data is discussed in the uncertainty section (Section 6.5.1).

Comment 10.

Comment: Section 6.1.1.4, Groundwater, Page 6-4:

The HHRA does not clarify whether the metals results in groundwater are representative of the total or dissolved fraction. Please revise the HHRA to indicate whether total or dissolved metals results are used in the HHRA and discuss any associated uncertainties in using these data within the uncertainty analysis.

Response: The metals results represent concentrations of total metals as analyzed in unfiltered groundwater samples. Evaluation of unfiltered data is considered to be conservative and is consistent with Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (USEPA, 1989). Use of these data may be uncertain because several of these samples were turbid due to length of time between sampling events and not representative of water that potential receptors are likely to drink. Text will be added to Section 6.5.1 to acknowledge the potential uncertainties associated with using unfiltered data.

Comment 11.

Comment: Section 6.1.2, Identification of COPCs, Page 6-4:

The third paragraph states, "Analytes for which no screening criteria exist were also selected as COPCs." This approach was followed for some chemicals but not others. It appears that screening criteria for surrogate chemicals may have been used for some chemicals for which screening criteria are not available (i.e., the screening value for pyrene was used for benzo(g,h,i)perylene). This approach is generally acceptable; however, the HHRA should discuss the use of surrogate chemicals in the COPC selection process, and clarify why the selected surrogates are considered appropriate. Please revise Section 6.1.2 to acknowledge the use of surrogates in the COPC selection process and to discuss the structure activity relationship between chemicals lacking toxicity criteria and any identified surrogates.

Response: The surrogates used in this HHRA were consistent with those selected as surrogates in the Virginia Department of Environmental Quality's (VDEQ's) risk assessment guidance (VDEQ, 2009). A brief discussion regarding the use of surrogates for chemicals lacking toxicity values will be briefly discussed in Section 6.1.2.

Comment 12.

Comment: Table 6-2: Summary of Chemicals of Potential Concern at SWMU 43:

Table 6-2 does not include tetrachloroethylene (PCE) even though this chemical was identified as a COPC for groundwater (Appendix E.1, Table E.1-8). Please revise Table 6-2 to identify PCE as a COPC for groundwater.

Response: Table 6-2 will be revised to include PCE as a COPC in groundwater.

Comment 13.

Comment: Section 6.2.1, Conceptual Site Model/Receptor Characterization, Page 6-6:

The sixth paragraph states that "maintenance workers, industrial workers, and excavation workers were evaluated for exposures to surface soil and total soil at SWMU 43." However, only the maintenance worker and industrial worker appear to have been evaluated for exposure to surface soil. The excavation worker was evaluated for exposure to total soil only (Appendix E.1, Tables E.1-48 and E.1-49). Evaluating the excavation worker for exposure to total soil only is appropriate as mixing of soil is expected during excavation activities, however, the HHRA should clearly state this. Please revise Section 6.2.1 to indicate that the excavation worker was evaluated for exposure to total soil only.

Response: The text will be revised to clarify that the excavation worker was evaluated for exposures to total soil only.

Comment 14.

Comment: Section 6.2.1, Conceptual Site Model/Receptor Characterization, Page 6-9:

An adult recreational user of the New River was evaluated for exposure to surface water, but the child recreational user and/or the adolescent recreational user were not evaluated. Sufficient justification for excluding these potential receptors has not been provided. Furthermore, RFAAP previously indicated that off-site adult and child receptors would be evaluated for exposure to groundwater, but again, only the off-site adult recreational user was evaluated (Attachment 9 of the Draft Notes from the RFAAP EPA/VDEQ Partnering Meeting, November 18, 2009, SWMU 43 – Sanitary Landfill No. 2 slide presentation). Please revise the HHRA to evaluate a child and/or adolescent recreational user's exposure to surface water, or provide sufficient justification for excluding these receptors from the evaluation. Additionally, clarify why an off-site child receptor was not evaluated even though this approach was discussed during the November 18, 2009 partnering meeting.

Response: Because the child receptors evaluated in this HHRA are assumed to be six years of age and under, it was considered highly unlikely that children in this age group would be wading or swimming in the New River, due to the depth and current of the river. The adolescent recreational user will be added to the HHRA. Exposure parameters will be obtained from *The Child-Specific Exposure Factors Handbook* (EPA, 2008) or the *Exposure Factors Handbook* (EPA, 1997), as appropriate. This additional scenario is not expected to change the overall conclusions of the HHRA. Because the site is adjacent to the New River and groundwater flow is in that direction, there is no place downgradient for a well. The onsite and offsite groundwater usage would then be identical and the offsite adult and child residential exposure scenario would be identical to the onsite residential scenarios. A note will be added to the text of the onsite residential scenarios to explain why the downgradient receptor is not possible. The recreational users were substituted as the next most likely downgradient receptor. (also see RTC to comment 17 below)

Comment 15.

Comment: Section 6.2.2, Identification of Exposure Pathways, Page 6-9:

An adult recreational user was evaluated in the HHRA, but this potential receptor is not identified in Section 6.2.2. Please revise Section 6.2.2 to identify the adult recreational user as a potential receptor.

Response: The text will be revised in Section 6.2.2 to include the adult recreational user.

Comment 16.

Comment: Section 6.4.2, Background, Page 6-15**:**

The last sentence indicates that aluminum, arsenic, cobalt, iron, and vanadium contributed to the total soil hazard index (HI) for the child resident, but "these constituents are within background." This section does not mention that manganese also contributed to an HI greater than 1 for the child resident, and, according to Table 6-5, Background Comparison for Total Soil at SWMU 43, manganese concentrations at the site are not consistent with background concentrations. Please revise the HHRA to discuss manganese concentrations in site soils and what impact this may have on the HHRA conclusions.

Response: For the child resident, manganese in soil is shown as a contributor to the HI (Table 6.-3) because the hazard quotients for ingestion (0.32) and dermal absorption (0.22) are above an HI of 0.1. However, the total HI for manganese in total soil is 0.5. The text in Section 6.4.2 will be revised to acknowledge that manganese concentrations in soil are above the background range, but that manganese in soil does not exceed an HI of 1.

Comment 17.

Comment: Section 6.6, HHRA Summary and Conclusions, Page 6-29:

This section states that off-site adult and child residents were evaluated for potential exposures to groundwater, but this scenario does not appear to have been evaluated in the HHRA. Additionally, an off-site adult recreational user was evaluated, but this receptor is not mentioned. Please revise the HHRA to address these discrepancies.

Response: Because it was found that groundwater at SWMU 43 flows toward the New River, off-site residential exposure due to migration of groundwater downgradient of SWMU 43 was no longer a relevant pathway. Recreational users were evaluated as the most likely potential future receptors downgradient of SWMU 43. This explanation will be added to the text. The results for the adult recreational user are presented at the in the last paragraph of Section 6.6. (also see RTC to comment 14 above)

Comment 18.

Comment: Section 7.1.2, Data Organization, Pages 7-6 and 7-7:

This section (and others, such as Section 7.1.8, 'Approach for the Evaluation of Direct Contact Toxicity', Page 7-20) indicates that only surface soil, sediment and surface water data were evaluated in the SLERA. However, Section 7.1 (page 7-1) includes groundwater. Section 7.2.1 (page 7-28) indicates that 'surface soil, surface water and groundwater' samples were used in the SLERA (sediments are not mentioned). Also, the RFI does not define and describe 'surface water' as the seep water linked to the groundwater resource. Please revise Section 7 in the RFI report, where appropriate, to ensure that the types of measured and modeled exposure media evaluated in the SLERA are consistently presented.

Response: The text will be revised where appropriate to clarify how measured (surface soil and surface water) and modeled (sediment) media were evaluated in the SLERA. The hydrologic link between groundwater and surface water will be included and the difference between the modeled (groundwater to New River) and measured (seeps) media will be clarified

Comment 19.

Comment: Section 7.1.3, Identification of Exposure Pathways and Potential Receptors for Analysis, Pages 7-7 and 7-8:

The text in this section describes the exposure pathway component of the conceptual site model. This should include the hydrologic linkage between site groundwater and the seeps considered as surface water exposure points. This information should be consistently described throughout the document and presented in this section in particular for clearer understanding of this potential pathway. Please revise the text accordingly.

Response: Please see the response to Comment 18.

Comment 20.

Comment: Section 7.1.4.2, Measurement Endpoints, Pages 7-14 and 7-15:

This section provides only cursory information on the measurement endpoints, and does not include the 'aquatic receptor' endpoints. Section 7.1.3.2 'Aquatic Receptors' identifies two food chain receptors (the great blue heron and the mink) evaluated in the SLERA, even though these species are omitted from the endpoint process. Please revise this section accordingly to link all of the measurement endpoints to their associated assessment endpoints. This information can best be summarized in table format.

Response: Agreed. Also, please see the response to General Comment 7.

Comment 21.

Comment: Section 7.1.8.2, Surface Water, Page 7-21:

This section (similar to the comment provided for Section 7.1.3) should clarify which receptors are evaluated using the process described in the text. It is apparent that the New River itself was not studied; therefore this approach appears to apply to incidental aquatic receptors that occur in the seep locations. Please revise this section to clearly describe the exposure setting and receptors evaluated using this surface water screening process.

Response: A more detailed description of the evaluation process used for exposure of aquatic receptors to surface water via groundwater seeps will be included in this section and throughout the SLERA.

Comment 22.

Comment: Section 7.1.11 General Uncertainty Analysis, Pages 7-25 to 7-27:

The uncertainty analysis is presented *before* the screening-level risk characterization is complete. It is recommended to combine this section with Section 7.2.7 (Uncertainty Analysis) in order to develop one, comprehensive uncertainty analysis at the end of the SLERA. Table 7-4 (page 7-27) is quite useful and should be further expanded to include other major sources of uncertainty and their impact on the risk evaluation (e.g., using generic direct-contact screening benchmarks, limitations associated with using two old seep samples to assess current surface water quality, assessing aquatic exposures to surface water and sediment in the New River based on modeled exposures). Please consider revising the text accordingly.

Response: Section 7.1.11 is a general uncertainty analysis and applies to the SLERA approach used, and is appropriate in the SLERA Approach section (Section 7.1). Section 7.2.7, on the other hand, includes detailed site-specific and chemical-specific sources of SLERA uncertainty, and is appropriate in Section 7.2. As requested, additional site-specific sources of uncertainty will be added to Section 7.2.7.

Comment 23.

Comment: Table 7-13, Direct Toxicity Evaluation for Surface Soil at SWMU 43:

The maximum concentrations listed for cobalt, copper, iron, lead, mercury, nickel, selenium and zinc do not match the descriptive statistics provided earlier (refer to Table 4-2, Summary of Analytes Detected in SWMU 43 Soil Samples). Please review the data to correct any errors, and verify that the appropriate concentrations are presented as the exposure point concentrations (EPCs).

Response: It will be confirmed that the correct version of Table 7-13 was included in the report. Table 4-2 lists all soil samples (surface and subsurface) for SWMU 43; however, only surface soil samples were evaluated for the SLERA. The maximum soil concentrations for the COPECs listed above were located in deeper soil samples; therefore they do not match the maximum surface soil concentrations presented in Table 7-13.

Comment 24.

Comment: Section 7.2.4.2, Surface Water, Page 7-45:

As previously pointed out in the comments above, this section also presents a confusing interpretation of the surface water setting. This section indicates that 'organisms inhabiting the streams near SWMU 43' would be potentially, adversely affected by (aluminum, barium, and iron). Yet, previous discussions state that no surface water features are associated with SWMU 43 outside of the adjacent New River. Please revise the RFI report to consistently present the surface water setting at and around the site.

Response: See response to Comment 21.

Comment 25.

Comment: Section 8.1, Contaminant Assessment, Page 8-1:

The first sentence of this section states, "The contamination assessment indicated that [volatile organic compounds] VOCs, non [polynuclear aromatic hydrocarbon] PAH [semi-volatile organic compounds] SVOCs, pesticides, herbicides, and metals are not a concern in soil at SWMU 43 since they were not greater than [screening levels] SLs in any soil samples." Metals should not be included in this statement since both arsenic and mercury were detected above SLs in soil samples. Please revise the above-referenced sentence to exclude metals.

Response: The text will be revised as requested.

Comment 26.

Comment: Section 8.5, Conclusion, Page 8-5:

This page indicates that the main drivers of risk/hazard in groundwater are arsenic and PCE. However, manganese should also be recognized as a risk/hazard driver. The HQ for ingestion of manganese in groundwater by a future child resident (2.2) exceeds 1. Additionally, the background assessment determined that manganese concentrations in total soil were not consistent with background. Therefore, manganese should also be recognized as a constituent that is contributing to a cumulative HI greater than 1 for the future child resident.

Response: Agreed. Manganese will be listed as a risk/hazard driver along with arsenic and PCE.

Minor Comments

Comment 1.

Comment: Section 7.1.2,

Methodologies for the Identification of COPECs and Concentration Statistics (Page 7-6): The last sentence in the first paragraph is repeated verbatim in the last sentence of the second paragraph. Please revise this section in order to remove the redundancy.

Response: The redundant text will be revised as requested.

From:	Druck, Dennis E Mr CIV USA MEDCOM PHC [dennis.druck@us.army.mil]
Sent:	Monday, May 10, 2010 10:30 AM
To:	Meyer, Tom NAB02; McKenna, Jim J Mr CIV USA AMC; Mendoza, Richard R Mr CIV USA IMCOM; Leahy, Timothy
Cc:	Parks, Jeffrey
Subject:	RE: SWMU 43 Response to EPA/VDEQ comments (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: FOUO

OK for me. Dennis

-----Original Message-----
From: Meyer, Tom NAB02 [mailto:Tom.Meyer@usace.army.mil]
Sent: Monday, May 10, 2010 10:25 AM
To: McKenna, Jim J Mr CIV USA AMC; Mendoza, Richard R Mr CIV USA IMCOM; Leahy, Timothy
Cc: Parks, Jeffrey; Druck, Dennis E Mr CIV USA MEDCOM PHC
Subject: RE: SWMU 43 Response to EPA/VDEQ comments (UNCLASSIFIED)

Ive talked to Tim this morning so were done..

Thanks TOM
410-962-0032

-----Original Message-----
From: McKenna, Jim J Mr CIV USA AMC [mailto:jim.mckenna@us.army.mil]
Sent: Monday, May 10, 2010 10:20 AM
To: Mendoza, Richard R Mr CIV USA IMCOM; Leahy, Timothy; Meyer, Tom
NAB02
Cc: Parks, Jeffrey; Druck, Dennis E Mr CIV USA MEDCOM PHC
Subject: RE: SWMU 43 Response to EPA/VDEQ comments

Still waiting to hear from Dennis and Tom.

-----Original Message-----
From: Mendoza, Richard R Mr CIV USA IMCOM
Sent: Friday, May 07, 2010 2:30 PM
To: Leahy, Timothy; McKenna, Jim J Mr CIV USA AMC; Meyer, Tom NAB02
Cc: Parks, Jeffrey; Druck, Dennis E Mr CIV USA MEDCOM PHC
Subject: RE: SWMU 43 Response to EPA/VDEQ comments

Not I. thanks and have a good weekend

Rich Mendoza
Army Environmental Command-RIA
Restoration Manager
309-782-1871

-----Original Message-----
From: Leahy, Timothy [mailto:Timothy.Leahy@shawgrp.com]
Sent: Wednesday, May 05, 2010 9:12 AM
To: McKenna, Jim J Mr CIV USA AMC; Meyer, Tom NAB02; Mendoza, Richard R Mr CIV USA IMCOM

Cc: Parks, Jeffrey; Druck, Dennis E Mr CIV USA MEDCOM PHC
Subject: RE: SWMU 43 Response to EPA/VDEQ comments

All,

Please find attached the revised Response to Comments for the SWMU 43 RFI. We changed RTC 26 based on Dennis's suggestion about manganese and added some clarification to RTC 18 about what was modeled (groundwater / surface water in the New River) and what was measured (seeps). Does anyone else have any questions or comments?

Thanks,

Tim

From: Leahy, Timothy
Sent: Monday, April 26, 2010 4:52 PM
To: McKenna, Jim J Mr CIV USA AMC; Meyer, Tom NAB02; Mendoza, Richard R Mr CIV USA IMCOM
Cc: Parks, Jeffrey; Sims, Robin E
Subject: SWMU 43 Response to EPA/VDEQ comments

Jim/Tom/Rich-

Here are the response to comments for the SWMU 43 RFI. I apologize for the delay -we were waiting for a few HHRA responses. Let me know if you have any questions or comments.

Thanks,

Tim

Timothy Leahy, PMP

Project Manager

Shaw Environmental, Inc

2113 Emmorton Park Road

Edgewood, MD 21040

(410) 612-6332 (phone)

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www.Shawgrp.com

Classification: UNCLASSIFIED
Caveats: FOUO

Classification: UNCLASSIFIED
Caveats: FOUO

Classification: UNCLASSIFIED
Caveats: FOUO

Leahy, Timothy

From:	Geiger.William@epamail.epa.gov
Sent:	Thursday, April 08, 2010 3:35 PM
To:	McKenna, Jim J Mr CIV USA AMC
Cc:	diane.wisbeck@arcadis-us.com; jim spencer; Parks, Jeffrey; jerome.redder@atk.com; jlcutler@deq.virginia.gov; Mendoza, Richard R Mr CIV USA IMCOM; Leahy, Timothy; Tina_MacGillivray@URSCorp.com; Meyer, Tom NAB02; Cramer.Mike@epamail.epa.gov
Subject:	SWMU 43 RFI Comments
Attachments:	SWMU43 RFI comments.doc

Jim, attached are EPA/VDEQ comments for the Nov '09 SWMU 43 RFI Report.

William A. Geiger
Remedial Project Manager
Office of Remediation (3LC20)
U.S. Environmental Protection Agency
1650 Arch Street
Philadelphia, PA 19103-2029
Phone: 215.814.3413
Geiger.William@epa.gov

4/8/10
Presented below are EPA/VDEQ comments on the *Final SWMU 43 RCRA Facility Investigation Report* for the Radford Army Ammunition Plant (RFAAP) located in Radford, Virginia, dated November 2009 (hereinafter referred to as the RFI).

GENERAL COMMENTS

1. Based on the results of the investigation and subsequent risk evaluations, the RCRA Facility Investigation (RFI) for Solid Waste Management Unit (SWMU) 43 recommends in Section 8.4, Controls, that institutional controls (ICs) be implemented at the site. Specifically, the RFI states that the site will be "incorporated into a plant management manual to ensure long-term protection of human health and the environment. The management manual provides for advance notice, assessment and approval of intrusive work that may occur within the plan with a general digging prohibition at sites such as this" (Page 8-4). Since elevated risks at the site are associated with exposure to contaminated groundwater, implementation of ICs at the site will need to incorporate groundwater use restrictions in addition to the general digging prohibition that is described. Please revise the RFI to incorporate a groundwater use restriction into the IC, and describe the mechanism for its implementation.

2. Tetrachloroethylene (PCE) and/or metals were detected in groundwater above applicable screening criteria in upgradient monitoring wells 43MW1 and 43MW2. The RFI suggests that the constituents detected in these two wells may not be associated with or originate from SWMU 43. However, the RFI does not discuss a potential source of these contaminants. Figure 1-1, SWMU 43, shows several other SWMUs in the vicinity of SWMU 43, but none appear to be south/southeast of the site, in what would be considered upgradient of SWMU 43. Please revise the RFI to identify the probable source of the PCE and metals contaminants detected in the SWMU 43 upgradient wells, and provide an update on any investigations that may be addressing the contamination.

3. Continued groundwater monitoring has not been proposed as part of the long-term monitoring of the site, and justification for this approach has not been provided. Several constituents were detected above screening criteria in groundwater, and PCE and arsenic were identified as risk drivers in the human health risk assessment (although arsenic was subsequently found to be within background). Additionally, Figure 2-4, Geologic Cross-Section A-A', appears to show that the groundwater table is in contact with the landfill waste, which will be left in place. Furthermore, several constituents were detected in soil above the soil screening levels (SSLs) for migration to groundwater. Based on these factors, it appears that future groundwater monitoring may be warranted. Revise the RFI to provide justification for not proposing long-term groundwater monitoring at SWMU 43 in light of the above-noted factors, or alternatively, propose a long-term groundwater monitoring program at the site.

4. Page 6-16 of the *Master Work Plan Addendum 19: SWMU 48, SWMU 49, SWMU 50, SWMU 59, SWMU 41, Area O, FLFA, SWMU 43, Area P (Work Plan Addendum 19)*, dated July 2007, stated that "Surface water/sediment in the ditch that bisects the site and in the adjacent New River is potentially impacted by runoff from the landfill or discharge of site groundwater." However, it does not appear that the surface media in the ditch that bisects the site was sampled as part of the 2007 investigation. Although sampling in the ditch was not initially proposed in the EPA-approved Work Plan Addendum 19, revise the RFI to address whether this sampling is now warranted based on the results of the 2007 investigation.

5. While most of the exposure factors used in the human health risk assessment (HHRA) have been appropriately obtained from applicable guidance documents, several exposure factors were used without sufficient justification. Please revise the HHRA to address the following:

   - The exposure frequency (EF) selected for a maintenance worker is 50 days a year, based on a best professional judgment that maintenance activities would occur one day a week, with two weeks of vacation a year. To support the use of this EF, please clarify what type(s) of maintenance activities are anticipated (mowing, etc.). Additionally, Section 6.2.1 indicates that part of the site has a gravel parking area, currently used to store office and equipment trailers. Please clarify whether the 50 day/yr EF is sufficiently conservative for workers who may frequent this parking area.

   - The EF selected for an excavation worker is 125 days a year, which according to the Appendix E tables, is a value from EPA's 2002 *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24 (SSL Guidance). However, the default EF for a construction worker listed in the SSL Guidance is 250 days/year (Exhibit 5-1). Revise the HHRA to use the default EF of 250 days/year or provide additional justification for using an EF of 125 days/year.

   - The ingestion rate of produce was extracted from the 1997 *Exposure Factors Handbook*, Volume I (EPA/600/P-95/002Fa), with the same value (18.6 g/d) being used for both the adult and child receptor. Please note that EPA's *Child-Specific Exposure Factors Handbook,* Final Report, dated 2008, (EPA/600/R-06/096F) includes produce ingestion rates specific to the child receptor. Revise the HHRA to use a child-specific produce ingestion rate.

6. The RFI report does not sufficiently and fully describe the hydrologic setting at the site. Section 2.5 provides a short description but does not mention the occurrence of the two sampled seeps (43SP-1 and 43SP-2) as surface water,

which represent potential groundwater release points. Figure 2-6 also presents ‘water features’ which appear to be stormwater channels around SWMU 43, even though these features are not discussed in the text. Please revise the RFI to describe the hydrologic connectivity between the groundwater resource, the seeps and the New River, as well as the potential stormwater channels shown in Figure 2-6.

7. The RFI report does not follow standard US EPA guidance to present the measurement endpoints. The document provides brief descriptions of what the endpoints should contain, yet does not identify in a clear, concise manner the endpoints chosen for the site. Please revise Section 7.1.4.2 to more clearly present the measurement endpoints selected for the site. Pleas refer to these guidance documents:

US Environmental Protection Agency (EPA), 1996. ECO Update: Ecological Significance and Selection of Candidate Assessment Endpoints. Publication 9345.0-11FSI, EPA 540/F-95/037. Volume 3, Number 1. January, 1996.

US Environmental Protection Agency (EPA), 2003. Generic Ecological Risk Assessment Endpoints (GEAEs) for Ecological Risk Assessment, Risk Assessment Forum, Washington DC. EPA/630/P-02/004F
http://cfpub.epa.gov/ncea/CFM/recordisplay.cfm?deid=55131

8. The SLERA conducts an assessment of the potential risk attributable to sediment exposure using groundwater partition models. This is a conservative and appropriate pathway to include in the SLERA in the absence of measured sediment analytical data from the New River. However, the RFI report should accurately describe how this pathway was evaluated earlier on in the text. For example, the fifth paragraph in Section 7.1 (p. 7-1) states that concentrations of chemicals were “measured” in sediment, even though the sediment exposure concentrations were modeled. Please revise the text accordingly.

9. The SLERA conclusions (Section 7.2.8, second paragraph) indicate that risk to receptors does not exist from food chain exposure, but rather a potential for ‘reduction in wildlife food supply’. The statement suggests that a phytotoxic threshold was exceeded, thereby eliminating forage, and limiting food chain exposure. This conclusion does not support earlier statements indicating that the plant community was (qualitatively) similar to other areas. The conclusions in this Section (as well as the Executive Summary and Conclusions sections) should be revised for consistency with earlier statements in the RFI report.

SPECIFIC COMMENTS

10. **Section 2.4, Site Geology, Page 2-4:** Geologic cross-sections were prepared for the site using data collected during installation of monitoring wells and soil borings. However, it appears that boring logs for only the monitoring wells have

been included in Appendix B. Boring logs for the ten borings installed in 2007 have not been provided; therefore, the generalizations presented in the geologic cross-sections cannot be verified. Please revise the RFI to include the boring logs for those borings that were installed during the 2007 investigation.

11. **Section 2.5, Site Hydrogeology, Page 2-4:** This section does not discuss hydraulic conductivities or anticipated groundwater flow rates for the site. If these data are available for SWMU 43 or other sites in the vicinity, this information should be provided to aid in the understanding of the conceptual site model. Please revise the RFI to include this information.

12. **Figures 2-4 and 2-5:** Please add sample depths to the cross sections to provide a better picture of how the landfill was sampled.

13. **Figure 2-6, SWMU 43, Potentiometric Surface Map:** Figure 2-6 appears to show a much higher groundwater elevation in the eastern section of the landfill than in the western section. The RFI does not address this observation. Please revise the RFI to address what may be causing the 4-5 foot difference in groundwater elevations between the eastern and western portions of the landfill.

14. **Section 3.1.1**: Figure 3 from the geophysics report showing the interpretation of waste location should be included in this section to compliment Figure 3-2 which depicts the soil sample results.

15. **Table 4-1, Analytes Detected in SWMU 43 Soil Samples – 2007 RFI:** This table identifies the laboratory qualifier “Q” for several of the dioxin results, but the meaning of this qualifier has not been defined in the legend. Please revise Table 4-1 to define the meaning of the “Q” qualifier.

16. **Section 4.1.4, Soil Screening Level Comparison, Page 4-27:** Four total dioxins/furans were detected above their migration to groundwater SSL, and the RFI concludes that “the low frequency of detection suggests that these compounds are not a concern in soil at SWMU 43.” While this may be probable for the other chemicals detected above SSLs, dioxins were only analyzed in a small number of samples (six samples) at only two locations. Furthermore, dioxins were not analyzed in groundwater so potential impacts to this medium are unknown. Please revise the RFI to address this apparent data gap. Additionally, revise the RFI to acknowledge the limited number of soil samples that were analyzed for dioxins/furans when discussing frequency of detection.

17. **Section 6.0, Human Health Risk Assessment (HHRA), Page 6-1:** The first sentence of this section states that the HHRA evaluates potential adverse effects “associated with exposure to site-related chemicals in soil, surface water, sediment, and groundwater.” However, sediment samples were not collected at SWMU 43, and are, therefore, not evaluated in the HHRA. Please revise the first

sentence of Section 6.0 to remove reference to sediment since this medium was not evaluated at SWMU 43.

18. **Section 6.1.1.3, Surface Water, Page 6-4:** Data from surface water samples collected in 1991 were used for the Chemical of Potential Concern (COPC) screening process. Given the age of the data (18 years old), the HHRA should indicate whether these data were validated, and whether they are considered appropriate for use in a risk assessment. Please revise the HHRA to address these concerns.

19. **Section 6.1.1.4, Groundwater, Page 6-4:** The HHRA does not clarify whether the metals results in groundwater are representative of the total or dissolved fraction. Please revise the HHRA to indicate whether total or dissolved metals results are used in the HHRA and discuss any associated uncertainties in using these data within the uncertainty analysis.

20. **Section 6.1.2, Identification of COPCs, Page 6-4**: The third paragraph states, "Analytes for which no screening criteria exist were also selected as COPCs." This approach was followed for some chemicals but not others. It appears that screening criteria for surrogate chemicals may have been used for some chemicals for which screening criteria are not available (i.e., the screening value for pyrene was used for benzo(g,h,i)perylene). This approach is generally acceptable; however, the HHRA should discuss the use of surrogate chemicals in the COPC selection process, and clarify why the selected surrogates are considered appropriate. Please revise Section 6.1.2 to acknowledge the use of surrogates in the COPC selection process and to discuss the structure activity relationship between chemicals lacking toxicity criteria and any identified surrogates.

21. **Table 6-2: Summary of Chemicals of Potential Concern at SWMU 43:** Table 6-2 does not include tetrachloroethylene (PCE) even though this chemical was identified as a COPC for groundwater (Appendix E.1, Table E.1-8). Please revise Table 6-2 to identify PCE as a COPC for groundwater.

22. **Section 6.2.1, Conceptual Site Model/Receptor Characterization, Page 6-6:** The sixth paragraph states that "maintenance workers, industrial workers, and excavation workers were evaluated for exposures to surface soil and total soil at SWMU 43." However, only the maintenance worker and industrial worker appear to have been evaluated for exposure to surface soil. The excavation worker was evaluated for exposure to total soil only (Appendix E.1, Tables E.1-48 and E.1-49). Evaluating the excavation worker for exposure to total soil only is appropriate as mixing of soil is expected during excavation activities, however, the HHRA should clearly state this. Please revise Section 6.2.1 to indicate that the excavation worker was evaluated for exposure to total soil only.

23. **Section 6.2.1, Conceptual Site Model/Receptor Characterization, Page 6-9:** An adult recreational user of the New River was evaluated for exposure to surface

water, but the child recreational user and/or the adolescent recreational user were not evaluated. Sufficient justification for excluding these potential receptors has not been provided. Furthermore, RFAAP previously indicated that off-site adult and child receptors would be evaluated for exposure to groundwater, but again, only the off-site adult recreational user was evaluated (Attachment 9 of the Draft Notes from the RFAAP EPA/VDEQ Partnering Meeting, November 18, 2009, SWMU 43 – Sanitary Landfill No. 2 slide presentation). Please revise the HHRA to evaluate a child and/or adolescent recreational user's exposure to surface water, or provide sufficient justification for excluding these receptors from the evaluation. Additionally, clarify why an off-site child receptor was not evaluated even though this approach was discussed during the November 18, 2009 partnering meeting.

24. **Section 6.2.2, Identification of Exposure Pathways, Page 6-9:** An adult recreational user was evaluated in the HHRA, but this potential receptor is not identified in Section 6.2.2. Please revise Section 6.2.2 to identify the adult recreational user as a potential receptor.

25. **Section 6.4.2, Background, Page 6-15**: The last sentence indicates that aluminum, arsenic, cobalt, iron, and vanadium contributed to the total soil hazard index (HI) for the child resident, but "these constituents are within background." This section does not mention that manganese also contributed to an HI greater than 1 for the child resident, and, according to Table 6-5, Background Comparison for Total Soil at SWMU 43, manganese concentrations at the site are not consistent with background concentrations. Please revise the HHRA to discuss manganese concentrations in site soils and what impact this may have on the HHRA conclusions.

26. **Section 6.6, HHRA Summary and Conclusions, Page 6-29:** This section states that off-site adult and child residents were evaluated for potential exposures to groundwater, but this scenario does not appear to have been evaluated in the HHRA. Additionally, an off-site adult recreational user was evaluated, but this receptor is not mentioned. Please revise the HHRA to address these discrepancies.

27. **Section 7.1.2, Data Organization, Pages 7-6 and 7-7:** This section (and others, such as Section 7.1.8, 'Approach for the Evaluation of Direct Contact Toxicity', Page 7-20) indicates that only surface soil, sediment and surface water data were evaluated in the SLERA. However, Section 7.1 (page 7-1) includes groundwater. Section 7.2.1 (page 7-28) indicates that 'surface soil, surface water and groundwater' samples were used in the SLERA (sediments are not mentioned). Also, the RFI does not define and describe 'surface water' as the seep water linked to the groundwater resource. Please revise Section 7 in the RFI report, where appropriate, to ensure that the types of measured and modeled exposure media evaluated in the SLERA are consistently presented.

28. **Section 7.1.3, Identification of Exposure Pathways and Potential Receptors for Analysis, Pages 7-7 and 7-8:** The text in this section describes the exposure pathway component of the conceptual site model. This should include the hydrologic linkage between site groundwater and the seeps considered as surface water exposure points. This information should be consistently described throughout the document and presented in this section in particular for clearer understanding of this potential pathway. Please revise the text accordingly.

29. **Section 7.1.4.2, Measurement Endpoints, Pages 7-14 and 7-15:** This section provides only cursory information on the measurement endpoints, and does not include the 'aquatic receptor' endpoints. Section 7.1.3.2 'Aquatic Receptors' identifies two food chain receptors (the great blue heron and the mink) evaluated in the SLERA, even though these species are omitted from the endpoint process. Please revise this section accordingly to link all of the measurement endpoints to their associated assessment endpoints. This information can best be summarized in table format.

30. **Section 7.1.8.2, Surface Water, Page 7-21:** This section (similar to the comment provided for Section 7.1.3) should clarify which receptors are evaluated using the process described in the text. It is apparent that the New River itself was not studied; therefore this approach appears to apply to incidental aquatic receptors that occur in the seep locations. Please revise this section to clearly describe the exposure setting and receptors evaluated using this surface water screening process.

31. **Section 7.1.11 General Uncertainty Analysis, Pages 7-25 to 7-27:** The uncertainty analysis is presented *before* the screening-level risk characterization is complete. It is recommended to combine this section with Section 7.2.7 (Uncertainty Analysis) in order to develop one, comprehensive uncertainty analysis at the end of the SLERA. Table 7-4 (page 7-27) is quite useful and should be further expanded to include other major sources of uncertainty and their impact on the risk evaluation (e.g., using generic direct-contact screening benchmarks, limitations associated with using two old seep samples to assess current surface water quality, assessing aquatic exposures to surface water and sediment in the New River based on modeled exposures). Please consider revising the text accordingly.

32. **Table 7-13, Direct Toxicity Evaluation for Surface Soil at SWMU 43:** The maximum concentrations listed for cobalt, copper, iron, lead, mercury, nickel, selenium and zinc do not match the descriptive statistics provided earlier (refer to Table 4-2, Summary of Analytes Detected in SWMU 43 Soil Samples). Please review the data to correct any errors, and verify that the appropriate concentrations are presented as the exposure point concentrations (EPCs).

33. **Section 7.2.4.2, Surface Water, Page 7-45:** As previously pointed out in the comments above, this section also presents a confusing interpretation of the

surface water setting. This section indicates that ‘organisms inhabiting the streams near SWMU 43’ would be potentially, adversely affected by (aluminum, barium, and iron). Yet, previous discussions state that no surface water features are associated with SWMU 43 outside of the adjacent New River. Please revise the RFI report to consistently present the surface water setting at and around the site.

34. **Section 8.1, Contaminant Assessment, Page 8-1:** The first sentence of this section states, “The contamination assessment indicated that [volatile organic compounds] VOCs, non [polynuclear aromatic hydrocarbon] PAH [semi-volatile organic compounds] SVOCs, pesticides, herbicides, and metals are not a concern in soil at SWMU 43 since they were not greater than [screening levels] SLs in any soil samples.” Metals should not be included in this statement since both arsenic and mercury were detected above SLs in soil samples. Please revise the above-referenced sentence to exclude metals.

35. **Section 8.5, Conclusion, Page 8-5:** This page indicates that the main drivers of risk/hazard in groundwater are arsenic and PCE. However, manganese should also be recognized as a risk/hazard driver. The HQ for ingestion of manganese in groundwater by a future child resident (2.2) exceeds 1. Additionally, the background assessment determined that manganese concentrations in total soil were not consistent with background. Therefore, manganese should also be recognized as a constituent that is contributing to a cumulative HI greater than 1 for the future child resident.

MINOR COMMENTS

1. Section 7.1.2, Methodologies for the Identification of COPECs and Concentration Statistics (Page 7-6): The last sentence in the first paragraph is repeated verbatim in the last sentence of the second paragraph. Please revise this section in order to remove the redundancy.

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November 30, 2009

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Richmond, VA 24143-0100

Subject: With Certification, SWMU 43 RCRA Facility Investigation Report, Draft November 2009
EPA ID# VA1 210020730

Dear Mr. Geiger and Mr. Cutler:

Enclosed is the certification for the subject document that was sent to you on November 24, 2009. Also enclosed is the 24 November 2009 transmittal email.

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

Sincerely,

Phillip Lockard for

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09-815-193
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Concerning the following:

Radford Army Ammunition Plant
SWMU 43 RCRA Facility Investigation Report
Draft November 2009

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.

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Subject: RE: Draft SWMU 43 RFI Report (UNCLASSIFIED)

Importance: High

Classification: UNCLASSIFIED
Caveats: FOUO

All:

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

A certification letter will follow.

Thank you for your support of the Radford Army Ammunition Plant Installation Restoration Program.

Jim McKenna

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Classification: UNCLASSIFIED
Caveats: FOUO

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

LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
ADAF	Age-Dependent Adjustment Factor
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances Disease Registry
AUF	Area Use Factor
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
bgs	below ground surface
BTAG	Biological Technical Assistance Group
CCA	Chromated Copper Arsenate
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
cm	centimeters
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSEM	Conceptual Site Exposure Model
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
DA	Dose Absorbed Per Unit Area Per Event
DQO	Data Quality Objective
EcoSSL	Ecological Soil Screening Level
EEQ	Environmental Effects Quotient
EM31	EM31 MK2 Terrain Conductivity Meter
EPC	Exposure Point Concentration
EPD	Effective Prediction Domain
EPI	Estimation Programs Interface
ERAGS	Ecological Risk Assessment Guidance for Superfund
FDEM	Frequency Domain Electromagnetic Induction
ft msl	feet above mean sea level
ft	feet
ft^2/min	square feet per minute
GI	Gastrointestinal
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IAEA	International Atomic Energy Agency
IC	Institutional Control
IRIS	Integrated Risk Information System
i-SL	Industrial Screening Level
kg	kilograms
LOAEL	Lowest-Observed-Adverse-Effect Level
MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
MDL	Method Detection Limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MMA	Main Manufacturing Area
MRL	Minimum Risk Level
MWP	Master Work Plan
NAWQC	National Ambient Water Quality Criteria
NOAEL	No-Observed-Adverse-Effect Level
ORNL	Oak Ridge National Laboratory
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene

PEF	Particulate Emission Factor
PPRTV	Provisional Peer Reviewed Toxicity Value
QA	Quality Assurance
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RBCA	Risk-Based Corrective Action
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Daily Allowance
RFAAP	Radford Army Ammunition Plant
RfD	Risk Reference Dose
RFI	RCRA Facility Investigation
r-SL	Residential Screening Level
RTE	Rare, Threatened, or Endangered
Shaw	Shaw Environmental, Inc.
SL	Screening Level
SLERA	Screening Level Ecological Risk Assessment
SMDP	Scientific/Management Decision Point
SSL	Soil Screening Level
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCL	Target Compound List
TEF	Toxicity Equivalence Factor
TNT	Trinitrotoluene
TOC	Total Organic Carbon
TOX	Total Organic Halides
TRV	Toxicity Reference Value
tw-SL	Tap Water Screening Level
UCL	Upper Confidence Limit
UF	Uncertainty Factor
USEPA	U.S. Environmental Protection Agency
VDEQ	Virginia Department of Environmental Quality
VI	Verification Investigation
VOC	Volatile Organic Compound
VRP	Voluntary Remediation Program
WHO	World Health Organization

EXECUTIVE SUMMARY

Shaw Environmental, Inc. (Shaw) conducted a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Solid Waste Management Unit (SWMU) 43 (RAAP-023) – Sanitary Landfill No. 2, during 2007. This investigation is required by the 2000 RCRA Corrective Action permit (USEPA, 2000a) for Radford Army Ammunition Plant (RFAAP) and was performed in accordance with *Master Work Plan (MWP) Addendum 019* (Shaw, 2007). MWP Addendum 019 was prepared to facilitate the investigation effort to comply with the requirements set forth in the 2000 RCRA Corrective Action permit and was approved by the U.S. Environmental Protection Agency (USEPA) Region III and the Virginia Department of Environmental Quality (VDEQ).

In addition to the MWP Addendum 019 field investigation, one other previous investigation was conducted at SWMU 43. This investigation was a Verification Investigation, which was prepared for the U.S. Army Toxic and Hazardous Materials Agency in 1992 and covered many RFAAP SWMUs. The objectives of the investigation were to determine whether toxic or hazardous contaminants were present and were, or had the potential of, migrating beyond the boundaries of the identified SWMU.

During the development of MWP Addendum 019, a review of the data indicated that the complete extent of the landfill had not yet been defined, representing a data gap. Another data gap was identified by a lack of soil samples from within the landfill material and the soil in and under the landfill. Additionally, current groundwater was needed in order to have new data to compare to the new soil data.

Once the data needs were identified, sampling strategies were developed to complete characterization of the site and refine the delineation of elevated constituents in site media. 2007 RFI activities at SWMU 43 included a geophysical survey and the collection and chemical analysis of 10 surface soil, 20 subsurface soil, and 6 groundwater samples. The results of the geophysical survey and the chemical results from the environmental samples were evaluated to assess: the nature and extent of contamination (*Section 4.0*), the fate and transport of chemical constituents in the environment (*Section 5.0*), and potential impacts to human health (*Section 6.0*) and/or ecological receptors (*Section 7.0*).

Contamination Assessment

Soil. Ten soil borings were advanced during the 2007 RFI fieldwork to characterize soil at this site. Five borings were placed in each of the two landfill cells and three soil samples were collected from each boring. Analytical results indicate that only arsenic exceeded its industrial screening level (i-SL) in site soil. The exceedance was limited to one of the 30 samples collected.

Of the 30 samples collected, residential screening level (r-SL) exceedances were limited to:

- one polynuclear aromatic hydrocarbon (PAH) [benzo(a)pyrene - 4 samples];
- two polychlorinated biphenyls (PCBs) (PCB-1016 - 1 sample; and PCB-1254 - 7 samples);
- one explosive [2,4,6-trinitrotoluene (TNT) - 1 sample];

- two metals (arsenic - 1 sample; and mercury - 2 samples); and,
- four total dioxins/furans [total PECDD > r-SL - two of six samples. Total HXCDD, total HPCDD, and total HXCDF > r-SL - one of six samples (sample 43SB03B)].

Some of the compounds (arsenic and dioxins/furans) that were found to be greater than soil r-SLs or i-SLs were also identified by the human health risk assessment (HHRA) or screening level ecological risk assessment (SLERA) as posing a potential risk to human health or the environment. Arsenic was the only analyte detected above its screening level (SL) in soil and also detected in groundwater. However, the results from the investigations at SWMU 43 indicate that there are no major concerns in soil because of the relatively low concentrations and sparsely located constituents of concern.

Surface Water. In 1992, two surface water samples [43SP1 (RDWB*7) and 43SP2 (RDWB*10)] were collected from the groundwater seeps at SWMU 43. Additional sampling was planned for 2007, but samplers were unable to collect the samples because the groundwater seeps sampled in 1992 were not flowing due to drought conditions.

Results from the 1992 SWMU 43 surface water sampling demonstrated that four metals (aluminum, arsenic, iron, and manganese) were detected above their screening limits. Aluminum was detected above its maximum contaminant level (MCL) in sample 43SP1. Arsenic was found above its tap water screening level (tw-SL) in sample 43SP2 and above both its MCL and tw-SL in sample 43SP1. Iron was detected above its MCL in both samples, and also above its tw-SL in sample 43SP1. Manganese was detected above both its tw-SL and MCL in both samples. It should be noted that the MCLs for aluminum, iron, and manganese are secondary MCLs based on cosmetic or aesthetic effects such as taste (and not health effects). Semivolatile organic compounds, pesticides, and PCBs were not detected in 1992 site surface water samples.

Four metals (aluminum, arsenic, iron, and manganese) were detected above SLs in 1992 and were also detected in 2007 groundwater samples.

Groundwater. Groundwater at SWMU 43 was investigated during both the 1992 and 2007 investigations. In both 1992 and 2007, six monitoring well groundwater samples (43MW1, 43MW2, 43MW3, 43MW4, 43MW5, and 43MW6-6) were collected to assess site groundwater.

SWMU 43 groundwater results from the 1992 sampling event indicated that one volatile organic compound (VOC) (benzene) and three metals (arsenic, iron, and manganese) were detected above their screening levels. Benzene was found at a concentration of 0.5 micrograms per liter (µg/L), slightly above its tw-SL of 0.41 µg/L, in one sample. The three metals were detected above their MCLs, tw-SLs, and background levels in site samples.

SWMU 43 groundwater results from the 2007 sampling event indicated that one VOC [tetrachloroethene (PCE)] and five metals (aluminum, arsenic, cobalt, iron, and manganese) were detected above their screening levels. PCE was detected above its tw-SL in four out of six samples. Arsenic, iron, and manganese were found above their MCLs, tw-SLs, and background levels. Aluminum was only detected above its MCL in two samples. Cobalt was only detected above its tw-SL in four samples, but did not have an MCL. However, PCE, arsenic, cobalt, and iron were detected above SLs in wells upgradient of the site and in wells downgradient of the site. Aluminum was only detected above SLs in the two upgradient wells (43MW1 and 43MW2). Because PCE had not been detected in the previous groundwater sampling event, the Army, USEPA, and VDEQ agreed to collect one additional round of groundwater samples for

VOC analysis. During the June 2010 Partnering meeting, it was agreed that the additional samples would be used as an indicator to judge future trends and that the data would not be incorporated into the Risk Assessments. The partnering team agreed to a cut-off level of 25 µg/L (10x existing levels) as the trigger for additional monitoring. The additional samples were collected in October 2010 and the results are presented in **Table ES-1**. As can be seen from the table, PCE was not detected in the October samples. None of the detected VOCs exceeded their respective MCLs. Chloroform and vinyl chloride exceeded their risk-based SLs in single samples (43MW3 for chloroform and 43MW2 for vinyl chloride). The low levels of chloroform can be attributed to leaking water supply lines throughout Radford, as has been shown at several other SWMUs in the Main Manufacturing Area (Shaw, 2010; URS, 2010). Pesticides, PCBs, explosives, and herbicides were not detected in 2007 site groundwater samples.

Some of the compounds (PCE, arsenic, cobalt, iron, and manganese) that were found to be greater than groundwater SLs were also identified by the HHRA or SLERA as posing a potential risk to human health or the environment. Because PCE concentrations in groundwater were well below the MCL (and are decreasing), and the risk pathway for groundwater exposure will be eliminated by the implementation of media-specific institutional controls, Long-Term Monitoring of the site is not necessary or proposed.

Fate and Transport Analysis

Fate and transport analysis (*Section 5.0*) indicates that the analytes that were detected above SLs in 2007 SWMU 43 soil samples were one PAH [benzo(a)pyrene], two PCBs (PCB-1016 and PCB-1254), one explosive (2,4,6-TNT), two metals (arsenic and mercury), and four dioxins/furans (total PECDD, total HXCDD, total HPCDD, and total HXCDF). Of those, the only analyte that was also identified as a soil and groundwater risk driver in the HHRA for SWMU 43 (*Section 6.0*) was arsenic.

Human Health Risk Assessment

An HHRA was performed to evaluate the potential human health effects associated with previous activities at SWMU 43. 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.

The total cancer risk for current maintenance worker exposures to surface soil was within the acceptable risk range (above the lower end of the range due to arsenic). Hazard index (HI) was less than 1. The total cancer risk associated with groundwater was below the acceptable risk range. The HI was below 1.

For the future maintenance worker, the total cancer risk for exposures to surface soil was within the acceptable risk range (above the lower end of the range due to arsenic). The total cancer risk for exposures to total soil and groundwater were below the acceptable risk range. All HIs were less than 1.

For the future industrial worker exposures to surface and total soil, the total cancer risks were within the acceptable risk ranges (above the lower end of the range due to arsenic). Both HIs were below 1. The total cancer risk associated with groundwater was above the acceptable risk range due to PCE and arsenic. The total HI for groundwater was above 1, due to arsenic.

For the future excavation worker, the total cancer risk for exposures to total soil and groundwater were below the acceptable risk ranges. Both HIs were below 1.

For the future lifetime resident, the total cancer risk for exposures to total soil was within the acceptable risk range [above the lower end of the range due to dioxins/furans, benzo(a)pyrene, and arsenic]. The total HI was less than 1. The total cancer risk associated with groundwater was above the acceptable risk range, primarily due to PCE and arsenic. The total HI was above 1, primarily due to arsenic.

For the child resident, the total cancer risk for exposures to total soil was within the acceptable risk range (above the lower end of the range due to dioxins/furans and arsenic). The total HI for total soil was above 1; however, no individual chemical of potential concern (COPC) had an HI above 1. Aluminum, arsenic, cobalt, and iron are within background concentrations for total soil. If hazard quotients (HQs) for background-related metals were excluded, the total HI for total soil would be 1. The total cancer risk associated with groundwater was above the acceptable risk range, due to PCE and arsenic. The total HI was above 1, due to arsenic, cobalt, iron, and manganese.

Off-site recreational users were evaluated to address potential future migration of COPCs in groundwater and springs/seeps at SWMU 43 to surface water at the New River. For the future recreational user, the total cancer risk for exposures to off-site surface water was within the acceptable risk range, primarily due to PCE and arsenic. The total HI was below 1.

Arsenic, dioxins/furans (TCDD TE), and benzo(a)pyrene are the main risk-drivers in soil, arsenic and PCE are the main risk-drivers in surface water and groundwater at SWMU 43.

Screening Level Ecological Risk Assessment

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 43. Common methods and procedures are presented in *Section 7.1*, and individual results for SWMU 43 are presented in *Section 7.2*, respectively.

The food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles for modeled contact with the hazard drivers (TCDD, arsenic, chromium, selenium, and zinc) in surface soil. However, arsenic and chromium in surface soil concentrations were determined to be background related.

When alternative exposure and/or toxicity factors were used in the Tier 2 lowest-observed-adverse-effect level (LOAEL)-based environmental effects quotient (EEQ) calculations, estimated EEQs would be expected to drop to 1 or less for all constituents except selenium, which had alternative EEQs that slightly exceeded 1 (EEQ = 2). The direct contact assessment results suggest a potential reduction in wildlife food supply due to selenium in surface soil and aluminum, barium, and iron in surface water. However, due to the relatively small size of the Site (approximately 3.0 acres), this potential reduction in food is not considered biologically significant. In addition, although three chemicals of potential ecological concern (COPECs) in surface water had concentrations that exceeded more than 50 percent of the available screening benchmarks and/or exceeded a promulgated criterion, the small size of the site, the lack of true aquatic habitat and the associated small size of the sampled aquatic habitat (ground water seeps), and the migration of COPECs in groundwater to surface water and sediment of the New River was determined not to be a significant ecological concern, suggests further ecological assessment is not warranted.

Based on uncertainties of toxicity, arsenic and chromium in soil concentrations are background related, no Tier 2 LOAEL EEQs except selenium (EEQ = 2) exceeding 1 (when rounded to one significant figure, and using alternative uncertainty factors and/or alternative LOAEL toxicity reference values), the fact that no wildlife rare, threatened, or endangered species have been confirmed at the SWMU study area, the relatively small size of the SWMU, and groundwater migration to the New River was determined not to be a significant ecological concern, remedial measures solely to address ecological concerns are not warranted for soil, surface water, or groundwater. The scientific/management decision point reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

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.

Conclusions

Total risk associated with exposures to COPCs in soil was within the acceptable risk range for the current and potential future maintenance worker, potential future industrial worker, potential future lifetime resident, and potential future child resident. For the industrial scenario, the risks were attributable to arsenic. For the residential scenario, these risks were attributable to dioxins/furans, benzo(a)pyrene, and arsenic. Although a single sample had an arsenic concentration above the background point estimate, statistical population comparisons (*Section 6.4.2*) shows that concentrations of arsenic in soil were within background levels at the site in both surface and total soil.

The total HIs for soil were below 1 for all receptors except the child resident. Although the child resident HI exceeded 1, the individual HQs for metals in soil were less than 1. Furthermore, when the background-related HQs were excluded, the total HI for soil was less than 1.

Total risks associated with exposures to COPCs in groundwater were above the acceptable risk range for the potential future industrial worker, potential future lifetime resident, and potential future child resident. These risks were attributable primarily to PCE and arsenic. However, as noted above, PCE was not detected in the October 2010 sampling event.

The total HIs for exposures to COPCs in groundwater were above 1 for the potential future industrial worker, potential future lifetime resident, and potential future child resident. For the industrial scenario, the elevated HI was attributable to arsenic. For the residential scenario, the elevated HIs were attributable to several metals.

Potential future migration of COPCs in groundwater and springs/seeps at SWMU 43 to surface water at the New River was evaluated in this HHRA. Total risk associated with exposures to off-site surface water by off-site recreational users was within the acceptable risk range, primarily attributable to PCE and arsenic. Concentrations of COPCs in SWMU 43 spring/seeps and groundwater were conservatively used in the risk and hazard calculations without adjustment for dilution. Therefore, considering the dilution factor of 100 assumed in the SLERA, the risk associated with discharge from SWMU 43 is expected to be below the acceptable risk range of 1E-06 to 1E-04. The total HI was below 1.

Overall, these potential risks and hazards can be associated with arsenic, dioxins/furans (TCDD TE), and benzo(a)pyrene in soil, and arsenic and PCE in surface water and groundwater at the site. It should be noted that the arsenic soil concentrations were within background levels at the site and that dioxin/furans (as TCDD TE) were not detected above SLs in any soil samples. Benzo(a)pyrene was only detected above its r-SL in four shallow samples out of the 30 soil samples collected in 2007. PCE was detected above its tw-SL in four out of six 2007 groundwater samples, but did not exceed the MCL in any of the samples. PCE was not detected in any of the wells during the 2010 sampling event. The SLERA concluded that although there may be potential adverse impacts to terrestrial wildlife from site media, remedial measures to address ecological concerns are not warranted, because:

- no rare, threatened, or endangered wildlife species have been confirmed at the site;
- the relatively small size of the site; and,
- groundwater migration to the New River was determined not to be a significant ecological concern.

Based on the results of the Nature and Extent of Contamination Assessment, as well as the results of Human Health and Ecological Risk Assessments, both of which show limited risk to theoretical receptors, Institutional Controls (ICs) are recommended for the site.

Institutional controls are being implemented at the site within the boundaries depicted on **Figure 8-1**. The objective of the ICs is to maintain the site in its current industrial/commercial state as a closed SWMU and to prevent any future residential use. Specifically, this site has been incorporated into a plant management manual to ensure long-term protection of human health and the environment. The management manual provides for advance notice, assessment, and approval of intrusive work that may occur within the plant with a general digging prohibition at sites such as this. In the event the property is transferred or leased, equivalent ICs will be put into terms and conditions of the deed or lease, which are no less restrictive than the IC objectives described above. Furthermore, the transferee or lessee will be responsible for ensuring IC compliance by any future users. However, the Army acknowledges the responsibility for all original liability under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and its right and responsibility to enforce ICs unless otherwise transferred to the new property recipient.

Table ES-1
Analytes Detected in SWMU 43 Groundwater Samples - 2010

Analyte		Sample ID Sample Date Sample Depth	**43MW01-100610 10/6/10 TBD-TBD**					**43MW02-100610 10/6/10 TBD-TBD**					**43MW03-100510 10/5/10 TBD-TBD**					**43MW04-100510 10/5/10 TBD-TBD**					**43MW05-100510 10/5/10 TBD-TBD**					**43MW06-100610 10/6/10 TBD-TBD**				
	MCL	**tw-SL**	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)																																
Carbon disulfide	na	100	0.8	U		*0.07*	*0.8*	0.8	U		*0.07*	*0.8*	0.8	U		*0.07*	*0.8*	0.8	U		*0.07*	*0.8*	0.72	J		*0.07*	*0.8*	0.17	J		*0.07*	*0.8*
Chlorobenzene	100	9.1	0.4	U		*0.03*	*0.4*	0.4	U		*0.03*	*0.4*	0.042	J		*0.03*	*0.4*	0.4	U		*0.03*	*0.4*	0.4	U		*0.03*	*0.4*	0.4	U		*0.03*	*0.4*
Chloroform	80	0.19	0.4	U		*0.01*	*0.4*	0.3	J		*0.01*	*0.4*	0.4	U		*0.01*	*0.4*	0.4	U		*0.01*	*0.4*	0.4	U		*0.01*	*0.4*	0.4	U		*0.01*	*0.4*
Chloromethane	na	19	0.4	U		*0.026*	*0.4*	0.08	JB		*0.026*	*0.4*	0.27	JB		*0.026*	*0.4*	0.4	U		*0.026*	*0.4*	0.4	U		*0.026*	*0.4*	0.4	U		*0.026*	*0.4*
cis-1,2-Dichloroethene	70	7.3	0.4	U		*0.022*	*0.4*	0.4	U		*0.022*	*0.4*	0.11	J		*0.022*	*0.4*	0.4	U		*0.022*	*0.4*	0.4	U		*0.022*	*0.4*	0.4	U		*0.022*	*0.4*
Vinyl chloride	2	0.016	0.2	U		*0.019*	*0.2*	0.2	U		*0.019*	*0.2*	0.068	J		*0.019*	*0.2*	0.2	U		*0.019*	*0.2*	0.2	U		*0.019*	*0.2*	0.2	U		*0.019*	*0.2*

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

SLs for non-carcinogenic compounds have been recalculated to a hazard index of 0.1.
SLs for carcinogenic compounds are shown in red font.
The pyrene SL was used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene and are shown in blue.
MCL source: 2006 Edition of the Drinking Water Standards and Health Advisories. USEPA, August 2006.
B = (organics) Blank contamination. Value detected in sample and associated blank.
J = (organics) Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.
MCL = Maximum Contaminant Level
MDL = Method Detection Limit
MRL = Minimum Reporting Limit
tw-SL = Tap Water Screening Level

1.0 INTRODUCTION

Shaw Environmental, Inc. (Shaw) was tasked by the U.S. Army Corp of Engineers, Baltimore District, to perform a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) and Corrective Measures Study at Solid Waste Management Unit (SWMU) 43 (RAAP-023) – Sanitary Landfill No. 2. The site is located in the northern portion of the Main Manufacturing Area (MMA) of Radford Army Ammunition Plant (RFAAP), adjacent to the New River, east of the main bridge over the New River (**Figure 1-1**). The work was performed in accordance with RFAAP's *Master Work Plan* (*MWP*) (URS, 2003) and *MWP Addendum 019* (Shaw, 2007) under Contract No. W912QR-04-D-0027.

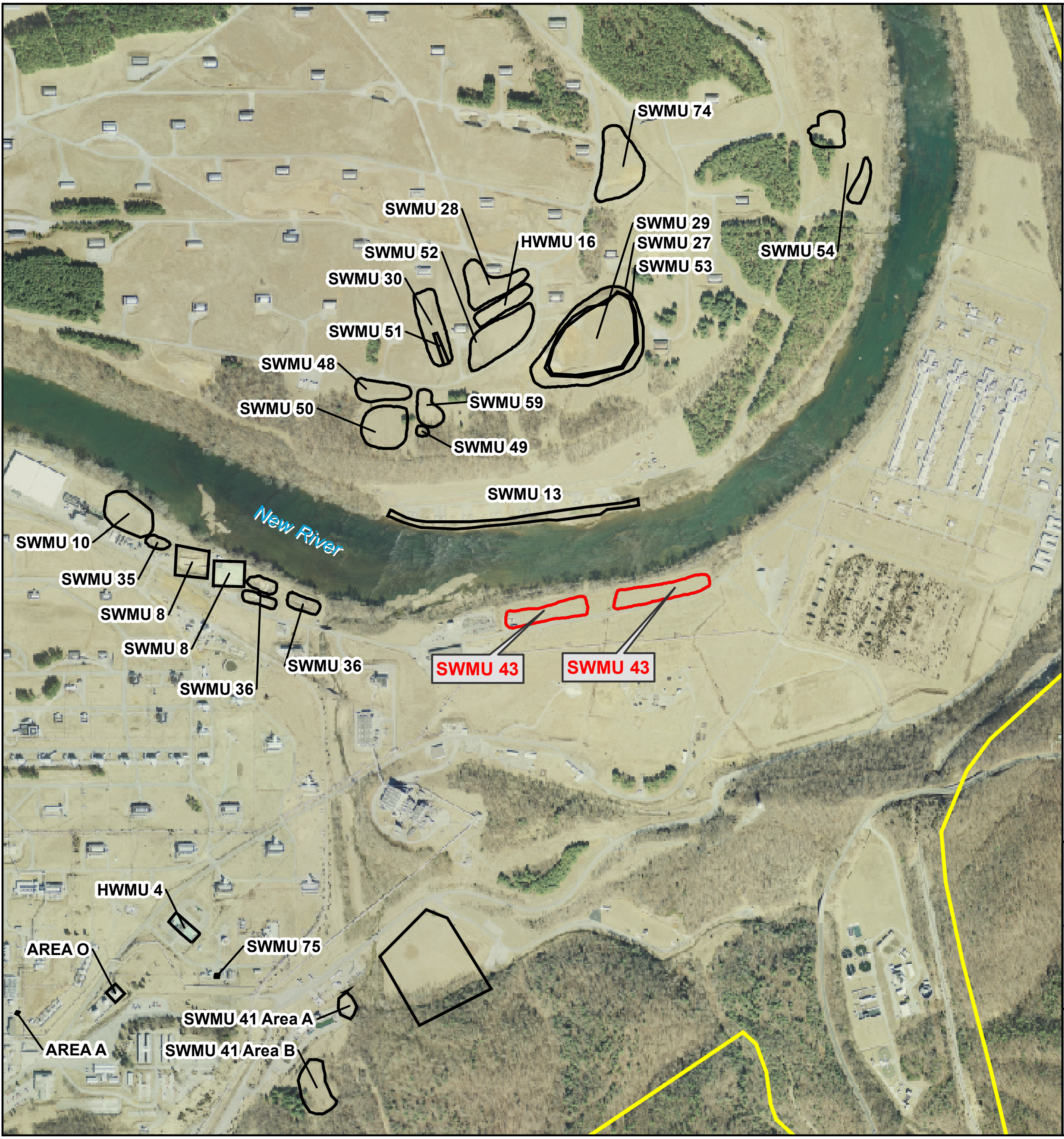
One previous investigation has been conducted at SWMU 43 and is discussed in the following section of this report. Data reviews, including the development of conceptual site models (CSMs) and data gap analyses, were performed in *MWP Addendum 019* (Shaw, 2007). Review of the SWMU 43 data indicated that additional samples needed to be collected in order to characterize the current state of potentially impacted media, representing a data gap. Once the data needs were identified, sampling strategies were developed to complete the characterization of SWMU 43.

The objectives of the field investigation at SWMU 43 were designed to:

- Assess the extent of the landfill through a geophysical investigation.
- Characterize the landfill material and the soil in and under the landfill.
- Obtain current chemical data that can be compared to existing data.

Field activities were conducted in accordance with the *MWP*, *Master Quality Assurance Plan*, *Master Health and Safety Plan* (URS, 2003), *MWP Addendum 012* (IT, 2002), and *MWP Addendum 019* (Shaw, 2007), as approved by U.S. Environmental Protection Agency (USEPA) Region III and the Virginia Department of Environmental Quality (VDEQ). Modifications to *MWP Addendum 019* proposed sampling activities are presented in *Section 3.1.6*.

The data collected in 2007, in conjunction with existing data, was sufficient to complete a Nature and Extent of Contamination Assessment (*Section 4.0*), Fate and Transport Evaluation (*Section 5.0*), Human Health Risk Assessment (HHRA) (*Section 6.0*), and Screening Level Ecological Risk Assessment (SLERA) (*Section 7.0*).



LEGEND

🟥 SWMU 43 Boundary

☐ Other SWMU Boundary

🟨 Installation Boundary

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

N

Scale:
0 500 1,000 2,000
Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 1-1
SWMU 43
Site Location Map
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\SWMU_43\RFAAP_Fig1-1_SWMU43_SiteLocMap_RFI.mxd (10/27/2009)

2.0 SITE BACKGROUND

2.1 Site Description

SWMU 43 is a closed unlined sanitary landfill located immediately adjacent to the New River in the northeast section of the MMA (**Figure 1-1**). As illustrated on **Figure 2-1**, the SWMU 43 study area consists of two adjacent approximately 1.5-acre cells divided by a central drainage ditch. Based on geophysics and aerial photography, the landfill extends east-west approximately 700 feet (ft) on either side of the drainage ditch. The north and south boundaries are the river bank and the paved roadway, respectively. The landfill has a north-south dimension of approximately 150 ft. The land surface in the study area is nearly level with an approximate elevation of 1,700 feet above mean sea level (ft msl). Based on the static water level measurements, groundwater flows north/northwest to the New River.

The western section of the landfill is mostly grassy but, has a small concrete pad and gravel parking area, which are currently used to store office and equipment trailers. Former descriptions of the site noted a pile of soil located adjacent to the roadway at the western end of the site which is no longer present. The eastern section is covered entirely with grass. Elongated depressions, which corresponded to the disposal trenches, were filled in and the site was regraded in accordance with the *SWMU 43 – Design of Filling and Grading*, prepared by Blasland, Bouck, and Lee, Inc., August 4, 1995.

2.2 Site History and Operations

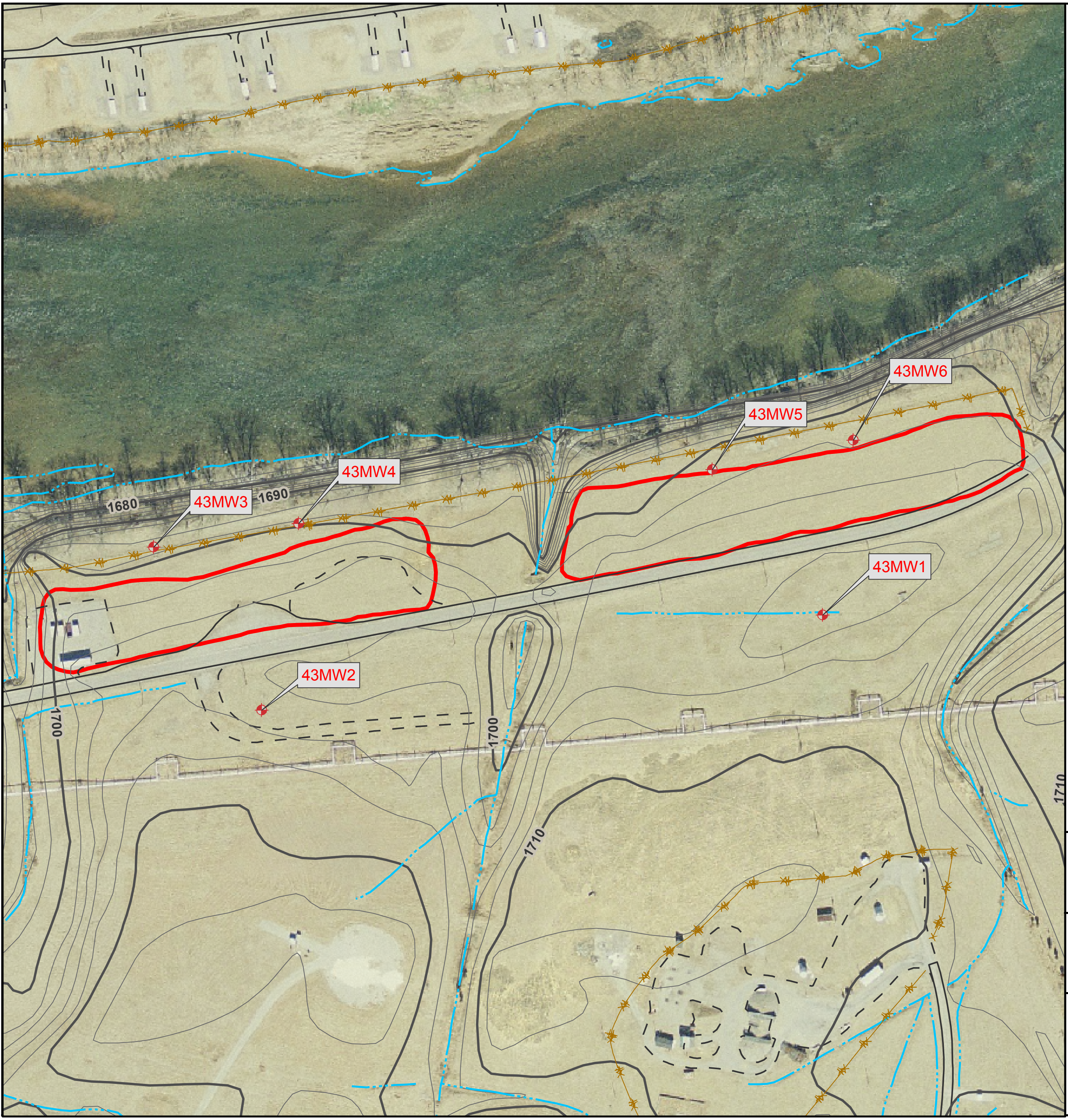
Aerial photographs taken in 2000 indicate that SWMU 43 consists of a closed sanitary landfill consisting of two adjacent cells, identified as the eastern and western cells.

The former trench-fill operation reportedly received at least 300 tons of paper and refuse over its active life. Sanitary landfill material, consisting of paper, rubber, and plastic debris down to 18 ft below ground surface (bgs), was encountered when monitoring well borings were advanced along the fence to the north during the 1992 Verification Investigation (VI). These same materials were also encountered during the advancement of soil borings in both cells during the 2007 RFI.

It is reported by RFAAP personnel that this landfill was operated from about 1958 to the early 1970s. A previous report (USATHAMA, 1976) described a sanitary landfill in the same location as having operated from 1958 to 1969.

2.3 Site Soil

Underlying SWMU 43, the U.S. Department of Agriculture has identified the soils as the Unison-Urban Land Complex (**Figure 2-2**) (SCS, 1985). These soils have been highly reworked through activities at RFAAP. Due to the nature of activities at SWMU 43, the majority of the soil in its study area is artificial fill. Based on site well borings, the soil columns range between different mixtures of sand, silt, clay, and gravels between 0 and 17 or up to 30 ft bgs in borings. Then, beneath those layers, weathered limestone was found starting at between 17 and 30 ft bgs and ending at the bottom of site borings between 28 and 40 ft bgs.



LEGEND

- ⊕ Monitoring Well
- — Water Feature
- — 2 ft Contour Line
- — 10 ft Contour Line
- – – – Dirt Road
- — Paved Road
- —+— Railroad
- —×— Fence
- ▭ SWMU 43 Boundary

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

N

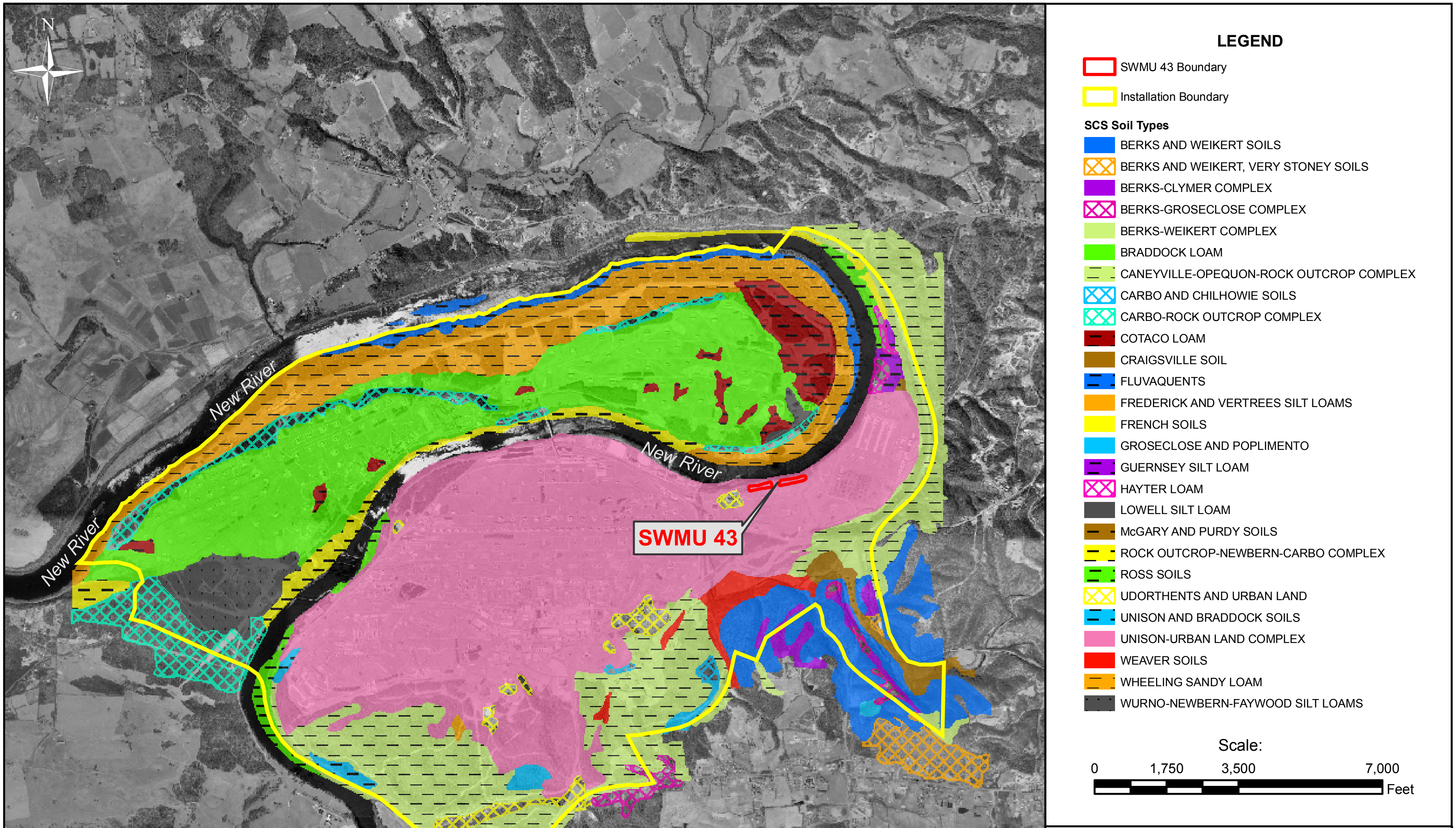
Scale:
0 100 200 400
Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-1
SWMU 43 Site Map
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\SWMU_43\RFAAP_Fig2-1_SWMU43_SiteMap_RFI.mxd (5/29/2009)



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

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\SWMU_43\RFAAP_Fig2-2_SWMU43_SCS_Soils_RFI.mxd (5/29/2009)

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-2
SCS Soil Types at the
Main Manufacturing Area
Radford Army Ammunition Plant,
Radford, VA

2.4 Site Geology

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

The geology of SWMU 43 was investigated during the VI (Dames and Moore, 1992) through the drilling of well borings south of the SWMU and four well borings north of the SWMU. Subsurface conditions consist of fine grained alluvial deposits overlying coarse-grained alluvial deposits which progressively thicken away from the New River. Alluvial deposits encountered in the vicinity consist of mainly of fine-grain micaceous brown, sandy silts and silty sand with some interbedded silty clays.

Eighteen (18) ft of sanitary landfill material was encountered during the drilling of two downgradient borings drilled along the fence to the north bordering the SWMU. Underlying the landfill material, a relatively thin layer of undisturbed fine grain silt to silty sand over weathered limestone was encountered. Where sediments were thicker in the upgradient borings, a basal layer of either river jack (silty gravel) or silty clay was present above weathered limestone bedrock.

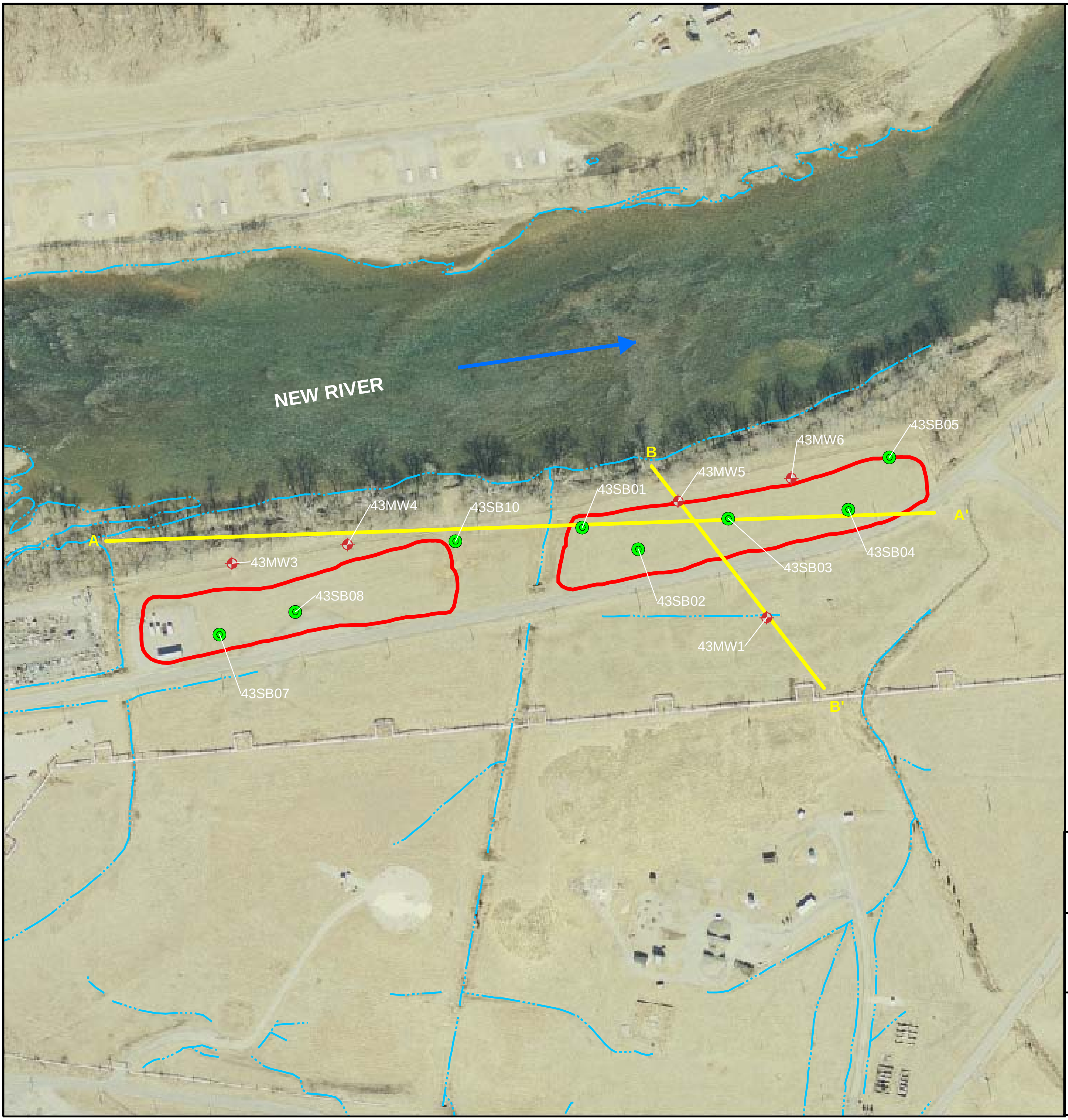
Bedrock encountered in the vicinity of SWMU 43 generally consisted of highly argillaceous gray limestone approximately 20 to 30 ft deep in the southern well borings and 17 to 23 ft deep in the northern well borings. Subsurface data from site borings were used to construct two geologic cross-sections. A plan view of the cross section lines is presented on **Figure 2-3**. Cross-section A-A’ is orientated generally west to east across the site (**Figure 2-4**) and cross-section B-B’ is orientated generally northwest to southeast across the site (**Figure 2-5**). The two cross-sections intersect within the eastern cell. Approximate waste locations are also shown on the cross sections, based on information obtained while performing soil borings. Well purge forms and boring logs for the wells and soil borings are presented in **Appendix B-1** and **Appendix B-2**, respectively.

2.5 Site Hydrogeology

A groundwater table was present below SWMU 43 in August 2007, ranging in depth from 17.31 to 25.95 ft bgs. The water table slopes north at a hydraulic gradient of a 0.5 to 1 percent. A potentiometric surface map of the area is provided on **Figure 2-6**, showing the groundwater contours generally oriented to the north/northwest. Groundwater was encountered within the limestone bedrock at wells installed within the landfill and in downgradient wells. There is a ditch, which leads to the New River, in between the Eastern and Western portions of the landfill. The groundwater slightly upgradient of the site’s ditch is higher in elevation due to the drag from the current in the New River. The ditch cuts off this drag effect, resulting in the lower water levels seen in the downgradient eastern cell.

Surface water runoff from the SWMU is expected to flow towards the drainage ditch located in the center of the site and is assumed to flow northward to the New River.

There are two seeps on site that are ephemeral and only present during periods of high groundwater flow. Both seeps were dry during recent field activities. Due to the ephemeral nature of the seeps, they are not a good indication of groundwater quality in the area. With the



LEGEND

⊕ Monitoring Well Location

● Soil Sample Location

— Water Feature

— Geologic Cross-Section Line

▭ SWMU 43 Boundary

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

N

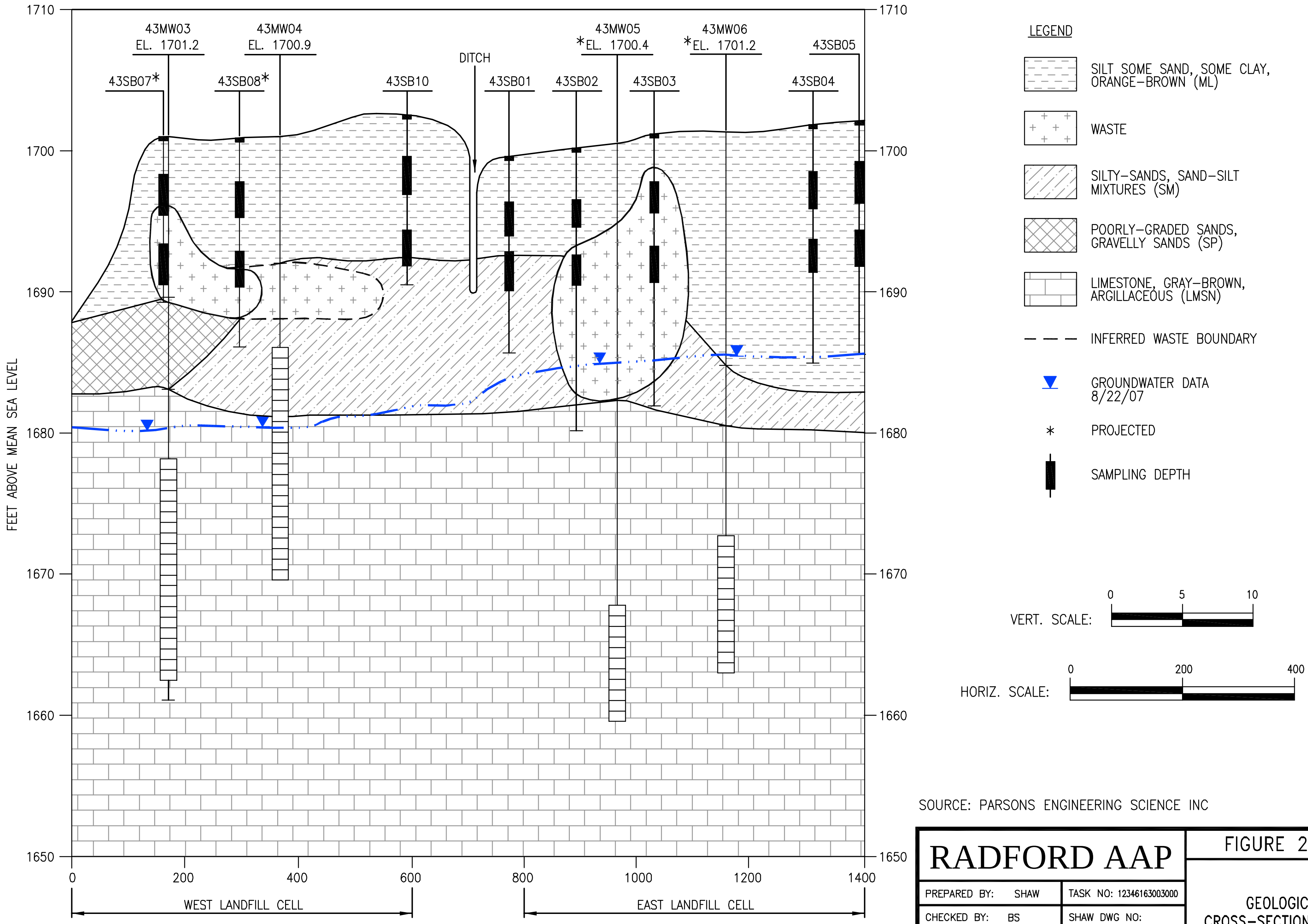
Scale:
0 125 250 500
Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-3
SWMU 43
Geologic Cross Section Plan View
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\SWMU_43\RFAAP_Fig2-3_SWMU43_XSect_RFI.mxd (10/20/2009)



SOURCE: PARSONS ENGINEERING SCIENCE INC

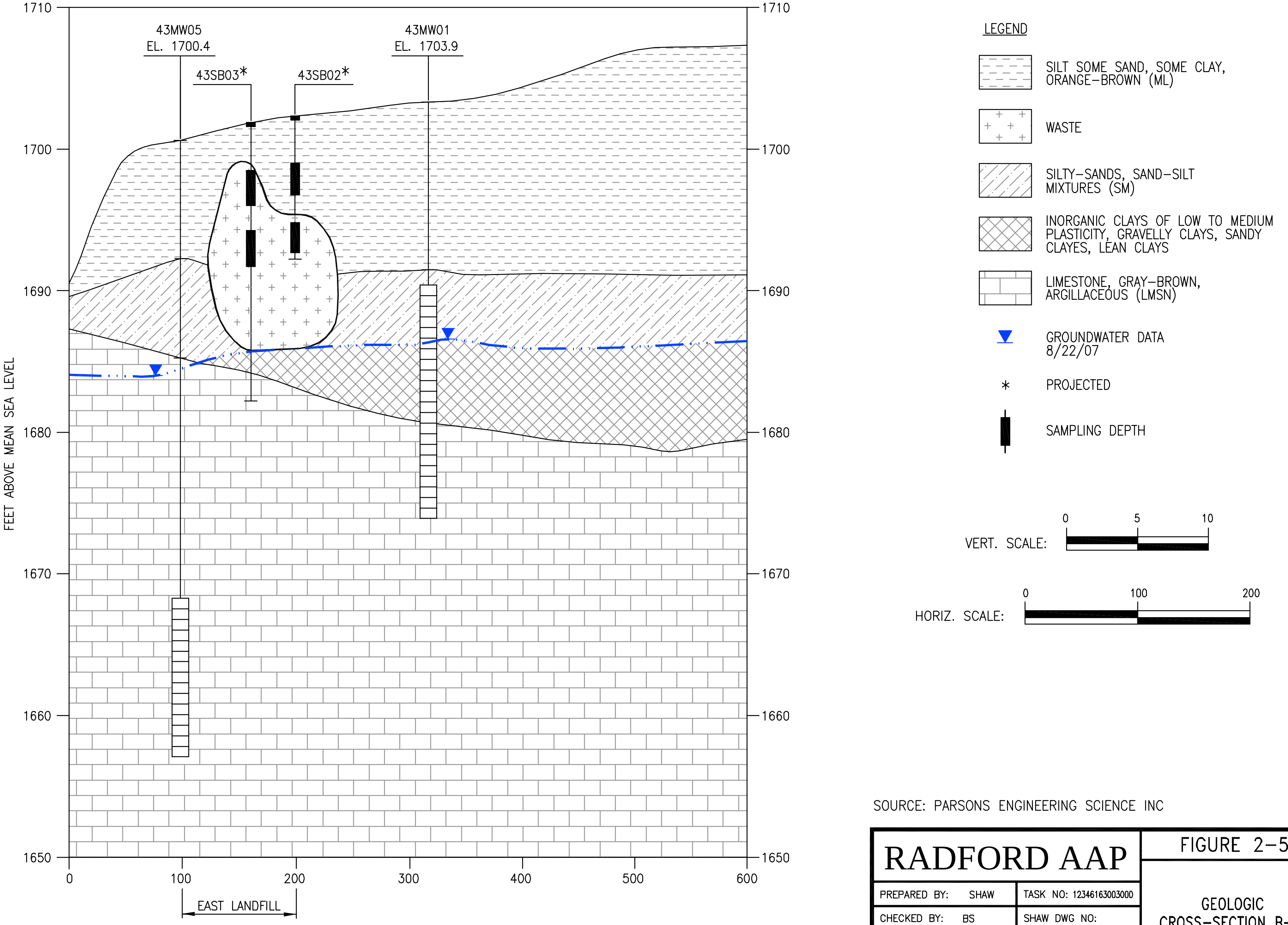
FILE: FIG2-4 (A-A').dwg PLOT: 6-22-09

RADFORD AAP

PREPARED BY: SHAW
CHECKED BY: BS
DATE: JUNE 22, 2009
TASK NO: 12346163003000
SHAW DWG NO:
FIG 2-4 (A-A').dwg

FIGURE 2-4

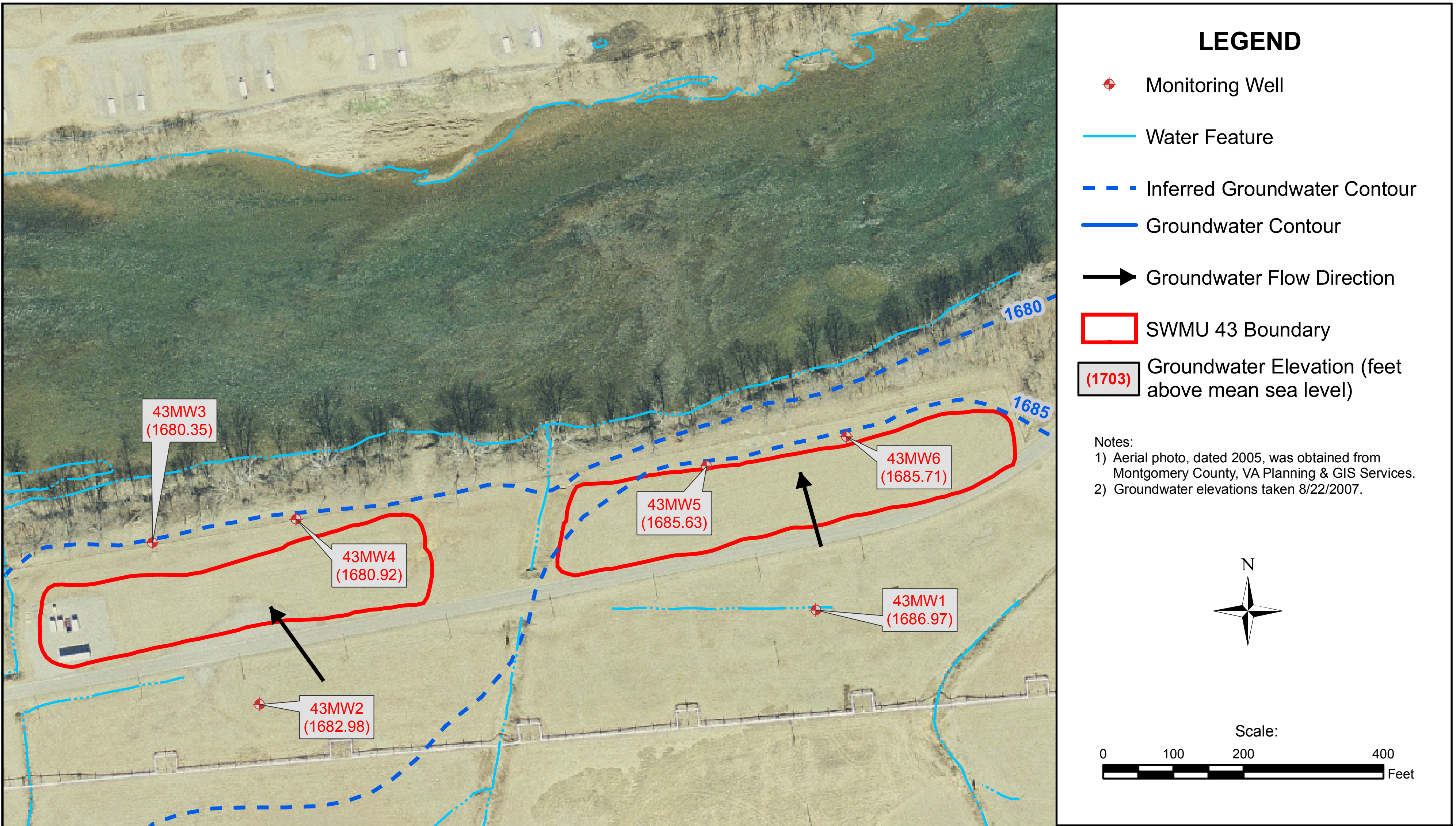
GEOLOGIC CROSS-SECTION A-A'



SOURCE: PARSONS ENGINEERING SCIENCE INC

FILE: FIG2-5 (B-B').dwg PLOT: 6-22-09

RADFORD AAP		FIGURE 2-5
PREPARED BY: SHAW	TASK NO: 12346163003000	GEOLOGIC CROSS-SECTION B-B'
CHECKED BY: BS	SHAW DWG NO: FIG 2-5 (B-B').dwg	
DATE: JUNE 22, 2009		



Notes:

1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Groundwater elevations taken 8/22/2007.

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-6
SWMU 43
Potentiometric Surface Map
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\SWMU_43\RFAAP_Fig2-6_SWMU43_Potentiometric_Surface_RFI.mxd (5/29/2009) exception of the large ditch running between the two landfill cells, the drainage features shown on **Figure 2-6** are storm water drainage ditches and are not expected to have an effect on the overall flow regime. During unusually wet periods when groundwater is extremely high, the ditches may act to cut off some flow in the New River. The large ditch between the two cells appears to affect the groundwater elevations on the "downstream" side of the ditch. Although the flow paths are primarily towards the New River, there appears to be some "drag" in the direction of flow in the New River. The ditch cuts off this drag effect and on the downstream side, resulting in lower water levels in the wells on that side of the ditch.

2.6 Previous Investigations

One previous investigation was conducted at SWMU 43 in 1992. The investigations and sample results are summarized below.

2.6.1 VI, Dames and Moore, 1992

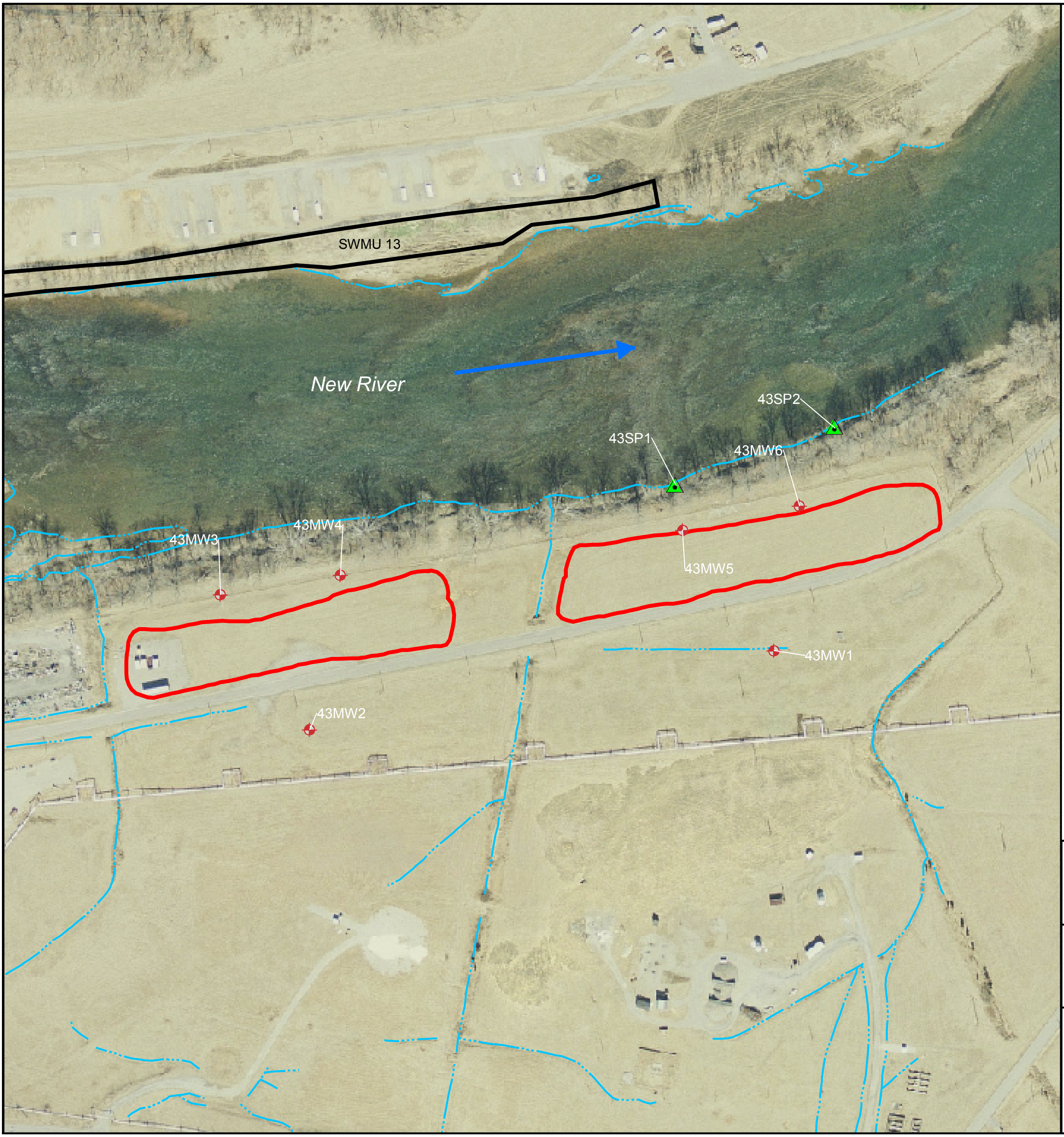
The objective of the VI at SWMU 43 was to determine whether toxic or hazardous contaminants are migrating beyond the boundaries of the identified SWMU. The investigation involved the installation and sampling of monitoring wells and the sampling of groundwater seeps in the vicinity of the unit. As shown in **Table 2-1**, two surface water and six groundwater samples were collected and analyzed for target analyte list (TAL) metals, volatile organic compounds (VOCs), and total organic carbon (TOC). In addition, groundwater samples were analyzed for pH and total organic halides (TOX). Sampling locations are depicted on **Figure 2-7**.

Table 2-1
SWMU 43 Previous Investigation Samples and Analyses – 1992 VI

Media	Sample ID	Analyses
Surface Water	43SP1 (RDWB*7)	TAL metals, VOCs, SVOCs, and TOC
	43SP2 (RDWB*10)	TAL metals, VOCs, SVOCs, and TOC
Groundwater	43MW1 (RDWB*1)	TAL metals, VOCs, SVOCs, pH, TOC, and TOX
	43MW2 (RDWB*2)	TAL metals, VOCs, SVOCs, pH, TOC, and TOX
	43MW3 (RDWB*3)	TAL metals, VOCs, SVOCs, pH, TOC, and TOX
	43MW4 (RDWB*4)	TAL metals, VOCs, SVOCs, pH, TOC, and TOX
	43MW5 (RDWB*5)	TAL metals, VOCs, SVOCs, pH, TOC, and TOX
	43MW6 (RDWB*6)	TAL metals, VOCs, SVOCs, pH, TOC, and TOX

Surface Water. As indicated in **Table 2-2**, one VOC (carbon disulfide) was detected at a concentration below its tap water screening level (tw-SL). Semivolatile organic compounds (SVOCs) were not detected. Four metals (aluminum, arsenic, iron, and manganese) were detected at concentrations above maximum contaminant levels (MCLs) and three metals were detected at concentrations above tw-SLs in the samples.

Groundwater. As shown in **Table 2-3**, three VOCs (1,2-dichloroethylene, benzene, and carbon disulfide) were detected in downgradient wells 43MW3 and 43MW6. Benzene was the only VOC detected above its tw-SL. SVOCs were not detected. Three metals (arsenic, iron, and manganese) were detected at concentrations above their MCLs and tw-SLs in downgradient wells.



LEGEND

⊕ Previous Investigation Monitoring Well Location

▲ Previous Investigation Seep Sample Location

— Water Feature

☐ Other SWMU Boundary

🟥 SWMU 43 Boundary

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

N

Scale:
0 125 250 500
Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-7
SWMU 43
Previous Investigation Sample Locations
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\SWMU_43\RFAAP_Fig2-7_SWMU43_PreSampleLocations_RFI.mxd (10/27/2009)

Table 2-2
Analytes Detected in SWMU 43 Surface Water Samples - 1992 VI

Analyte	Sample ID Sample Date		43SP1 (RDWB*7) 10/31/91		43SP2 (RDWB*10) 10/31/91	
	MCL	**tw-SL**	Result	Lab Q	Result	Lab Q
VOCs (ug/L)						
Carbon disulfide	na	100	3.3		0.5	U
SVOCs (ug/L)	None detected					
Metals (ug/L)						
Aluminum	50	3700	403		141	U
Arsenic	10	0.045	15.2		3.94	
Barium	2000	730	194		84	
Calcium	na	na	92000		72300	
Iron	300	2600	32300		1730	
Magnesium	na	na	41100		28300	
Manganese	50	88	1300		98.1	
Potassium	na	na	856		1510	
Sodium	na	na	20800		9170	
Vanadium	na	26	13.2		11	U
Misc. (ug/L)						
Total Organic Carbon	na	na	12200		6140	

**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-SL exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

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

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

The 2-methylnaphthalene tw-SL was used for 1-methylnaphthalene.

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

MCL Action Levels were used for copper and lead.

MCL = Maximum Contaminant Level (Source: 2006 Edition of the Drinking Water Standards and Health Advisories. USEPA, August 2006).

tw-SL = Tap Water Screening Level (Source: ORNL Regional Screening Table, September 2008).

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

tw-SL 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
Analytes Detected in SWMU 43 Groundwater Samples - 1992 VI

Analyte	Sample ID		43MW1 (RDWB*1)		43MW2 (RDWB*2)		43MW3 (RDWB*3)		43MW4 (RDWB*4)		43MW5 (RDWB*5)		43MW6 (RDWB*6)	
	Sample Date		10/29/91		10/29/91		10/30/91		10/30/91		10/31/91		11/1/91	
	MCL	**tw-SL**	Result	Lab Q	Result	Lab Q	Result	Lab Q	Result	Lab Q	Result	Lab Q	Result	Lab Q
VOCs (ug/L)														
1,2-Dichloroethylene (cis and trans)	70	33	0.5	U	0.5	U	0.58		0.5	U	0.5	U	1.4	
Benzene	5	0.41	0.5	U	0.5	U	0.5		0.5	U	0.5	U	0.5	U
Carbon disulfide	na	100	0.5	U	0.5	U	6		0.5	U	0.5	U	2.3	
SVOCs (ug/L)	None detected													
Metals (ug/L)														
Arsenic	10	0.045	2.54	U	2.54	U	5.54		4.16		3.09		14	
Barium	2000	730	55.6		86.9		45.7		152		44.2		165	
Calcium	na	na	55900		47200		139000		85800		113000		111000	
Iron	300	2600	38.8	U	38.8	U	659		6630		84.5		14500	
Magnesium	na	na	23800		20500		58400		30900		42300		47900	
Manganese	50	88	4.81		2.75	U	41.7		974		41		208	
Potassium	na	na	779		1020		1300		827		1060		1410	
Sodium	na	na	10400		5980		23000		10200		11100		27900	
Misc.														
Total Organic Carbon (ug/L)	na	na	2820		5330		4620		14300		7620		6690	
Total Organic Halides (ug/L)	na	na	141		14.8		65.7		52.5		66.5		59.8	
pH	na	na	6.73		6.59		6.57		6.53		NT		NT	

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

Table 2-3
Legend

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

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

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

The 2-methylnaphthalene tw-SL was used for 1-methylnaphthalene.

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

MCL Action Levels were used for copper and lead.

MCL = Maximum Contaminant Level (Source: 2006 Edition of the Drinking Water Standards and Health Advisories. USEPA, August 2006).

tw-SL = Tap Water Screening Level (Source: ORNL Regional Screening Table, September 2008).

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

    tw-SL 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.

3.0 FIELD INVESTIGATION PROGRAM

3.1 RFI, Shaw, 2007

A geophysical survey (see **Appendix C-1**) and an additional field sampling event were conducted by Shaw in 2007 based on the EPA/VDEQ approved *MWP Addendum 019* (Shaw, 2007). These investigations were performed in order to determine landfill boundaries and obtain current analytical data for the site to complete their characterization. Five soil borings were advanced in each landfill cell. Soil samples were collected for testing from each soil boring at three depth intervals (surface, within the waste, and below the waste). In addition to the soil samples, the six existing wells were sampled in order to assess potential contaminant migration from the landfill cells. The data was used to perform human health and ecological risk assessments presented in *Sections 6.0 and 7.0*, respectively. Samples and chemical analyses performed in support of the investigation are presented in **Table 3-1** below. Results from the investigation are discussed in *Section 4.0.* Surface water was not observed in the ditch during this site work and; therefore, was not collected.

Table 3-1
SWMU 43 Environmental Samples and Analyses – 2007 RFI

Media	Sampling ID	Depth (ft bgs)	Location	Analytes
Surface Soil	43SB01A	0-0.5	east cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB02A	0-0.5	east cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB03A	0-0.5	east cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and dioxins/furans
	43SB04A	0-0.5	east cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB05A	0-0.5	east cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB06A	0-0.5	west cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB07A	0-0.5	west cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB08A	0-0.5	west cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and dioxins/furans
	43SB09A	0-0.5	west cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB010A	0-0.5	west cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
Subsurface Soil	43SB01B	4-6	in east cell (within waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB01C	8-10	in east cell (below waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB02B	4-6	in east cell (within waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB02C	8-10	in east cell (below waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals

Table 3-1
SWMU 43 Environmental Samples and Analyses – 2007 RFI, Continued

Media	Sampling ID	Depth (ft bgs)	Location	Analytes
	43SB03B	4-6	in east cell (within waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and dioxins/furans
	43SB03C	8-10	in east cell (below waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and dioxins/furans
	43SB04B	4-6	in east cell (within waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB04C	8-10	in east cell (below waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB05B	4-6	in east cell (within waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB05C	8-10	in east cell (below waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB06B	4-6	in west cell (within waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB06C	8-10	in west cell (below waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB07B	4-6	in west cell (within waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB07C	8-10	in west cell (below waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB08B	4-6	in west cell (within waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and dioxins/furans
	43SB08C	8-10	in west cell (below waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and dioxins/furans
	43SB09B	4-6	in west cell (within waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB09C	8-10	in west cell (below waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB10B	4-6	in west cell (within waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	43SB10C	8-10	in west cell (below waste)	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
Groundwater	43MW1	na	upgradient, east cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and perchlorate
	43MW2	na	upgradient, west cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and perchlorate
	43MW3	na	downgradient, west cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and perchlorate
	43MW4	na	downgradient, west cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and perchlorate
	43MW5	na	downgradient, east cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and perchlorate
	43MW6	na	downgradient, east cell	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and perchlorate

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

3.1.1 Geophysical Survey

A geophysical survey was conducted in April 2007 to assist in defining the extent of the landfill boundaries. The investigation was performed prior to the collection of soil samples so that boring locations could be adjusted to investigate anomalies identified in the geophysical survey. The geophysical investigation area was approximately 100-250 ft wide in a north-south direction and approximately 1,400 ft long in an east-west direction. The survey area was bounded on the north and east by the Installation security fence, to the south by a paved access road, and to the west by the area of trailers and staged materials. At the time of the survey, the ground surface was open and covered with about 6 inches of mowed grass. The methods, procedures, and results of the survey are detailed in **Appendix C-1**.

Frequency Domain Electromagnetic Induction (FDEM) was used to assess the location of the buried non-metallic and metallic materials. The Geonics, Ltd. EM31 MK2 terrain Conductivity Meter (EM31), which is commonly used to explore for buried metallic and non-metallic debris to depths ranging to 18 ft under favorable conditions, was utilized for this survey. The EM31 is used to locate and delineate many subsurface features including underground storage tanks, groundwater contaminant plumes, oil brine pits, landfill boundaries, metallic bodies, and pits and/or trenches containing metallic and nonmetallic debris.

FDEM instrumentation consists of a transmitter coil and a receiver coil. An alternating current is applied to the transmitter coil, causing the coil to radiate a primary electromagnetic field, which generates eddy currents in conductive subsurface materials. These eddy currents have associated secondary magnetic fields whose strength and phase shift (relative to the primary field) are dependent on the conductivity of the medium. The combined effect of the primary and secondary fields is measured by the receiver coil. Both in phase and 90 degrees out of phase (quadrature) components are measured. The quadrature component, also referred to as terrain conductivity, is representative of the conductivity of subsurface materials in milli-Siemens/ meter. The in-phase component is measured in parts per thousand, also referred to as current density, and its value is generally representative of the presence or absence of accumulations of buried metallic debris.

3.1.2 Soil Results

As presented in **Table 3-1**, 10 surface and 20 subsurface samples were collected for chemical analysis. One surface and two subsurface samples were collected from ten soil borings (43SB01 through 43SB10) to characterize the landfill material and soil above, within, and below the landfill. Sample locations are depicted on **Figure 3-1**. As shown in **Table 3-1**, all soil samples were analyzed for target compound list (TCL) VOCs, SVOCs, polynuclear aromatic hydrocarbons (PAHs), pesticides/polychlorinated biphenyls (PCBs), herbicides, explosives, and TAL metals. Additionally, samples 43SB03A, 43SB03B, 43SB03C, 43SB08A, 43SB08B, and 43SB08C were analyzed for dioxins/furans as well. Soil detections above screening levels (SLs) are illustrated on **Figure 3-2**. **Figure 3-3**, originally Figure 3 from the Geophysical Survey Report, found in **Appendix C-1**, shows an interpretation of the waste location and this was used to help plan out the soil sample locations.

3.1.3 Groundwater Results

Six groundwater samples (43MW1, 43MW2, 43MW3, 43MW4, 43MW5, and 43MW6) were collected from the existing monitoring wells to assess potential contaminant migration. As shown in **Table 3-1**, groundwater samples were analyzed for TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and perchlorate.

Well purge forms are presented in **Appendix B**. Groundwater sample locations are illustrated on **Figure 3-1** and the detections above SLs are illustrated on **Figure 3-2**.

3.1.4 Global Positioning System Activities

For SWMU 43, sample location coordinates and elevations were obtained for soil borings 43SB01 through 43SB10 using a Trimble Geo XH Global Positioning System. The Geo XH system was used to obtain real-time position information with sub-meter accuracy and elevations at 1.5 to 2 times the horizontal accuracy. Horizontal position information was recorded in the U.S. State Plane [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 1988. Position information will be entered into the Environmental Restoration Information System database. Sample location coordinates and elevations are presented in **Appendix C-2**.

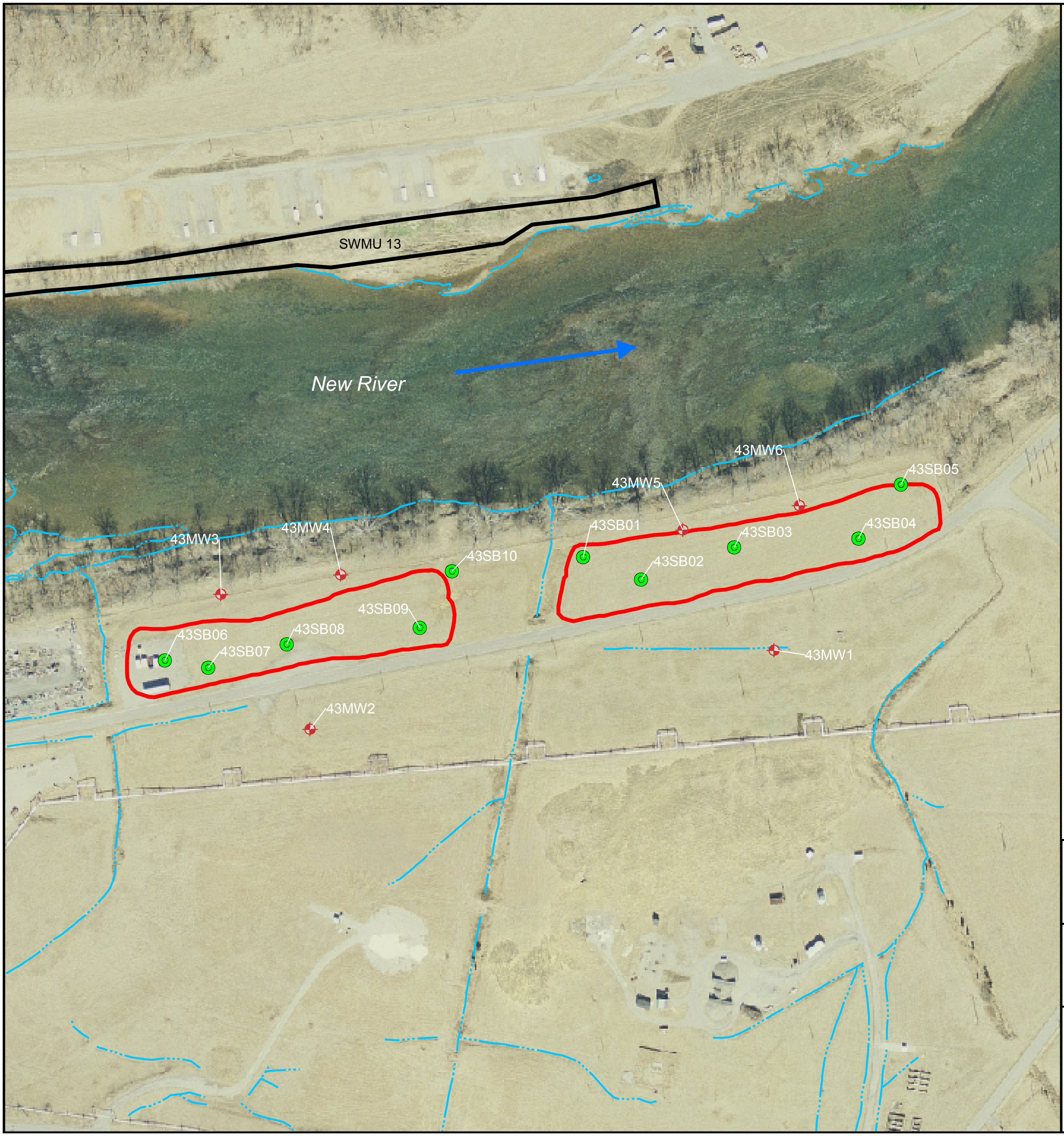
3.1.5 Quality Assurance

The accuracy and integrity of 2007 RFI SWMU 43 data were ensured through the implementation of internal quality control (QC) measures in accordance with *MWP Addendum 019* (Shaw, 2007), as approved by USEPA Region III and the VDEQ. Quality assurance (QA) and QC activities, including field QC, laboratory QC, data management, and data validation were integrated into the investigation program to meet data quality objectives (DQOs) established for the RFI. The data were evaluated for each of the DQO indicators in **Appendix A-2, Table A-3** and found to meet the pre-established goals. Qualified data did not impact the data quality of the RFI. Complete details of the RFI QA/QC analysis and activities are presented in **Appendix A-2**. Chemical data validation reports and analytical data are provided in **Appendix A-3**.

3.1.6 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. Adjustments to *MWP Addendum 019* (Shaw, 2007) were necessary during sampling activities at SWMU 43.

Two surface water samples were proposed to be collected from the seeps where previous samples were collected. However, none of the seep samples were collected because of a drought at the time of sampling.



LEGEND

- ⌖ Monitoring Well Location
- ● Soil Sample Location
- — Water Feature
- 🟥 SWMU 43 Boundary
- ☐ Other SWMU Boundary

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

N

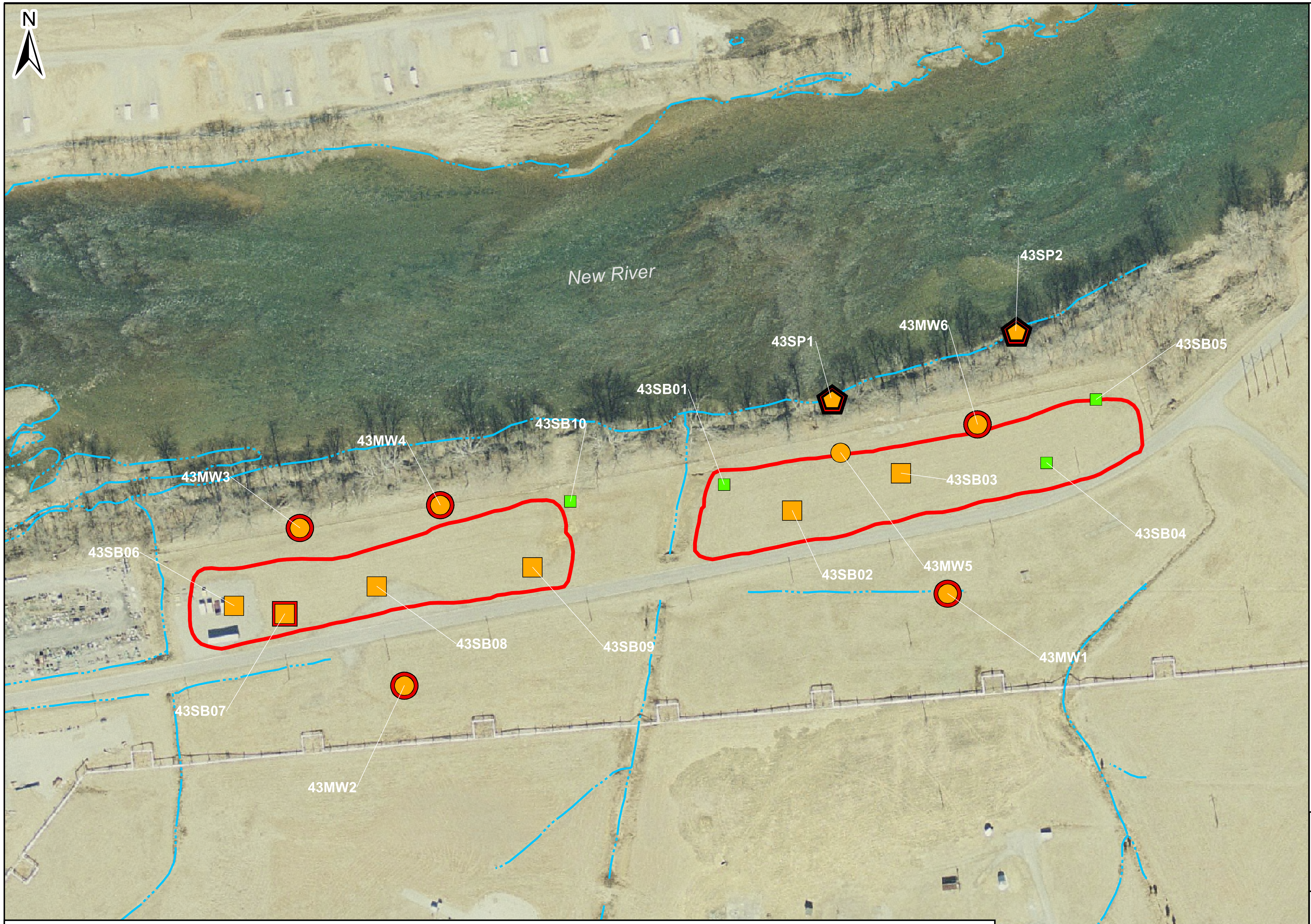
Scale:
0 125 250 500
Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 3-1
SWMU 43
2007 Sample Locations
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\SWMU_43\RFAAP_Fig3-1_SWMU43_2007_SampleLocations_RFI.mxd (10/27/2009)



LEGEND

🟩	Soil Sample Location Result < r-SL and i-SL	⬠	Surface Water Sample Location Result < tw-SL and MCL	●	Groundwater Sample Location Result < MCL and tw-SL	—	Water Feature
🟧	Soil Sample Location Result >= r-SL	⬠	Surface Water Sample Location Result >= tw-SL	●	Groundwater Sample Location Result >= tw-SL	▭	SWMU 43 Boundary
🟥	Soil Sample Location Result >= i-SL	⬠	Surface Water Sample Location Result >= MCL	●	Groundwater Sample Location Result >= MCL		

Soil, Surface Water, and Groundwater Results

Soil Results

Sample ID	Soil r-SL Exceedances	Soil i-SL Exceedances
43SB02A	1 PAH	
43SB02B	1 PCB	
43SB03A	1 PAH, 1 DIOXIN/FURAN	
43SB03B	1 PAH, 2 PCBs, 1 METAL, 1 EXPL, 4 DIOXINS/FURANS	
43SB06B	1 PCB	
43SB07A	1 PCB, 1 METAL	1 METAL
43SB07B	1 PCB	
43SB08B	1 PCB	
43SB09A	1 PAH	
43SB09B	1 PCB, 1 METAL	

Surface Water Results

Sample ID	Surface Water tw-SL Exceedances	Surface Water MCL Exceedances
43SP1	3 METALS	4 METALS
43SP2	2 METALS	2 METALS

Groundwater Results

Sample ID	Groundwater tw-SL Exceedances	Groundwater MCL Exceedances
43MW1	1 VOC, 1 METAL	1 METAL
43MW2	2 METALS	2 METALS
43MW3	1 VOC, 4 METALS	3 METALS
43MW4	1 VOC, 7 METALS	4 METALS
43MW5	1 VOC, 1 METAL	
43MW6	1 VOC, 6 METALS	5 METALS

Scale:
0 75 150 300
Feet

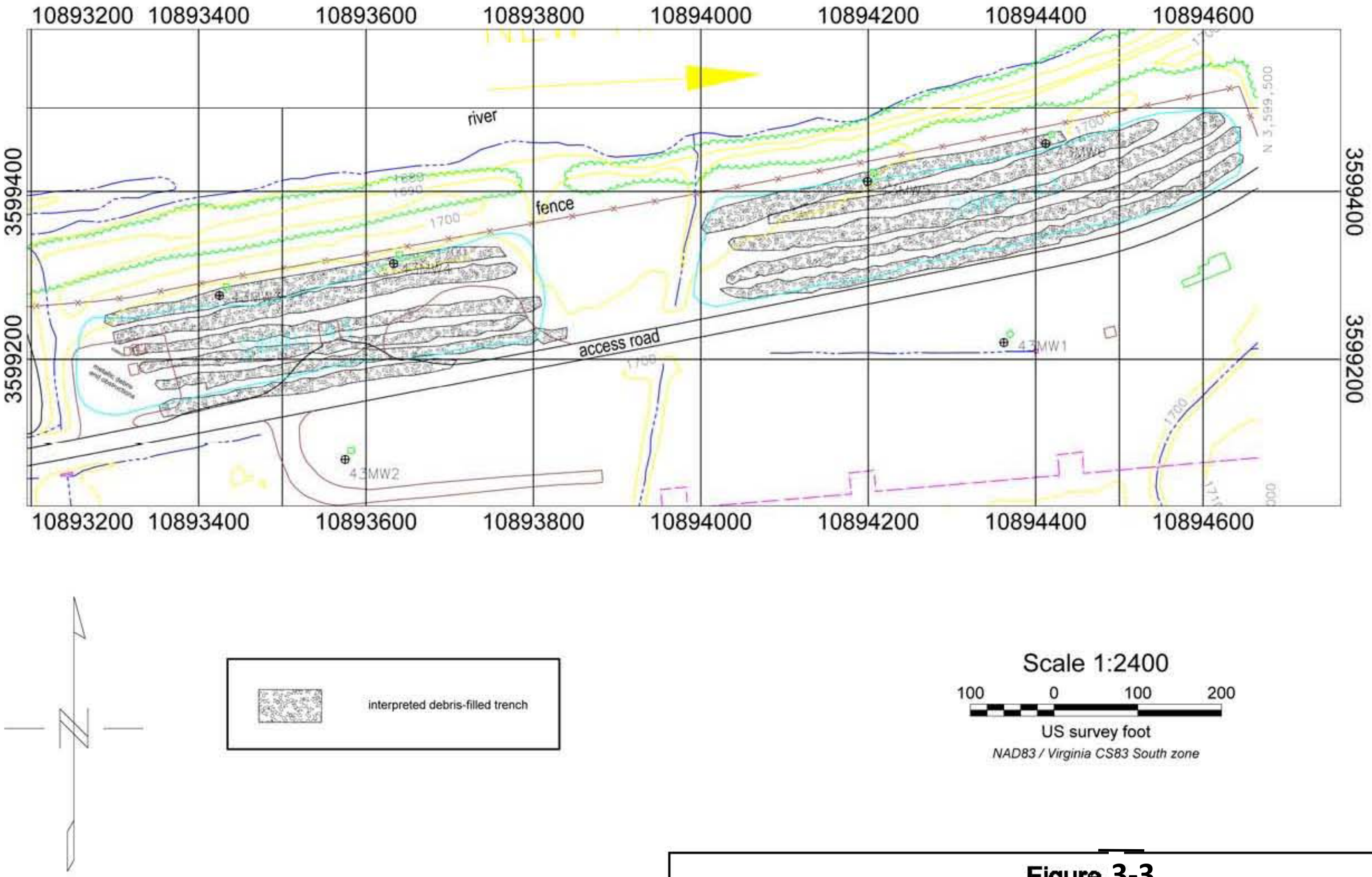
Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 3-2
Soil, Surface Water,
and Groundwater Results at SWMU 43
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\SWMU_43\RFAAP_Fig3-2_SWMU43_Sample_Results.mxd (5/29/2009 3:50:44 PM)



prepared by **Shaw** Environmental & Infrastructure Geophysics & Mapping Group

Figure 3-3
RAAP
EM31 Terrain Conductivity Survey

SWMU43 - Interpreted Subsurface Features

survey date: April 22, 2007
DRAFT

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, surface water, and groundwater at SWMU 43. 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/Oak Ridge National Laboratory (ORNL) Regional industrial screening levels (i-SLs) and residential screening levels (r-SLs) (USEPA, 2008a), as well as facility-wide background inorganic concentrations (IT, 2001), and other regulatory criteria. I-SLs and r-SLs 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 (September 2008) screening values and background 95% upper tolerance limits are presented for comparison in the soil result tables. Analytical results for inorganics in soil are indicated on the tables and figures as constituents of concern when they were above both the background value and a screening value. Eliminating analytes as constituents of concern when they are above an SL but below their background value allows site-specific constituents to be more clearly indicated on the tables and figures. Soil results from the 2007 RFI are presented in *Section 4.1*.2.

Groundwater/Surface Water Screening. Surface water and groundwater sampling results are compared to the 2006 Edition of the Drinking Water Standards and Health Advisories (i.e., MCLs and secondary MCLs) (USEPA, 2006a) and adjusted tw-SLs (USEPA, 2008a). Consistent with soil screening, tw-SLs 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. Groundwater results from the 2007 RFI are presented in *Section 4.1*.3.

4.1 RFI, Shaw, 2007

4.1.1 Geophysical Survey Results

As described in *Section 2.1*, SWMU 43 consists of two adjacent approximately 1.5-acre cells divided by a central drainage ditch. Aerial photographic interpretations indicate that the landfill was used as a trench-fill operation. Previous subsidence of the ground surface in the form of elongated depressions suggested that disposal occurred in within trenches on the eastern and western sections.

Geophysical survey results are consistent with historical information and aerial photographic interpretations. As shown in **Appendix C-1, Figures 1 through 3**, survey results indicate that a series of extensive, backfilled trenches oriented approximately parallel to the asphalt road are present within the eastern and western sections of the site. As illustrated in **Appendix C-1, Figure 3**, the disposal trenches are closely spaced and span the entire length and width of the eastern section and most likely span the entire length and width of the western section. The far western edge of the survey area in the western section was not accessible due to the presence of office and equipment trailers on the surface, which would have grossly interfered with the EM31 measurements.

4.1.2 Soil Analytical Results

Ten surface samples (43SB01A through 43SB10A) and 20 subsurface samples (43SB01B/C through 43SB10B/C) were collected at SWMU 43 and analyzed for TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals. Six subsurface soil samples (43SB03A/B/C and 43SB0 8A/B/C) were also analyzed for dioxins/furans. Detected results are presented in **Table 4-1**, summarized in **Table 4-2**, and illustrated on **Figure 3-2**.

VOCs. Eight VOCs (2-butanone, acetone, carbon disulfide, ethylbenzene, m- & p-xylene, o-xylene, toluene, and vinyl chloride) were detected in SWMU 43 soil samples. The maximum concentration of the VOCs was located at sample 43SB02B. All the concentrations were well below the adjusted industrial and residential SLs.

PAHs. Fifteen (15) PAHs were detected in site soil samples. Benzo(a)pyrene was detected at levels greater than its r-SL in three surface soil sample locations (43SB02A, 43SB03A, and 43SB09A) and one subsurface soil sample (43SB03B). Concentrations of benzo(a)pyrene were below its i-SL in all soil samples.

SVOCs. Five SVOCs [bis(2-ethylhexyl)phthalate, dibenzofuran, diethylphthalate, di-n-butylphthalate, and n-nitrosodiphenylamine] were detected in on-site soils, with maximum concentrations found in 43SB09B. However, the concentrations were well below the adjusted industrial and residential SLs.

Pesticides. Two pesticides (4,4-DDD and dieldrin) were each detected once in on-site soil samples. 4,4-DDD and dieldrin were detected at 43SB03B and 43SB06B, respectively. All concentrations were well below the adjusted industrial and residential SLs.

PCBs. Three PCBs (PCB-1016, PCB-1254, and PCB-1260) were detected in soil samples. PCB-1016 was only detected in subsurface soil samples 43SB02B, 43SB03B, 43SB08B, and 43SB09B and was detected above its r-SL only in 43SB03B. PCB-1254 was detected in 43SB02B, 43SB03B, 43SB05A, 43SB06B, 43SB07A, 43SB07B, 43SB08B, and 43SB09B. All of these detections were above their r-SLs, except for 43SB05A. PCB-1260 was only detected in subsurface soil samples 43SB06B and 43SB07B at concentrations below residential and industrial SLs.

Explosives. Three explosives [2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene, 2-amino-4,6-dinitrotoluene] were detected in SWMU 43 soil samples. All explosives were detected in subsurface soil sample 43SB03B. 2,4,6-TNT was the only explosive that was found above its r-SL.

Herbicides. One herbicide (dicamba) was detected in one surface sample (43SB01A) at a concentration well below the adjusted SLs.

TAL Metals. Twenty-two (22) TAL metals were detected in the site soil samples. Two metals (arsenic and mercury) were detected above the adjusted SLs. Arsenic was detected above its background level, i-SL, and r-SL in 43SB07A. Mercury was detected above both its background level and r-SL in samples 43SB03B and 43SB09B. Arsenic, beryllium, cadmium, copper, lead, and mercury were detected above their background levels, but below residential and industrial SLs.

Table 4-1
Analytes Detected in SWMU 43 Soil Samples - 2007 RFI
Page 1 of 12

Analyte			Sample ID	43SB01A					43SB01B					43SB01C					43SB02A					43SB02B				
			Sample Date	7/26/07					7/26/07					7/26/07					7/26/07					7/26/07				
			Sample Depth	0-0.5					4-6					8-10					0-0.5					4-6				
	i-SL	r-SL	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	19000000	2800000	na	22	U		9	22	24	U		9.7	24	26	U		10	26	29	U		11	29	13.7	J	J	11	27
Acetone	61000000	6100000	na	40.5	J	J	22	45	48	U		24	48	30.9	J	J	26	51	57	U		29	57	82.8			27	54
Carbon disulfide	300000	67000	na	2.1	J	J	0.9	4.5	4.8	U		0.97	4.8	5.1	U		1	5.1	5.7	U		1.1	5.7	9		J	1.1	5.4
Ethylbenzene	29000	5700	na	4.5	U		0.9	4.5	4.8	U		0.97	4.8	5.1	U		1	5.1	5.7	U		1.1	5.7	5.4	U	UJ	1.1	5.4
m- & p-Xylene	na	na	na	9	U		0.99	9	9.7	U		1.1	9.7	10	U		1.1	10	11	U		1.3	11	11	U		1.2	11
o-Xylene	2300000	530000	na	4.5	U		0.9	4.5	4.8	U		0.97	4.8	5.1	U		1	5.1	5.7	U		1.1	5.7	5.4	U		1.1	5.4
Toluene	4600000	500000	na	4.5	U		0.9	4.5	4.8	U		0.97	4.8	5.1	U		1	5.1	5.7	U		1.1	5.7	5.4	U		1.1	5.4
Vinyl chloride	1700	60	na	4.5	U		1.3	4.5	4.8	U		1.4	4.8	5.1	U		1.4	5.1	5.7	U		1.6	5.7	5.4	U		1.5	5.4
PAHs (ug/kg)																												
1-Methylnaphthalene	99000	22000	na	300	U		45	300	310	U		46	310	300	U		46	300	290	U		43	290	320	U		48	320
2-Methylnaphthalene	410000	31000	na	300	U		45	300	310	U		46	310	300	U		46	300	290	U		43	290	52.1	J	J	48	320
Acenaphthene	3300000	340000	na	300	U		74	300	310	U		77	310	300	U		76	300	290	U		71	290	320	U		80	320
Benz(a)anthracene	2100	150	na	59	U		15	59	62	U		15	62	61	U		15	61	23.2	J	J	14	57	16.4	J	J	16	64
Benzo(a)pyrene	210	15	na	59	U		15	59	62	U		15	62	61	U		15	61	31.4	J	J	14	57	64	U		16	64
Benzo(b)fluoranthene	2100	150	na	59	U		15	59	62	U		15	62	61	U		15	61	29.9	J	J	14	57	64	U		16	64
Benzo(g,h,i)perylene	1700000	170000	na	59	U		15	59	62	U		15	62	61	U		15	61	20.6	J	J	14	57	64	U		16	64
Benzo(k)fluoranthene	21000	1500	na	59	U		15	59	62	U		15	62	61	U		15	61	21.9	J	J	14	57	64	U		16	64
Chrysene	210000	15000	na	59	U		15	59	62	U		15	62	61	U		15	61	29.7	J	J	14	57	20	J	J	16	64
Fluoranthene	2200000	230000	na	300	U		52	300	310	U		54	310	300	U		53	300	290	U		50	290	320	U		56	320
Fluorene	2200000	230000	na	300	U		45	300	310	U		46	310	300	U		46	300	290	U		43	290	320	U		48	320
Indeno(1,2,3-cd)pyrene	2100	150	na	59	U		15	59	62	U		15	62	61	U		15	61	18.4	J	J	14	57	64	U		16	64
Naphthalene	20000	3900	na	300	U		45	300	310	U		46	310	300	U		46	300	290	U		43	290	77.9	J	J	48	320
Phenanthrene	1700000	170000	na	300	U		45	300	310	U		46	310	300	U		46	300	290	U		43	290	320	U		48	320
Pyrene	1700000	170000	na	300	U		52	300	310	U		54	310	300	U		53	300	290	U		50	290	320	U		56	320
SVOCs (ug/kg)																												
bis(2-Ethylhexyl)phthalate	120000	35000	na	370	U		190	370	390	U		190	390	380	U		190	380	360	U		180	360	366	J	J	200	400
Dibenzofuran	na	na	na	190	U		37	190	190	U		39	190	190	U		38	190	180	U		36	180	200	U		40	200
Diethylphthalate	49000000	4900000	na	370	U		190	370	390	U		190	390	380	U		190	380	360	U		180	360	400	U		200	400
Di-n-butylphthalate	6200000	610000	na	370	U		93	370	390	U		96	390	380	U		95	380	360	U		89	360	400	U	UJ	100	400
N-nitrosodiphenylamine	350000	99000	na	190	U		37	190	190	U		39	190	190	U		38	190	180	U		36	180	442		J	40	200
Pesticides (ug/kg)																												
4,4'-DDD	7200	2000	na	3.7	U		0.74	3.7	3.8	U		0.77	3.8	3.9	U		0.77	3.9	3.6	U		0.71	3.6	20	U		3.9	20
Dieldrin	110	30	na	1.9	U		0.41	1.9	1.9	U		0.42	1.9	1.9	U		0.42	1.9	1.8	U		0.39	1.8	9.8	U		2.2	9.8
PCBs (mg/kg)																												
PCB-1016	2.1	0.39	na	0.019	U		0.0093	0.019	0.019	U		0.0096	0.019	0.019	U		0.0096	0.019	0.018	U		0.0089	0.018	0.104	J	J	0.049	0.098
PCB-1254	0.74	0.022	na	0.019	U		0.0093	0.019	0.019	U		0.0096	0.019	0.019	U		0.0096	0.019	0.018	U		0.0089	0.018	0.451	J	J	0.049	0.098
PCB-1260	0.74	0.22	na	0.019	U		0.0093	0.019	0.019	U		0.0096	0.019	0.019	U		0.0096	0.019	0.018	U		0.0089	0.018	0.098	U		0.049	0.098
Explosives (mg/kg)																												
2,4,6-Trinitrotoluene	7.9	1.9	na	0.21	U		0.042	0.21	0.18	U		0.036	0.18	0.18	U		0.036	0.18	0.2	U		0.039	0.2	0.2	U		0.039	0.2
2,4-Dinitrotoluene	120	12	na	0.21	U		0.042	0.21	0.18	U		0.036	0.18	0.18	U		0.036	0.18	0.2	U		0.039	0.2	0.2	U		0.039	0.2
2-amino-4,6-Dinitrotoluene	200	15	na	0.21	U		0.042	0.21	0.18	U		0.036	0.18	0.18	U		0.036	0.18	0.2	U		0.039	0.2	0.2	U		0.039	0.2
Herbicides (ug/kg)																												
Dicamba	1800000	180000	na	6.7	J	J	5.7	7.6	7.7	U		5.8	7.7	7.7	U		5.8	7.7	7.3	U		5.4	7.3	8	U	UL	6	8

Table 4-1
Analytes Detected in SWMU 43 Soil Samples - 2007 RFI
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Analyte			Sample ID	43SB02C					43SB03A					43SB03B					43SB03C					43SB04A				
			Sample Date	7/26/07					7/26/07					7/26/07					7/26/07					7/26/07				
			Sample Depth	8-10					0-0.5					4-6					8-10					0-0.5				
	i-SL	**r-SL**	**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	19000000	2800000	na	25	U		10	25	28	U		11	28	26	U	UL	11	26	23	U		9.1	23	32	U		13	32
Acetone	61000000	6100000	na	50	U		25	50	55	U		28	55	58.5		L	26	53	68.8			23	46	63	U		32	63
Carbon disulfide	300000	67000	na	5	U		1	5	5.5	U		1.1	5.5	5.3	U		1.1	5.3	4.6	U		0.91	4.6	6.3	U		1.3	6.3
Ethylbenzene	29000	5700	na	5	U		1	5	5.5	U		1.1	5.5	5.3	U		1.1	5.3	4.6	U		0.91	4.6	6.3	U		1.3	6.3
m- & p-Xylene	na	na	na	10	U		1.1	10	11	U		1.2	11	11	U		1.2	11	9.1	U		1	9.1	13	U		1.4	13
o-Xylene	2300000	530000	na	5	U		1	5	5.5	U		1.1	5.5	5.3	U		1.1	5.3	4.6	U		0.91	4.6	6.3	U		1.3	6.3
Toluene	4600000	500000	na	5	U		1	5	5.5	U		1.1	5.5	5.3	U		1.1	5.3	4.6	U		0.91	4.6	6.3	U		1.3	6.3
Vinyl chloride	1700	60	na	5	U		1.4	5	5.5	U		1.5	5.5	6.6		K	1.5	5.3	4.6	U		1.3	4.6	6.3	U		1.8	6.3
PAHs (ug/kg)																												
1-Methylnaphthalene	99000	22000	na	320	U		47	320	310	U		46	310	300	U		45	300	290	U		44	290	290	U		43	290
2-Methylnaphthalene	410000	31000	na	320	U		47	320	310	U		46	310	300	U		45	300	290	U		44	290	290	U		43	290
Acenaphthene	3300000	340000	na	320	U		79	320	310	U		77	310	300	U		74	300	290	U		73	290	290	U		72	290
Benz(a)anthracene	2100	150	na	63	U		16	63	17.9	J	J	15	62	60	U		15	60	59	U		15	59	58	U		14	58
Benzo(a)pyrene	210	15	na	63	U		16	63	18.9	J	J	15	62	15.2	J	J	15	60	59	U		15	59	58	U		14	58
Benzo(b)fluoranthene	2100	150	na	63	U		16	63	17.1	J	J	15	62	25.7	J	J	15	60	59	U		15	59	58	U		14	58
Benzo(g,h,i)perylene	1700000	170000	na	63	U		16	63	62	U		15	62	60	U		15	60	59	U		15	59	58	U		14	58
Benzo(k)fluoranthene	21000	1500	na	63	U		16	63	62	U		15	62	60	U		15	60	59	U		15	59	58	U		14	58
Chrysene	210000	15000	na	63	U		16	63	16.9	J	J	15	62	20.6	J	J	15	60	59	U		15	59	58	U		14	58
Fluoranthene	2200000	230000	na	320	U		55	320	310	U		54	310	300	U		52	300	290	U		51	290	290	U		51	290
Fluorene	2200000	230000	na	320	U		47	320	310	U		46	310	300	U		45	300	290	U		44	290	290	U		43	290
Indeno(1,2,3-cd)pyrene	2100	150	na	63	U		16	63	62	U		15	62	60	U		15	60	59	U		15	59	58	U		14	58
Naphthalene	20000	3900	na	320	U		47	320	310	U		46	310	300	U		45	300	290	U		44	290	290	U		43	290
Phenanthrene	1700000	170000	na	320	U		47	320	310	U		46	310	64.5	J	J	45	300	290	U		44	290	290	U		43	290
Pyrene	1700000	170000	na	320	U		55	320	310	U		54	310	300	U		52	300	290	U		51	290	290	U		51	290
SVOCs (ug/kg)																												
bis(2-Ethylhexyl)phthalate	120000	35000	na	400	U		200	400	390	U		190	390	418			190	370	370	U		180	370	360	U		180	360
Dibenzofuran	na	na	na	200	U		40	200	190	U		39	190	190	U		37	190	180	U		37	180	180	U		36	180
Diethylphthalate	49000000	4900000	na	400	U		200	400	390	U		190	390	370	U		190	370	370	U		180	370	360	U		180	360
Di-n-butylphthalate	6200000	610000	na	400	U		99	400	390	U		97	390	512			93	370	370	U		91	370	360	U		90	360
N-nitrosodiphenylamine	350000	99000	na	200	U		40	200	190	U		39	190	856			37	190	180	U		37	180	180	U		36	180
Pesticides (ug/kg)																												
4,4'-DDD	7200	2000	na	3.9	U		0.79	3.9	3.7	U		0.74	3.7	14.1	J	J	7.3	37	3.6	U		0.72	3.6	3.6	U		0.72	3.6
Dieldrin	110	30	na	2	U		0.43	2	1.8	U		0.4	1.8	18	U		4	18	1.8	U		0.39	1.8	1.8	U		0.39	1.8
PCBs (mg/kg)																												
PCB-1016	2.1	0.39	na	0.02	U		0.0098	0.02	0.018	U		0.0092	0.018	0.694	J	J	0.091	0.18	0.018	U		0.0089	0.018	0.018	U		0.0089	0.018
PCB-1254	0.74	0.022	na	0.02	U		0.0098	0.02	0.018	U		0.0092	0.018	0.462	J	J	0.091	0.18	0.018	U		0.0089	0.018	0.018	U		0.0089	0.018
PCB-1260	0.74	0.22	na	0.02	U		0.0098	0.02	0.018	U		0.0092	0.018	0.18	U		0.091	0.18	0.018	U		0.0089	0.018	0.018	U		0.0089	0.018
Explosives (mg/kg)																												
2,4,6-Trinitrotoluene	7.9	1.9	na	0.19	U		0.038	0.19	0.2	U		0.041	0.2	6.37		J	0.047	0.23	0.21	U		0.043	0.21	0.23	U		0.047	0.23
2,4-Dinitrotoluene	120	12	na	0.19	U		0.038	0.19	0.2	U		0.041	0.2	0.727			0.047	0.23	0.21	U		0.043	0.21	0.23	U		0.047	0.23
2-amino-4,6-Dinitrotoluene	200	15	na	0.19	U		0.038	0.19	0.2	U		0.041	0.2	0.136	J	J	0.047	0.23	0.21	U		0.043	0.21	0.23	U		0.047	0.23
Herbicides (ug/kg)																												
Dicamba	1800000	180000	na	7.9	U		5.9	7.9	7.6	U	UL	5.7	7.6	7.6	U	UJ	5.7	7.6	7.2	U	UL	5.4	7.2	7.1	U		5.3	7.1

Table 4-1
Analytes Detected in SWMU 43 Soil Samples - 2007 RFI

Analyte			Sample ID	43SB04B					43SB04C					43SB05A					43SB05B					43SB05C				
			Sample Date	7/26/07					7/26/07					7/26/07					7/26/07					7/26/07				
			Sample Depth	4-6					8-10					0-0.5					4-6					8-10				
	i-SL	r-SL	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	19000000	2800000	na	28	U		11	28	26	U		10	26	27	U		11	27	27	U		11	27	27	U		11	27
Acetone	61000000	6100000	na	56	U		28	56	48.5	J	J	26	52	54	U		27	54	43.6	J	J	27	54	42.3	J	J	27	54
Carbon disulfide	300000	67000	na	5.6	U		1.1	5.6	5.3			1	5.2	5.4	U		1.1	5.4	5.4	U		1.1	5.4	5.4	U		1.1	5.4
Ethylbenzene	29000	5700	na	5.6	U		1.1	5.6	5.2	U		1	5.2	5.4	U		1.1	5.4	5.4	U		1.1	5.4	5.4	U		1.1	5.4
m- & p-Xylene	na	na	na	11	U		1.2	11	10	U		1.1	10	11	U		1.2	11	11	U		1.2	11	11	U		1.2	11
o-Xylene	2300000	530000	na	5.6	U		1.1	5.6	5.2	U		1	5.2	5.4	U		1.1	5.4	5.4	U		1.1	5.4	5.4	U		1.1	5.4
Toluene	4600000	500000	na	5.6	U		1.1	5.6	5.2	U		1	5.2	5.4	U		1.1	5.4	5.4	U		1.1	5.4	5.4	U		1.1	5.4
Vinyl chloride	1700	60	na	5.6	U		1.6	5.6	5.2	U		1.5	5.2	5.4	U		1.5	5.4	5.4	U		1.5	5.4	5.4	U		1.5	5.4
PAHs (ug/kg)																												
1-Methylnaphthalene	99000	22000	na	320	U		47	320	310	U		47	310	290	U		43	290	310	U		47	310	310	U		47	310
2-Methylnaphthalene	410000	31000	na	320	U		47	320	310	U		47	310	290	U		43	290	310	U		47	310	310	U		47	310
Acenaphthene	3300000	340000	na	320	U		79	320	310	U		78	310	290	U		72	290	310	U		79	310	310	U		79	310
Benz(a)anthracene	2100	150	na	63	U		16	63	62	U		16	62	57	U		14	57	63	U		16	63	63	U		16	63
Benzo(a)pyrene	210	15	na	63	U		16	63	62	U		16	62	57	U		14	57	63	U		16	63	63	U		16	63
Benzo(b)fluoranthene	2100	150	na	63	U		16	63	62	U		16	62	57	U		14	57	63	U		16	63	63	U		16	63
Benzo(g,h,i)perylene	1700000	170000	na	63	U		16	63	62	U		16	62	57	U		14	57	63	U		16	63	63	U		16	63
Benzo(k)fluoranthene	21000	1500	na	63	U		16	63	62	U		16	62	57	U		14	57	63	U		16	63	63	U		16	63
Chrysene	210000	15000	na	63	U		16	63	62	U		16	62	57	U		14	57	63	U		16	63	63	U		16	63
Fluoranthene	2200000	230000	na	320	U		55	320	310	U		55	310	290	U		50	290	310	U		55	310	310	U		55	310
Fluorene	2200000	230000	na	320	U		47	320	310	U		47	310	290	U		43	290	310	U		47	310	310	U		47	310
Indeno(1,2,3-cd)pyrene	2100	150	na	63	U		16	63	62	U		16	62	57	U		14	57	63	U		16	63	63	U		16	63
Naphthalene	20000	3900	na	320	U		47	320	310	U		47	310	290	U		43	290	310	U		47	310	310	U		47	310
Phenanthrene	1700000	170000	na	320	U		47	320	310	U		47	310	290	U		43	290	310	U		47	310	310	U		47	310
Pyrene	1700000	170000	na	320	U		55	320	310	U		55	310	290	U		50	290	310	U		55	310	310	U		55	310
SVOCs (ug/kg)																												
bis(2-Ethylhexyl)phthalate	120000	35000	na	400	U		200	400	390	U		190	390	360	U		180	360	390	U		200	390	390	U		200	390
Dibenzofuran	na	na	na	200	U		40	200	190	U		39	190	180	U		36	180	200	U		39	200	200	U		39	200
Diethylphthalate	49000000	4900000	na	400	U		200	400	390	U		190	390	360	U		180	360	390	U		200	390	390	U		200	390
Di-n-butylphthalate	6200000	610000	na	400	U		99	400	390	U		97	390	360	U		90	360	390	U		98	390	390	U		98	390
N-nitrosodiphenylamine	350000	99000	na	200	U		40	200	190	U		39	190	180	U		36	180	200	U		39	200	200	U		39	200
Pesticides (ug/kg)																												
4,4'-DDD	7200	2000	na	3.9	U		0.77	3.9	3.9	U		0.78	3.9	3.7	U		0.73	3.7	3.9	U		0.79	3.9	4	U		0.8	4
Dieldrin	110	30	na	1.9	U		0.42	1.9	1.9	U		0.43	1.9	1.8	U		0.4	1.8	2	U		0.43	2	2	U		0.44	2
PCBs (mg/kg)																												
PCB-1016	2.1	0.39	na	0.019	U		0.0097	0.019	0.019	U		0.0097	0.019	0.018	U		0.0091	0.018	0.02	U		0.0099	0.02	0.02	U		0.01	0.02
PCB-1254	0.74	0.022	na	0.019	U		0.0097	0.019	0.019	U		0.0097	0.019	0.0094	J	J	0.0091	0.018	0.02	U		0.0099	0.02	0.02	U		0.01	0.02
PCB-1260	0.74	0.22	na	0.019	U		0.0097	0.019	0.019	U		0.0097	0.019	0.018	U		0.0091	0.018	0.02	U		0.0099	0.02	0.02	U		0.01	0.02
Explosives (mg/kg)																												
2,4,6-Trinitrotoluene	7.9	1.9	na	0.21	U		0.042	0.21	0.2	U		0.041	0.2	0.19	U		0.038	0.19	0.2	U		0.04	0.2	0.19	U		0.039	0.19
2,4-Dinitrotoluene	120	12	na	0.21	U		0.042	0.21	0.2	U		0.041	0.2	0.19	U		0.038	0.19	0.2	U		0.04	0.2	0.19	U		0.039	0.19
2-amino-4,6-Dinitrotoluene	200	15	na	0.21	U		0.042	0.21	0.2	U		0.041	0.2	0.19	U		0.038	0.19	0.2	U		0.04	0.2	0.19	U		0.039	0.19
Herbicides (ug/kg)																												
Dicamba	1800000	180000	na	7.9	U		5.9	7.9	7.8	U		5.9	7.8	7.2	U		5.4	7.2	7.9	U		5.9	7.9	8.1	U		6	8.1

Table 4-1
Analytes Detected in SWMU 43 Soil Samples - 2007 RFI
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Analyte			Sample ID	43SB06A					43SB06B					43SB06C					43SB07A					43SB07B				
			Sample Date	7/25/07					7/25/07					7/25/07					7/25/07					7/25/07				
			Sample Depth	0-0.5					4-6					8-10					0-0.5					4-6				
	i-SL	r-SL	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	19000000	2800000	na	23	U		9.3	23	36	U		14	36	23	U		9.3	23	36	U		14	36	27	U		11	27
Acetone	61000000	6100000	na	29.1	J	J	23	46	94			36	71	43.5	J	J	23	47	72	U		36	72	44.8	J	J	27	54
Carbon disulfide	300000	67000	na	4.6	U		0.93	4.6	7.1	U		1.4	7.1	4.7	U		0.93	4.7	7.2	U		1.4	7.2	5.4	U		1.1	5.4
Ethylbenzene	29000	5700	na	4.6	U	UJ	0.93	4.6	7.1	U	UJ	1.4	7.1	4.7	U	UJ	0.93	4.7	7.2	U	UJ	1.4	7.2	5.4	U	UJ	1.1	5.4
m- & p-Xylene	na	na	na	9.3	U		1	9.3	14	U		1.6	14	9.3	U		1	9.3	14	U		1.6	14	9.8	J	J	1.2	11
o-Xylene	2300000	530000	na	4.6	U		0.93	4.6	7.1	U		1.4	7.1	4.7	U		0.93	4.7	7.2	U		1.4	7.2	5.4	U		1.1	5.4
Toluene	4600000	500000	na	4.6	U		0.93	4.6	7.1	U		1.4	7.1	4.7	U		0.93	4.7	7.2	U		1.4	7.2	5.4	U		1.1	5.4
Vinyl chloride	1700	60	na	4.6	U		1.3	4.6	7.1	U		2	7.1	4.7	U		1.3	4.7	7.2	U		2	7.2	5.4	U		1.5	5.4
PAHs (ug/kg)																												
1-Methylnaphthalene	99000	22000	na	310	U	UJ	46	310	320	U	UJ	48	320	290	U	UJ	44	290	300	U		44	300	310	U		47	310
2-Methylnaphthalene	410000	31000	na	310	U		46	310	320	U		48	320	290	U		44	290	300	U		44	300	310	U		47	310
Acenaphthene	3300000	340000	na	310	U		77	310	320	U		81	320	290	U		73	290	300	U		74	300	310	U		78	310
Benz(a)anthracene	2100	150	na	62	U		15	62	64	U		16	64	59	U		15	59	59	U		15	59	62	U		16	62
Benzo(a)pyrene	210	15	na	62	U		15	62	64	U		16	64	59	U		15	59	59	U		15	59	62	U		16	62
Benzo(b)fluoranthene	2100	150	na	62	U		15	62	64	U		16	64	59	U		15	59	59	U		15	59	62	U		16	62
Benzo(g,h,i)perylene	1700000	170000	na	62	U		15	62	64	U		16	64	59	U		15	59	59	U		15	59	62	U		16	62
Benzo(k)fluoranthene	21000	1500	na	62	U		15	62	64	U		16	64	59	U		15	59	59	U		15	59	62	U		16	62
Chrysene	210000	15000	na	62	U	UJ	15	62	64	U	UJ	16	64	59	U	UJ	15	59	59	U		15	59	62	U		16	62
Fluoranthene	2200000	230000	na	310	U		54	310	320	U		56	320	290	U		51	290	300	U		52	300	310	U		55	310
Fluorene	2200000	230000	na	310	U		46	310	320	U		48	320	290	U		44	290	300	U		44	300	310	U		47	310
Indeno(1,2,3-cd)pyrene	2100	150	na	62	U		15	62	64	U		16	64	59	U		15	59	59	U		15	59	62	U		16	62
Naphthalene	20000	3900	na	310	U		46	310	320	U		48	320	290	U		44	290	300	U		44	300	65.8	J	J	47	310
Phenanthrene	1700000	170000	na	310	U		46	310	320	U		48	320	290	U		44	290	300	U		44	300	310	U		47	310
Pyrene	1700000	170000	na	310	U		54	310	320	U		56	320	290	U		51	290	300	U		52	300	310	U		55	310
SVOCs (ug/kg)																												
bis(2-Ethylhexyl)phthalate	120000	35000	na	390	U		190	390	810	U		400	810	370	U		180	370	370	U		180	370	373	J	J	200	390
Dibenzofuran	na	na	na	190	U		39	190	400	U		81	400	180	U		37	180	180	U		37	180	200	U		39	200
Diethylphthalate	49000000	4900000	na	390	U		190	390	810	U		400	810	370	U		180	370	370	U		180	370	390	U		200	390
Di-n-butylphthalate	6200000	610000	na	390	U		97	390	2350			200	810	370	U		92	370	370	U		92	370	390	U		98	390
N-nitrosodiphenylamine	350000	99000	na	190	U		39	190	400	U		81	400	180	U		37	180	180	U		37	180	200	U		39	200
Pesticides (ug/kg)																												
4,4'-DDD	7200	2000	na	3.8	U		0.76	3.8	4.1	U	UJ	0.82	4.1	3.7	U		0.74	3.7	3.7	U		0.74	3.7	3.9	U	UJ	0.77	3.9
Dieldrin	110	30	na	1.9	U		0.42	1.9	0.85	J	J	0.45	2	1.8	U		0.41	1.8	1.8	U		0.41	1.8	1.9	U	UJ	0.43	1.9
PCBs (mg/kg)																												
PCB-1016	2.1	0.39	na	0.019	U		0.0095	0.019	0.02	U		0.01	0.02	0.018	U		0.0092	0.018	0.018	U		0.0092	0.018	0.019	U		0.0097	0.019
PCB-1254	0.74	0.022	na	0.019	U		0.0095	0.019	0.0299	J		0.01	0.02	0.018	U		0.0092	0.018	0.0712			0.0092	0.018	0.043	J		0.0097	0.019
PCB-1260	0.74	0.22	na	0.019	U		0.0095	0.019	0.0398	J		0.01	0.02	0.018	U		0.0092	0.018	0.018	U		0.0092	0.018	0.0174	J		0.0097	0.019
Explosives (mg/kg)																												
2,4,6-Trinitrotoluene	7.9	1.9	na	0.25	U		0.049	0.25	0.24	U		0.047	0.24	0.23	U		0.045	0.23	0.23	U		0.045	0.23	0.24	U		0.048	0.24
2,4-Dinitrotoluene	120	12	na	0.25	U		0.049	0.25	0.24	U		0.047	0.24	0.23	U		0.045	0.23	0.23	U		0.045	0.23	0.24	U		0.048	0.24
2-amino-4,6-Dinitrotoluene	200	15	na	0.25	U		0.049	0.25	0.24	U		0.047	0.24	0.23	U		0.045	0.23	0.23	U		0.045	0.23	0.24	U		0.048	0.24
Herbicides (ug/kg)																												
Dicamba	1800000	180000	na	7.6	U		5.7	7.6	8.1	U		6.1	8.1	7.4	U		5.6	7.4	7.2	U		5.4	7.2	7.7	U		5.8	7.7

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Analyte			Sample ID	43SB07C					43SB08A					43SB08B					43SB08C					43SB09A				
			Sample Date	7/25/07					7/25/07					7/25/07					7/25/07					7/25/07				
			Sample Depth	8-10					0-0.5					4-6					8-10					0-0.5				
	i-SL	r-SL	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	19000000	2800000	na	28	U		11	28	24	U		9.5	24	26	U		10	26	29	U		12	29	36	U		14	36
Acetone	61000000	6100000	na	56	U		28	56	48	U		24	48	95.2			26	51	33.5	J	J	29	59	71	U		36	71
Carbon disulfide	300000	67000	na	5.6	U		1.1	5.6	4.8	U		0.95	4.8	2.1	J	J	1	5.1	5.9	U		1.2	5.9	7.1	U		1.4	7.1
Ethylbenzene	29000	5700	na	5.6	U	UJ	1.1	5.6	4.8	U	UJ	0.95	4.8	5.1	U	UJ	1	5.1	5.9	U	UJ	1.2	5.9	7.1	U	UJ	1.4	7.1
m- & p-Xylene	na	na	na	11	U		1.2	11	9.5	U		1.1	9.5	10	U		1.1	10	12	U		1.3	12	14	U		1.6	14
o-Xylene	2300000	530000	na	5.6	U		1.1	5.6	4.8	U		0.95	4.8	5.1	U		1	5.1	5.9	U		1.2	5.9	7.1	U		1.4	7.1
Toluene	4600000	500000	na	5.6	U		1.1	5.6	4.8	U		0.95	4.8	5.1	U		1	5.1	5.9	U		1.2	5.9	7.1	U		1.4	7.1
Vinyl chloride	1700	60	na	5.6	U		1.6	5.6	4.8	U		1.3	4.8	5.1	U		1.4	5.1	5.9	U		1.6	5.9	7.1	U		2	7.1
PAHs (ug/kg)																												
1-Methylnaphthalene	99000	22000	na	310	U		47	310	270	U		41	270	310	U		46	310	300	U		45	300	290	U		44	290
2-Methylnaphthalene	410000	31000	na	310	U		47	310	270	U		41	270	310	U		46	310	300	U		45	300	290	U		44	290
Acenaphthene	3300000	340000	na	310	U		78	310	270	U		68	270	310	U		77	310	300	U		74	300	290	U		74	290
Benz(a)anthracene	2100	150	na	63	U		16	63	55	U		14	55	61	U		15	61	59	U		15	59	88.8			15	59
Benzo(a)pyrene	210	15	na	63	U		16	63	55	U		14	55	61	U		15	61	59	U		15	59	140			15	59
Benzo(b)fluoranthene	2100	150	na	63	U		16	63	55	U		14	55	61	U		15	61	59	U		15	59	80.1			15	59
Benzo(g,h,i)perylene	1700000	170000	na	63	U		16	63	55	U		14	55	61	U		15	61	59	U		15	59	65.5			15	59
Benzo(k)fluoranthene	21000	1500	na	63	U		16	63	55	U		14	55	61	U		15	61	59	U		15	59	93.5			15	59
Chrysene	210000	15000	na	63	U		16	63	55	U		14	55	61	U		15	61	59	U		15	59	81.8			15	59
Fluoranthene	2200000	230000	na	310	U		55	310	270	U		48	270	310	U		54	310	300	U		52	300	69.4	J	J	52	290
Fluorene	2200000	230000	na	310	U		47	310	270	U		41	270	310	U		46	310	300	U		45	300	290	U		44	290
Indeno(1,2,3-cd)pyrene	2100	150	na	63	U		16	63	55	U		14	55	61	U		15	61	59	U		15	59	72.8			15	59
Naphthalene	20000	3900	na	310	U		47	310	270	U		41	270	310	U		46	310	300	U		45	300	290	U		44	290
Phenanthrene	1700000	170000	na	310	U		47	310	270	U		41	270	310	U		46	310	300	U		45	300	290	U		44	290
Pyrene	1700000	170000	na	310	U		55	310	270	U		48	270	310	U		54	310	300	U		52	300	118	J	J	52	290
SVOCs (ug/kg)																												
bis(2-Ethylhexyl)phthalate	120000	35000	na	390	U		200	390	340	U		170	340	380	U		190	380	370	U		190	370	370	U		180	370
Dibenzofuran	na	na	na	200	U		39	200	170	U		34	170	190	U		38	190	190	U		37	190	180	U		37	180
Diethylphthalate	49000000	4900000	na	390	U		200	390	340	U		170	340	380	U		190	380	370	U		190	370	370	U		180	370
Di-n-butylphthalate	6200000	610000	na	390	U		98	390	340	U		85	340	380	U		96	380	370	U		93	370	370	U		92	370
N-nitrosodiphenylamine	350000	99000	na	200	U		39	200	170	U		34	170	190	U		38	190	190	U		37	190	180	U		37	180
Pesticides (ug/kg)																												
4,4'-DDD	7200	2000	na	3.9	U		0.78	3.9	3.4	U		0.69	3.4	3.9	U		0.78	3.9	3.8	U		0.76	3.8	3.7	U		0.73	3.7
Dieldrin	110	30	na	2	U		0.43	2	1.7	U		0.38	1.7	2	U		0.43	2	1.9	U		0.42	1.9	1.8	U		0.4	1.8
PCBs (mg/kg)																												
PCB-1016	2.1	0.39	na	0.02	U		0.0098	0.02	0.017	U		0.0086	0.017	0.0848	J		0.0098	0.02	0.019	U		0.0095	0.019	0.018	U		0.0092	0.018
PCB-1254	0.74	0.022	na	0.02	U		0.0098	0.02	0.017	U		0.0086	0.017	0.22	J		0.0098	0.02	0.019	U		0.0095	0.019	0.018	U		0.0092	0.018
PCB-1260	0.74	0.22	na	0.02	U		0.0098	0.02	0.017	U		0.0086	0.017	0.02	U		0.0098	0.02	0.019	U		0.0095	0.019	0.018	U		0.0092	0.018
Explosives (mg/kg)																												
2,4,6-Trinitrotoluene	7.9	1.9	na	0.24	U		0.047	0.24	0.25	U		0.049	0.25	0.24	U		0.048	0.24	0.23	U		0.046	0.23	0.24	U		0.048	0.24
2,4-Dinitrotoluene	120	12	na	0.24	U		0.047	0.24	0.25	U		0.049	0.25	0.24	U		0.048	0.24	0.23	U		0.046	0.23	0.24	U		0.048	0.24
2-amino-4,6-Dinitrotoluene	200	15	na	0.24	U		0.047	0.24	0.25	U		0.049	0.25	0.24	U		0.048	0.24	0.23	U		0.046	0.23	0.24	U		0.048	0.24
Herbicides (ug/kg)																												
Dicamba	1800000	180000	na	7.7	U		5.8	7.7	6.9	U		5.1	6.9	7.7	U		5.8	7.7	7.6	U		5.7	7.6	7.4	U		5.5	7.4

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Analyte			Sample ID	43SB09B					43SB09C					43SB10A					43SB10B					43SB10C				
			Sample Date	7/25/07					7/25/07					7/25/07					7/25/07					7/25/07				
			Sample Depth	4-6					8-10					0-0.5					4-6					8-10				
	i-SL	r-SL	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	19000000	2800000	na	28	U		11	28	33	U		13	33	35	U		14	35	29	U		12	29	22	U		8.8	22
Acetone	61000000	6100000	na	61.2			28	55	33.6	J	J	33	66	70	U		35	70	59	U		29	59	44	U	UJ	22	44
Carbon disulfide	300000	67000	na	7.3			1.1	5.5	6.6	U		1.3	6.6	7	U		1.4	7	5.9	U		1.2	5.9	4.4	U		0.88	4.4
Ethylbenzene	29000	5700	na	61.8		J	1.1	5.5	6.6	U	UJ	1.3	6.6	7	U	UJ	1.4	7	5.9	U	UJ	1.2	5.9	4.4	U	UJ	0.88	4.4
m- & p-Xylene	na	na	na	12.4			1.2	11	13	U		1.5	13	14	U		1.5	14	12	U		1.3	12	8.8	U		0.97	8.8
o-Xylene	2300000	530000	na	8.9			1.1	5.5	6.6	U		1.3	6.6	7	U		1.4	7	5.9	U		1.2	5.9	4.4	U		0.88	4.4
Toluene	4600000	500000	na	2.7	J	J	1.1	5.5	6.6	U		1.3	6.6	7	U		1.4	7	5.9	U		1.2	5.9	4.4	U		0.88	4.4
Vinyl chloride	1700	60	na	5.5	U		1.6	5.5	6.6	U		1.9	6.6	7	U		2	7	5.9	U		1.6	5.9	4.4	U		1.2	4.4
PAHs (ug/kg)																												
1-Methylnaphthalene	99000	22000	na	95.9	J	J	46	310	300	U		45	300	300	U		45	300	300	U		45	300	320	U		48	320
2-Methylnaphthalene	410000	31000	na	152	J	J	46	310	300	U		45	300	300	U		45	300	300	U		45	300	320	U		48	320
Acenaphthene	3300000	340000	na	152	J	J	77	310	300	U		74	300	300	U		76	300	300	U		75	300	320	U		80	320
Benz(a)anthracene	2100	150	na	61	U		15	61	59	U		15	59	61	U		15	61	60	U		15	60	64	U		16	64
Benzo(a)pyrene	210	15	na	61	U		15	61	59	U		15	59	61	U		15	61	60	U		15	60	64	U		16	64
Benzo(b)fluoranthene	2100	150	na	61	U		15	61	59	U		15	59	61	U		15	61	60	U		15	60	64	U		16	64
Benzo(g,h,i)perylene	1700000	170000	na	61	U		15	61	59	U		15	59	61	U		15	61	60	U		15	60	64	U		16	64
Benzo(k)fluoranthene	21000	1500	na	61	U		15	61	59	U		15	59	61	U		15	61	60	U		15	60	64	U		16	64
Chrysene	210000	15000	na	61	U		15	61	59	U		15	59	61	U		15	61	60	U		15	60	64	U		16	64
Fluoranthene	2200000	230000	na	77.7	J	J	54	310	300	U		52	300	300	U		53	300	300	U		52	300	320	U		56	320
Fluorene	2200000	230000	na	160	J	J	46	310	300	U		45	300	300	U		45	300	300	U		45	300	320	U		48	320
Indeno(1,2,3-cd)pyrene	2100	150	na	61	U		15	61	59	U		15	59	61	U		15	61	60	U		15	60	64	U		16	64
Naphthalene	20000	3900	na	92.1	J	J	46	310	300	U		45	300	300	U		45	300	300	U		45	300	320	U		48	320
Phenanthrene	1700000	170000	na	347			46	310	300	U		45	300	300	U		45	300	300	U		45	300	320	U		48	320
Pyrene	1700000	170000	na	310	U		54	310	300	U		52	300	300	U		53	300	300	U		52	300	320	U		56	320
SVOCs (ug/kg)																												
bis(2-Ethylhexyl)phthalate	120000	35000	na	707			190	380	370	U		190	370	380	U		190	380	370	U		190	370	400	U		200	400
Dibenzofuran	na	na	na	105	J	J	38	190	190	U		37	190	190	U		38	190	190	U		37	190	200	U		40	200
Diethylphthalate	49000000	4900000	na	210	J	J	190	380	370	U		190	370	380	U		190	380	370	U		190	370	400	U		200	400
Di-n-butylphthalate	6200000	610000	na	96.4	J	J	96	380	370	U		93	370	380	U		95	380	370	U		93	370	400	U		99	400
N-nitrosodiphenylamine	350000	99000	na	280			38	190	124	J	J	37	190	190	U		38	190	190	U		37	190	200	U		40	200
Pesticides (ug/kg)																												
4,4'-DDD	7200	2000	na	7.4	U	UJ	7.4	7.4	3.8	U	UJ	0.76	3.8	3.7	U	UJ	0.75	3.7	3.8	U	UJ	0.75	3.8	4	U		0.79	4
Dieldrin	110	30	na	1.9	U	UJ	1.9	1.9	1.9	U	UJ	0.42	1.9	1.9	U	UJ	0.41	1.9	1.9	U	UJ	0.42	1.9	2	U		0.43	2
PCBs (mg/kg)																												
PCB-1016	2.1	0.39	na	0.0493	J		0.0094	0.019	0.019	U		0.0095	0.019	0.019	U		0.0093	0.019	0.019	U		0.0094	0.019	0.02	U		0.0099	0.02
PCB-1254	0.74	0.022	na	0.112	J		0.0094	0.019	0.019	U		0.0095	0.019	0.019	U		0.0093	0.019	0.019	U		0.0094	0.019	0.02	U		0.0099	0.02
PCB-1260	0.74	0.22	na	0.019	U		0.0094	0.019	0.019	U		0.0095	0.019	0.019	U		0.0093	0.019	0.019	U		0.0094	0.019	0.02	U		0.0099	0.02
Explosives (mg/kg)																												
2,4,6-Trinitrotoluene	7.9	1.9	na	0.24	U		0.047	0.24	0.25	U		0.049	0.25	0.25	U		0.05	0.25	0.23	U		0.045	0.23	0.25	U		0.049	0.25
2,4-Dinitrotoluene	120	12	na	0.24	U		0.047	0.24	0.25	U		0.049	0.25	0.25	U		0.05	0.25	0.23	U		0.045	0.23	0.25	U		0.049	0.25
2-amino-4,6-Dinitrotoluene	200	15	na	0.24	U		0.047	0.24	0.25	U		0.049	0.25	0.25	U		0.05	0.25	0.23	U		0.045	0.23	0.25	U		0.049	0.25
Herbicides (ug/kg)																												
Dicamba	1800000	180000	na	7.7	U		5.7	7.7	7.6	U		5.7	7.6	7.6	U		5.7	7.6	7.6	U		5.7	7.6	7.9	U		6	7.9

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Analyte			Sample ID	**43SB01A**					**43SB01B**					**43SB01C**					**43SB02A**					**43SB02B**				
			Sample Date	**7/26/07**					**7/26/07**					**7/26/07**					**7/26/07**					**7/26/07**				
			Sample Depth	**0-0.5**					**4-6**					**8-10**					**0-0.5**					**4-6**				
	i-SL	**r-SL**	**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
Metals (mg/kg)																												
Aluminum	99000	7700	40041	10100		J	2.6	11	14000		J	2.7	11	15000		J	2.7	11	12400		J	2.6	11	11200		J	2.8	11
Antimony	41	3.1	na	0.78	J	B	0.21	3.3	1.4	J	B	0.21	3.3	1	J	B	0.21	3.3	1.1	J	B	0.2	3.2	1.3	J	B	0.22	3.4
Arsenic	1.6	0.39	15.8	3.1		L	0.21	0.44	1.8		L	0.22	0.44	1.9		L	0.22	0.44	2.4		L	0.21	0.43	4.9		J	0.22	0.46
Barium	19000	1500	209	165		J	0.27	11	134		J	0.28	11	125		J	0.28	11	120		J	0.27	11	91.8		J	0.29	11
Beryllium	200	16	1.02	0.93		L	0.055	0.27	0.97		L	0.056	0.28	1		L	0.056	0.28	0.78		L	0.054	0.27	0.76		J	0.057	0.29
Cadmium	81	7	0.69	0.055	U	UL	0.055	0.22	0.56	U	UL	0.56	1.1	0.56	U	UL	0.56	1.1	0.54	U	UL	0.54	1.1	0.057	U	UL	0.057	0.23
Calcium	na	na	na	1060		J	5.5	270	1170		J	5.6	280	1240		J	5.6	280	1860		J	5.4	270	2530		J	5.7	290
Chromium	1400	280	65.3	16		J	0.076	0.55	19.8		J	0.078	0.56	21.8		J	0.078	0.56	18.8		J	0.075	0.54	19		J	0.08	0.57
Cobalt	30	2.3	72.3	7.6		J	0.06	2.7	12		J	0.061	2.8	10.8		J	0.061	2.8	9.2		J	0.059	2.7	10.8		J	0.063	2.9
Copper	4100	310	53.5	9.2		J	0.1	1.4	11.4		J	0.11	1.4	13.4		J	0.11	1.4	9.3		J	0.1	1.3	24.1		J	0.11	1.4
Iron	72000	5500	50962	13100		J	0.76	5.5	20200		J	0.78	5.6	21600		J	0.78	5.6	18300		J	0.75	5.4	20700		J	0.8	5.7
Lead	800	400	26.8	**36.2**		**J**	0.13	5.5	7.8		J	0.13	5.6	8.5		J	0.13	5.6	13.7		J	0.13	5.4	**34.4**		**J**	0.14	5.7
Magnesium	na	na	na	2130		J	5.5	270	3570		J	5.6	280	3670		J	5.6	280	2260		J	5.4	270	3580		J	5.7	290
Manganese	2300	180	2543	488		J	0.27	4.1	779		J	0.28	4.2	534		J	0.28	4.2	708		J	0.27	4	625		J	0.29	4.3
Mercury	2.8	0.67	0.13	0.035	J	J	0.011	0.089	0.035	J	J	0.012	0.094	0.036	J	J	0.012	0.097	0.043	J	J	0.011	0.087	**0.63**		**J**	0.022	0.17
Nickel	2000	160	62.8	11.8		J	0.14	2.2	13.5		J	0.14	2.2	13.2		J	0.14	2.2	9.2		J	0.13	2.2	12.2		J	0.14	2.3
Potassium	na	na	na	922		B	5.5	550	2120		J	5.6	560	1720		J	5.6	560	757		B	5.4	540	1470		J	5.7	570
Selenium	510	39	na	4.4	J	J	0.25	5.5	6.2		J	0.25	5.6	6.6		J	0.25	5.6	5.7		J	0.24	5.4	6.2		J	0.26	5.7
Silver	510	39	na	0.076	U	UL	0.076	0.55	0.078	U	UL	0.078	0.56	0.078	U	UL	0.078	0.56	0.075	U	UL	0.075	0.54	0.08	U	UL	0.08	0.57
Sodium	na	na	na	27	U		27	550	28	U		28	560	28	U		28	560	30.6	J	B	27	540	29	U		29	570
Vanadium	720	55	108	20.4		J	0.055	2.7	36.2		J	0.056	2.8	36.6		J	0.056	2.8	34.3		J	0.054	2.7	29.7		J	0.057	2.9
Zinc	31000	2300	202	105		J	0.27	1.1	55.9		J	0.28	1.1	54.6		J	0.28	1.1	55.7		J	0.27	1.1	75		J	0.29	1.1
Dioxins/Furans (ng/kg)																												
2,3,7,8-TCDF	130	37	na	NT					NT					NT					NT					NT				
2,3,7,8-TCDD	18	4.5	na	NT					NT					NT					NT					NT				
1,2,3,7,8-PECDD	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,6,7,8-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,7,8,9-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,4,6,7,8-HPCDD	na	na	na	NT					NT					NT					NT					NT				
OCDD	61000	15000	na	NT					NT					NT					NT					NT				
1,2,3,7,8-PECDF	440	120	na	NT					NT					NT					NT					NT				
2,3,4,7,8-PECDF	44	12	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,6,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
2,3,4,6,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,7,8,9-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,6,7,8-HPCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8,9-HPCDF	na	na	na	NT					NT					NT					NT					NT				
OCDF	44000	12000	na	NT					NT					NT					NT					NT				
TOTAL TCDD	na	na	na	NT					NT					NT					NT					NT				
TOTAL PECDD	18	4.5	na	NT					NT					NT					NT					NT				
TOTAL HXCDD	180	45	na	NT					NT					NT					NT					NT				
TOTAL HPCDD	1800	450	na	NT					NT					NT					NT					NT				
TOTAL TCDF	na	na	na	NT					NT					NT					NT					NT				
TOTAL PECDF	na	na	na	NT					NT					NT					NT					NT				
TOTAL HXCDF	130	37	na	NT					NT					NT					NT					NT				
TOTAL HPCDF	1300	370	na	NT					NT					NT					NT					NT				

Table 4-1
Analytes Detected in SWMU 43 Soil Samples - 2007 RFI

Analyte			Sample ID	43SB02C					43SB03A					43SB03B					43SB03C					43SB04A				
			Sample Date	7/26/07					7/26/07					7/26/07					7/26/07					7/26/07				
			Sample Depth	8-10					0-0.5					4-6					8-10					0-0.5				
	i-SL	**r-SL**	**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
Metals (mg/kg)																												
Aluminum	99000	7700	40041	4620		J	2.8	12	12400		J	2.6	11	10400		J	2.6	11	9410		J	2.6	11	11900		J	2.5	10
Antimony	41	3.1	na	0.36	J	B	0.23	3.6	1.2	J	B	0.21	3.3	1.1	J	B	0.21	3.3	1.3	J	B	0.2	3.2	1.4	J	B	0.2	3.1
Arsenic	1.6	0.39	15.8	1.9		L	0.23	0.47	2.9		L	0.22	0.44	7.2		K	0.21	0.44	2.4		K	0.21	0.43	2.1		L	0.2	0.42
Barium	19000	1500	209	21.1		J	0.3	12	127		J	0.28	11	93.7		J	0.27	11	90.6		J	0.27	11	108		J	0.26	10
Beryllium	200	16	1.02	0.33		L	0.059	0.3	0.88		L	0.055	0.28	0.69		L	0.054	0.27	0.59		L	0.053	0.27	0.81		L	0.052	0.26
Cadmium	81	7	0.69	0.059	U	UL	0.059	0.24	0.55	U	UL	0.55	1.1	0.27	U	UL	0.27	1.1	0.053	U	UL	0.053	0.21	0.52	U	UL	0.52	1.1
Calcium	na	na	na	95900		J	120	5900	1440		J	5.5	280	1030		J	5.4	270	809		J	5.3	270	1330		J	5.2	260
Chromium	1400	280	65.3	8.7		J	0.083	0.59	19.5		J	0.077	0.55	15.7		J	0.076	0.54	14.6		J	0.075	0.53	18.1		J	0.073	0.52
Cobalt	30	2.3	72.3	3.8		J	0.065	3	9.5		J	0.061	2.8	9		J	0.06	2.7	11.6		J	0.059	2.7	9.7		J	0.058	2.6
Copper	4100	310	53.5	4		J	0.11	1.5	11.7		J	0.1	1.4	**71.9**		**J**	0.1	1.4	35.5		J	0.1	1.3	12.3		J	0.099	1.3
Iron	72000	5500	50962	9750		J	0.83	5.9	17600		J	0.77	5.5	16400		J	0.76	5.4	20800		J	0.75	5.3	18500		J	0.73	5.2
Lead	800	400	26.8	2.2	J	J	0.14	5.9	13.6		J	0.13	5.5	**95.6**		**J**	0.13	5.4	4	J	J	0.13	5.3	9.6		J	0.13	5.2
Magnesium	na	na	na	58700		J	120	5900	2520		J	5.5	280	2470		J	5.4	270	2560		J	5.3	270	3310		J	5.2	260
Manganese	2300	180	2543	227		J	0.059	0.89	582		J	0.28	4.1	363		J	0.27	4.1	733		J	0.27	4	570		J	0.26	3.9
Mercury	2.8	0.67	0.13	0.011	U		0.011	0.088	0.053	J	J	0.011	0.086	**1.5**		**J**	0.071	0.58	0.049	J	J	0.01	0.084	0.064	J	J	0.01	0.081
Nickel	2000	160	62.8	6.4		J	0.15	2.4	10.6		J	0.14	2.2	12.9		J	0.14	2.2	16.3		J	0.13	2.1	11.4		J	0.13	2.1
Potassium	na	na	na	1200		J	5.9	590	930		B	5.5	550	1170		J	5.4	540	1120		J	5.3	530	1420		J	5.2	520
Selenium	510	39	na	0.27	U	UL	0.27	5.9	5.4	J	J	0.25	5.5	5.9		J	0.24	5.4	6.7		J	0.24	5.3	5.7		J	0.24	5.2
Silver	510	39	na	0.083	U	UL	0.083	0.59	0.077	U	UL	0.077	0.55	0.076	U		0.076	0.54	0.075	U		0.075	0.53	0.073	U	UL	0.073	0.52
Sodium	na	na	na	377	J	B	30	590	28	U		28	550	92.1	J	B	27	540	414	J	B	27	530	26	U		26	520
Vanadium	720	55	108	11.1		J	0.059	3	32.8		J	0.055	2.8	23.7		J	0.054	2.7	20.6		J	0.053	2.7	31.1		J	0.052	2.6
Zinc	31000	2300	202	12.3		J	0.3	1.2	78.3		J	0.28	1.1	64.4		J	0.27	1.1	37.7		J	0.27	1.1	50.7		J	0.26	1
Dioxins/Furans (ng/kg)																												
2,3,7,8-TCDF	130	37	na	NT					0.423	A	J			1.57	EMPC	J	0.433	0.433	0.184	U		0.184	0.184	NT				
2,3,7,8-TCDD	18	4.5	na	NT					0.263	A, EMPC	J	0.282	0.282	0.51	A	J			0.197	U		0.197	0.197	NT				
1,2,3,7,8-PECDD	na	na	na	NT					0.946	A	J			0.506	A, EMPC	J	0.567	0.567	0.507	U		0.507	0.507	NT				
1,2,3,4,7,8-HXCDD	460	100	na	NT					1.51	A	J			1.47	A	J			0.225	A	J			NT				
1,2,3,6,7,8-HXCDD	460	100	na	NT					4.82	A	J			7.84					0.507	U		0.507	0.507	NT				
1,2,3,7,8,9-HXCDD	460	100	na	NT					3.77	A	J			3.8	A	J			0.264	A, EMPC	J	0.507	0.507	NT				
1,2,3,4,6,7,8-HPCDD	na	na	na	NT					162					342					5.39					NT				
OCDD	61000	15000	na	NT					4420	E	J			5830	E	J			99.1					NT				
1,2,3,7,8-PECDF	440	120	na	NT					0.239	A, EMPC	J	0.548	0.548	1.33	Q, A	J			0.112	A, EMPC	J	0.507	0.507	NT				
2,3,4,7,8-PECDF	44	12	na	NT					0.372	A	J			2.62	Q, A	J			0.172	A, EMPC	J	0.507	0.507	NT				
1,2,3,4,7,8-HXCDF	na	na	na	NT					1.26	A	B			8.87					0.17	A	B			NT				
1,2,3,6,7,8-HXCDF	na	na	na	NT					0.6	A, EMPC	B	0.548	0.548	3.11	A	J			0.185	A, EMPC	B	0.507	0.507	NT				
2,3,4,6,7,8-HXCDF	na	na	na	NT					0.863	A	J			2.73	A	J			0.101	A, EMPC	J	0.507	0.507	NT				
1,2,3,7,8,9-HXCDF	na	na	na	NT					0.412	A	J			1.43	A	J			0.0892	A	J			NT				
1,2,3,4,6,7,8-HPCDF	na	na	na	NT					24.8					50.4					1.25	A	B			NT				
1,2,3,4,7,8,9-HPCDF	na	na	na	NT					1.94	A	J			4.24	A	J			0.105	A	J			NT				
OCDF	44000	12000	na	NT					79.7					142					3.58	A	B			NT				
TOTAL TCDD	na	na	na	NT					3.48	EMPC	J			7.63	Q, EMPC	J			0.329	EMPC	J	0.197	0.197	NT				
TOTAL PECDD	18	4.5	na	NT					9.21	EMPC	J			12	EMPC	J			0.746	EMPC	J			NT				
TOTAL HXCDD	180	45	na	NT					32	EMPC	J			68.8					2.28					NT				
TOTAL HPCDD	1800	450	na	NT					352					865					12.5					NT				
TOTAL TCDF	na	na	na	NT					1.71	EMPC	J			18.1	Q, EMPC	J			0.31	EMPC	J			NT				
TOTAL PECDF	na	na	na	NT					2.66	EMPC	J			17.3	Q, EMPC	J			0.495	EMPC	J			NT				
TOTAL HXCDF	130	37	na	NT					19.7	EMPC	J			48.4	EMPC	J			1.23	EMPC	B			NT				
TOTAL HPCDF	1300	370	na	NT					98.9	EMPC	J			174					3.79	EMPC	B			NT				

Table 4-1
Analytes Detected in SWMU 43 Soil Samples - 2007 RFI
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Analyte			Sample ID	43SB04B					43SB04C					43SB05A					43SB05B					43SB05C				
			Sample Date	7/26/07					7/26/07					7/26/07					7/26/07					7/26/07				
			Sample Depth	4-6					8-10					0-0.5					4-6					8-10				
	i-SL	**r-SL**	**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
Metals (mg/kg)																												
Aluminum	99000	7700	40041	14100		J	2.7	11	12700		J	2.9	12	11100		J	2.6	11	14700		J	2.8	12	7000		J	2.8	12
Antimony	41	3.1	na	1.5	J	B	0.22	3.4	1.4	J	B	0.23	3.6	1.1	J	B	0.2	3.2	1.4	J	B	0.22	3.5	0.85	J	B	0.23	3.6
Arsenic	1.6	0.39	15.8	1.9		L	0.22	0.46	2		L	0.23	0.48	2.2		L	0.21	0.43	2.1		L	0.23	0.46	1.6		L	0.23	0.47
Barium	19000	1500	209	91.1		J	0.29	11	103		J	0.3	12	110		J	0.27	11	96.1		J	0.29	12	50.6		J	0.3	12
Beryllium	200	16	1.02	0.83		L	0.057	0.29	0.85		L	0.06	0.3	0.8		L	0.053	0.27	0.93		L	0.058	0.29	0.49		L	0.059	0.3
Cadmium	81	7	0.69	0.57	U	UL	0.57	1.2	0.6	U	UL	0.6	1.2	0.53	U	UL	0.53	1.1	0.58	U	UL	0.58	1.2	0.059	U	UL	0.059	0.24
Calcium	na	na	na	1040		J	5.7	290	846		J	6	300	1300		J	5.3	270	982		J	5.8	290	830		J	5.9	300
Chromium	1400	280	65.3	19.2		J	0.08	0.57	22.1		J	0.083	0.6	17.5		J	0.075	0.53	22.3		J	0.081	0.58	13.9		J	0.083	0.59
Cobalt	30	2.3	72.3	11.4		J	0.063	2.9	10.9		J	0.066	3	9.4		J	0.059	2.7	10.6		J	0.064	2.9	7.2		J	0.065	3
Copper	4100	310	53.5	11.8		J	0.11	1.4	12.5		J	0.11	1.5	10.5		J	0.1	1.3	12.1		J	0.11	1.4	7.9		J	0.11	1.5
Iron	72000	5500	50962	21600		J	0.8	5.7	21200		J	0.83	6	17800		J	0.75	5.3	22100		J	0.81	5.8	10600		J	0.83	5.9
Lead	800	400	26.8	6.6		J	0.14	5.7	6.4		J	0.14	6	7.8		J	0.13	5.3	8		J	0.14	5.8	5.1	J	J	0.14	5.9
Magnesium	na	na	na	3830		J	5.7	290	3830		J	6	300	3140		J	5.3	270	3840		J	5.8	290	2310		J	5.9	300
Manganese	2300	180	2543	540		J	0.29	4.3	530		J	0.3	4.5	472		J	0.27	4	505		J	0.29	4.3	84.2		J	0.059	0.89
Mercury	2.8	0.67	0.13	0.031	J	J	0.011	0.089	0.018	J	J	0.011	0.088	**0.2**		**J**	0.01	0.084	0.039	J	J	0.012	0.094	0.012	U		0.012	0.098
Nickel	2000	160	62.8	12		J	0.14	2.3	12.9		J	0.15	2.4	11.2		J	0.13	2.1	13.1		J	0.14	2.3	8.6		J	0.15	2.4
Potassium	na	na	na	1640		J	5.7	570	1560		J	6	600	1290		J	5.3	530	1640		J	5.8	580	1130		J	5.9	590
Selenium	510	39	na	6.7		J	0.26	5.7	6.8		J	0.27	6	5.8		J	0.24	5.3	6.9		J	0.26	5.8	3.5	J	J	0.27	5.9
Silver	510	39	na	0.08	U	UL	0.08	0.57	0.083	U	UL	0.083	0.6	0.075	U	UL	0.075	0.53	0.081	U	UL	0.081	0.58	0.083	U	UL	0.083	0.59
Sodium	na	na	na	29	U		29	570	30	U		30	600	27	U		27	530	29	U		29	580	30	U		30	590
Vanadium	720	55	108	36.8		J	0.057	2.9	35.1		J	0.06	3	29.5		J	0.053	2.7	39.8		J	0.058	2.9	21.3		J	0.059	3
Zinc	31000	2300	202	48.3		J	0.29	1.1	47.8		J	0.3	1.2	48.7		J	0.27	1.1	56.7		J	0.29	1.2	30.7		J	0.3	1.2
Dioxins/Furans (ng/kg)																												
2,3,7,8-TCDF	130	37	na	NT					NT					NT					NT					NT				
2,3,7,8-TCDD	18	4.5	na	NT					NT					NT					NT					NT				
1,2,3,7,8-PECDD	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,6,7,8-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,7,8,9-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,4,6,7,8-HPCDD	na	na	na	NT					NT					NT					NT					NT				
OCDD	61000	15000	na	NT					NT					NT					NT					NT				
1,2,3,7,8-PECDF	440	120	na	NT					NT					NT					NT					NT				
2,3,4,7,8-PECDF	44	12	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,6,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
2,3,4,6,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,7,8,9-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,6,7,8-HPCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8,9-HPCDF	na	na	na	NT					NT					NT					NT					NT				
OCDF	44000	12000	na	NT					NT					NT					NT					NT				
TOTAL TCDD	na	na	na	NT					NT					NT					NT					NT				
TOTAL PECDD	18	4.5	na	NT					NT					NT					NT					NT				
TOTAL HXCDD	180	45	na	NT					NT					NT					NT					NT				
TOTAL HPCDD	1800	450	na	NT					NT					NT					NT					NT				
TOTAL TCDF	na	na	na	NT					NT					NT					NT					NT				
TOTAL PECDF	na	na	na	NT					NT					NT					NT					NT				
TOTAL HXCDF	130	37	na	NT					NT					NT					NT					NT				
TOTAL HPCDF	1300	370	na	NT					NT					NT					NT					NT				

Table 4-1
Analytes Detected in SWMU 43 Soil Samples - 2007 RFI
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Analyte			Sample ID	43SB06A					43SB06B					43SB06C					43SB07A					43SB07B				
			Sample Date	7/25/07					7/25/07					7/25/07					7/25/07					7/25/07				
			Sample Depth	0-0.5					4-6					8-10					0-0.5					4-6				
	i-SL	r-SL	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
Metals (mg/kg)																												
Aluminum	99000	7700	40041	15600		J	1.3	12	6990		J	1.3	12	7010		J	1.2	11	11900		J	1.2	11	8040		J	1.2	11
Antimony	41	3.1	na	0.71	J	B	0.31	3.5	0.73	J	B	0.32	3.6	0.47	J	B	0.29	3.3	0.67	J	B	0.29	3.2	0.54	J	B	0.3	3.4
Arsenic	1.6	0.39	15.8	1.4		J	0.23	0.46	6.8		J	0.24	0.48	1.5		J	0.21	0.44	**17.7**		**J**	0.21	0.43	1.1		J	0.22	0.45
Barium	19000	1500	209	192		J	0.29	12	83.9		J	0.3	12	54.7		J	0.27	11	142		J	0.27	11	104		J	0.28	11
Beryllium	200	16	1.02	**1.3**			0.058	0.29	0.77		B	0.061	0.3	0.77		B	0.055	0.27	**1.1**			0.054	0.27	0.89			0.056	0.28
Cadmium	81	7	0.69	0.29	U	UL	0.29	0.46	0.061	U	UL	0.061	0.24	0.55	U	UL	0.55	1.1	0.054	U	UL	0.054	0.22	0.056	U	UL	0.056	0.23
Calcium	na	na	na	2150		J	3.3	290	15200		J	3.5	300	773		J	3.1	270	1840		J	3.1	270	3090		J	3.2	280
Chromium	1400	280	65.3	24.3		J	0.052	0.58	13.2		J	0.055	0.61	13.4		J	0.049	0.55	18.4		J	0.048	0.54	14.3		J	0.051	0.56
Cobalt	30	2.3	72.3	9.9		J	0.058	2.9	5		J	0.061	3	7.3		J	0.055	2.7	10.7		J	0.054	2.7	8.1		J	0.056	2.8
Copper	4100	310	53.5	14		J	0.052	1.4	45.1		J	0.055	1.5	9.9		J	0.049	1.4	16.8		J	0.048	1.3	8.9		J	0.051	1.4
Iron	72000	5500	50962	19800		J	0.69	5.8	21000		J	0.73	6.1	14300		J	0.66	5.5	19800		J	0.65	5.4	13700		J	0.68	5.6
Lead	800	400	26.8	16.4		J	0.12	5.8	19.6		J	0.12	6.1	5.8		J	0.11	5.5	16.2		J	0.11	5.4	**28.4**		**J**	0.11	5.6
Magnesium	na	na	na	3130		J	0.43	290	5670		J	0.45	300	2180		J	0.41	270	2400		J	0.4	270	2800		J	0.42	280
Manganese	2300	180	2543	428		J	0.29	4.3	238		J	0.036	0.91	411		J	0.27	4.1	708		J	0.54	8.1	655		J	0.56	8.4
Mercury	2.8	0.67	0.13	0.061	J	J	0.007	0.087	**0.4**			0.007	0.096	0.015	J	K	0.007	0.089	**0.31**			0.007	0.092	**0.47**			0.007	0.091
Nickel	2000	160	62.8	12.6		J	0.058	2.3	10.5		J	0.061	2.4	9.9		J	0.055	2.2	11.7		J	0.054	2.2	9.6		J	0.056	2.3
Potassium	na	na	na	1030		J	5.8	580	886		J	6.1	610	840		J	5.5	550	1090		J	5.4	540	1040		J	5.6	560
Selenium	510	39	na	0.12	U	UL	0.12	5.8	0.51	J	L	0.12	6.1	0.19	J	L	0.11	5.5	0.31	J	L	0.11	5.4	0.27	J	L	0.11	5.6
Silver	510	39	na	0.052	U	UL	0.052	0.58	0.18	J	L	0.055	0.61	0.049	U	UL	0.049	0.55	0.048	U	UL	0.048	0.54	0.051	U	UL	0.051	0.56
Sodium	na	na	na	369	J	L	48	580	390	J	L	50	610	340	J	L	45	550	381	J	L	44	540	356	J	L	46	560
Vanadium	720	55	108	42.4		J	0.035	2.9	17.6		J	0.036	3	22.8		J	0.033	2.7	33		J	0.032	2.7	21.3		J	0.034	2.8
Zinc	31000	2300	202	89.9		J	0.075	1.2	111		J	0.079	1.2	29.3		J	0.071	1.1	68.4		J	0.07	1.1	115		J	0.073	1.1
Dioxins/Furans (ng/kg)																												
2,3,7,8-TCDF	130	37	na	NT					NT					NT					NT					NT				
2,3,7,8-TCDD	18	4.5	na	NT					NT					NT					NT					NT				
1,2,3,7,8-PECDD	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,6,7,8-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,7,8,9-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,4,6,7,8-HPCDD	na	na	na	NT					NT					NT					NT					NT				
OCDD	61000	15000	na	NT					NT					NT					NT					NT				
1,2,3,7,8-PECDF	440	120	na	NT					NT					NT					NT					NT				
2,3,4,7,8-PECDF	44	12	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,6,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
2,3,4,6,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,7,8,9-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,6,7,8-HPCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8,9-HPCDF	na	na	na	NT					NT					NT					NT					NT				
OCDF	44000	12000	na	NT					NT					NT					NT					NT				
TOTAL TCDD	na	na	na	NT					NT					NT					NT					NT				
TOTAL PECDD	18	4.5	na	NT					NT					NT					NT					NT				
TOTAL HXCDD	180	45	na	NT					NT					NT					NT					NT				
TOTAL HPCDD	1800	450	na	NT					NT					NT					NT					NT				
TOTAL TCDF	na	na	na	NT					NT					NT					NT					NT				
TOTAL PECDF	na	na	na	NT					NT					NT					NT					NT				
TOTAL HXCDF	130	37	na	NT					NT					NT					NT					NT				
TOTAL HPCDF	1300	370	na	NT					NT					NT					NT					NT				

Table 4-1
Analytes Detected in SWMU 43 Soil Samples - 2007 RFI

Analyte			Sample ID Sample Date Sample Depth	**43SB07C 7/25/07 8-10**					**43SB08A 7/25/07 0-0.5**					**43SB08B 7/25/07 4-6**					**43SB08C 7/25/07 8-10**					**43SB09A 7/25/07 0-0.5**				
	i-SL	**r-SL**	**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
Metals (mg/kg)																												
Aluminum	99000	7700	40041	11500		J	1.3	11	8690		J	1.1	10	11800		J	1.3	12	9260		J	1.2	11	11900		J	1.2	11
Antimony	41	3.1	na	0.59	J	B	0.3	3.4	0.53	J	B	0.28	3.1	0.83	J	B	0.31	3.5	0.67	J	B	0.3	3.4	0.65	J	B	0.28	3.2
Arsenic	1.6	0.39	15.8	1.3		L	0.22	0.46	2.8		L	0.2	0.42	2.9		L	0.23	0.47	1.5		L	0.22	0.45	2.1		L	0.21	0.42
Barium	19000	1500	209	67.6		J	0.29	11	98.9		J	0.26	10	97.1		J	0.29	12	69.1		J	0.28	11	199		J	0.26	11
Beryllium	200	16	1.02	1			0.057	0.29	0.75			0.052	0.26	0.99			0.059	0.29	0.88			0.056	0.28	1			0.053	0.26
Cadmium	81	7	0.69	0.57	U	UL	0.57	1.2	**0.93**		**L**	0.052	0.21	0.059	U	UL	0.059	0.23	0.56	U	UL	0.56	1.1	0.53	U	UL	0.53	1
Calcium	na	na	na	765		J	3.3	290	15900		J	3	260	1910		J	3.3	290	747		J	3.2	280	3470		J	3	260
Chromium	1400	280	65.3	16.9		J	0.051	0.57	14.4		J	0.047	0.52	20.4		J	0.053	0.59	15		J	0.05	0.56	22.1		J	0.047	0.53
Cobalt	30	2.3	72.3	8.2		J	0.057	2.9	6.6		J	0.052	2.6	9.8		J	0.059	2.9	8.9		J	0.056	2.8	12.6		J	0.053	2.6
Copper	4100	310	53.5	12.4		J	0.051	1.4	10.3		J	0.047	1.3	20.3		J	0.053	1.5	11.3		J	0.05	1.4	10.5		J	0.047	1.3
Iron	72000	5500	50962	17700		J	0.68	5.7	12600		J	0.62	5.2	18500		J	0.7	5.9	16000		J	0.67	5.6	20100		J	0.63	5.3
Lead	800	400	26.8	5	J	J	0.11	5.7	13.5		J	0.1	5.2	**29.2**		**J**	0.12	5.9	3.4	J	J	0.11	5.6	12.6		J	0.11	5.3
Magnesium	na	na	na	2760		J	0.42	290	8180		J	0.39	260	3030		J	0.43	290	2380		J	0.41	280	2490		J	0.39	260
Manganese	2300	180	2543	404		J	0.29	4.3	349		J	0.26	3.9	377		J	0.29	4.4	455		J	0.28	4.2	1710		J	0.53	7.9
Mercury	2.8	0.67	0.13	0.023	J	J	0.006	0.086	0.071	J	J	0.006	0.087	0.087			0.007	0.087	0.015	J	J	0.007	0.091	0.037	J	J	0.007	0.091
Nickel	2000	160	62.8	10.6		J	0.057	2.3	9.1		J	0.052	2.1	12.3		J	0.059	2.3	10.3		J	0.056	2.2	9.8		J	0.053	2.1
Potassium	na	na	na	1310		J	5.7	570	1220		J	5.2	520	1430		J	5.9	590	1270		J	5.6	560	856		J	5.3	530
Selenium	510	39	na	0.17	J	J	0.11	5.7	1.3	J	J	0.1	5.2	0.38	J	J	0.12	5.9	0.25	J	J	0.11	5.6	0.7	J	J	0.11	5.3
Silver	510	39	na	0.051	U		0.051	0.57	0.047	U		0.047	0.52	0.053	U		0.053	0.59	0.05	U		0.05	0.56	0.047	U		0.047	0.53
Sodium	na	na	na	557	J	J	47	570	348	J	J	43	520	514	J	J	48	590	462	J	J	46	560	313	J	J	44	530
Vanadium	720	55	108	33.7		J	0.034	2.9	22.3		J	0.031	2.6	33.6		J	0.035	2.9	28.5		J	0.034	2.8	34.9		J	0.032	2.6
Zinc	31000	2300	202	39.3		J	0.074	1.1	92.5		J	0.068	1	77		J	0.076	1.2	34.1		J	0.073	1.1	66		J	0.069	1.1
Dioxins/Furans (ng/kg)																												
2,3,7,8-TCDF	130	37	na	NT					0.415	A	J	NA	NA	5.53			NA	NA	0.268	A	J	NA	NA	NT				
2,3,7,8-TCDD	18	4.5	na	NT					0.18	U		0.18	0.18	0.659	A, EMPC	J	0.186	0.186	0.143	U		0.143	0.143	NT				
1,2,3,7,8-PECDD	na	na	na	NT					0.32	A, EMPC	J	0.519	0.519	0.576	A, EMPC	J	0.59	0.59	0.519	U		0.519	0.519	NT				
1,2,3,4,7,8-HXCDD	460	100	na	NT					0.521	A, EMPC	J	0.519	0.519	0.468	A	J	NA	NA	0.519	U		0.519	0.519	NT				
1,2,3,6,7,8-HXCDD	460	100	na	NT					1.78	A	J	NA	NA	5.62	A	J	NA	NA	0.519	U		0.519	0.519	NT				
1,2,3,7,8,9-HXCDD	460	100	na	NT					1.25	A	J	NA	NA	2.37	A	J	NA	NA	0.519	U		0.519	0.519	NT				
1,2,3,4,6,7,8-HPCDD	na	na	na	NT					42.8		J	NA	NA	169		J	NA	NA	1.65	A	B	NA	NA	NT				
OCDD	61000	15000	na	NT					764		J	NA	NA	2080		J	NA	NA	32.9		B	NA	NA	NT				
1,2,3,7,8-PECDF	440	120	na	NT					0.178	A	J	NA	NA	0.593	A	J	NA	NA	0.0914	A, EMPC	J	0.519	0.519	NT				
2,3,4,7,8-PECDF	44	12	na	NT					0.369	A	J	NA	NA	0.924	A	J	NA	NA	0.519	U		0.519	0.519	NT				
1,2,3,4,7,8-HXCDF	na	na	na	NT					0.934	A	B	NA	NA	2.14	A	J	NA	NA	0.519	U		0.519	0.519	NT				
1,2,3,6,7,8-HXCDF	na	na	na	NT					0.417	A	B	NA	NA	1.09	A	J	NA	NA	0.519	U		0.519	0.519	NT				
2,3,4,6,7,8-HXCDF	na	na	na	NT					0.562	A	J	NA	NA	1.02	A	J	NA	NA	0.519	U		0.519	0.519	NT				
1,2,3,7,8,9-HXCDF	na	na	na	NT					0.519	U		0.519	0.519	0.508	A	J	NA	NA	0.519	U		0.519	0.519	NT				
1,2,3,4,6,7,8-HPCDF	na	na	na	NT					0.519	U	UJ	0.519	0.519	24.3		J	NA	NA	0.515	A	B	NA	NA	NT				
1,2,3,4,7,8,9-HPCDF	na	na	na	NT					0.502	A, EMPC	J	0.519	0.519	1.88	A	J	NA	NA	0.519	U		0.519	0.519	NT				
OCDF	44000	12000	na	NT					21.1		B	NA	NA	103		J	NA	NA	1.54	A, EMPC	B	1.04	1.04	NT				
TOTAL TCDD	na	na	na	NT					0.237			NA	NA	0.475			NA	NA	0.143	U		0.143	0.143	NT				
TOTAL PECDD	18	4.5	na	NT					1.05			NA	NA	3.4			NA	NA	0.316			NA	NA	NT				
TOTAL HXCDD	180	45	na	NT					8.9			NA	NA	34.2			NA	NA	0.519	U		0.519	0.519	NT				
TOTAL HPCDD	1800	450	na	NT					91.3			NA	NA	379			NA	NA	4.47			NA	NA	NT				
TOTAL TCDF	na	na	na	NT					0.853			NA	NA	15.8			NA	NA	0.268			NA	NA	NT				
TOTAL PECDF	na	na	na	NT					1.2			NA	NA	4.97			NA	NA	0.519	U		0.519	0.519	NT				
TOTAL HXCDF	130	37	na	NT					8.52			NA	NA	22			NA	NA	0.0748			NA	NA	NT				
TOTAL HPCDF	1300	370	na	NT					25.5			NA	NA	108			NA	NA	1.13			NA	NA	NT				

Table 4-1
Analytes Detected in SWMU 43 Soil Samples - 2007 RFI
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Analyte			Sample ID	**43SB09B**					**43SB09C**					**43SB10A**					**43SB10B**					**43SB10C**				
			Sample Date	**7/25/07**					**7/25/07**					**7/25/07**					**7/25/07**					**7/25/07**				
			Sample Depth	**4-6**					**8-10**					**0-0.5**					**4-6**					**8-10**				
	i-SL	**r-SL**	**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
Metals (mg/kg)																												
Aluminum	99000	7700	40041	11300		J	1.2	11	10500		J	1.2	11	14400		J	1.2	11	11100		J	1.3	11	10600		J	1.3	12
Antimony	41	3.1	na	0.68	J	B	0.3	3.4	0.68	J	B	0.3	3.3	0.89	J	B	0.3	3.4	0.89	J	B	0.3	3.4	0.72	J	B	0.31	3.5
Arsenic	1.6	0.39	15.8	6.1		J	0.22	0.45	1.4		L	0.22	0.45	1.2		L	0.22	0.45	1.2		L	0.22	0.46	1.9		L	0.23	0.47
Barium	19000	1500	209	90.5		J	0.28	11	72.4		J	0.28	11	121		J	0.28	11	89.5		J	0.29	11	94.3		J	0.3	12
Beryllium	200	16	1.02	0.97			0.056	0.28	0.92			0.056	0.28	**1.2**			0.056	0.28	0.99			0.057	0.29	0.97			0.059	0.3
Cadmium	81	7	0.69	0.056	U	UL	0.056	0.23	0.56	U	UL	0.56	1.1	0.056	U	UL	0.056	0.23	0.28	U	UL	0.28	0.46	0.3	U	UL	0.3	0.48
Calcium	na	na	na	9430		J	3.2	280	633		J	3.2	280	1690		J	3.2	280	945		J	3.3	290	1880		J	3.4	300
Chromium	1400	280	65.3	18.5		J	0.051	0.56	17.4		J	0.05	0.56	22.2		J	0.051	0.56	17.4		J	0.051	0.57	18.3		J	0.053	0.59
Cobalt	30	2.3	72.3	7.8		J	0.056	2.8	9.3		J	0.056	2.8	10.9		J	0.056	2.8	10.4		J	0.057	2.9	16.5		J	0.059	3
Copper	4100	310	53.5	19.2		J	0.051	1.4	12.4		J	0.05	1.4	12.9		J	0.051	1.4	11		J	0.051	1.4	10.5		J	0.053	1.5
Iron	72000	5500	50962	17900		J	0.68	5.6	18000		J	0.67	5.6	19900		J	0.68	5.6	17000		J	0.69	5.7	15400		J	0.71	5.9
Lead	800	400	26.8	11.2		J	0.11	5.6	4	J	J	0.11	5.6	7		J	0.11	5.6	4	J	J	0.11	5.7	5.7	J	J	0.12	5.9
Magnesium	na	na	na	6490		J	0.42	280	2700		J	0.41	280	3500		J	0.42	280	2890		J	0.42	290	3250		J	0.44	300
Manganese	2300	180	2543	383		J	0.11	1.7	169		J	0.033	0.84	521		J	0.28	4.2	490		J	0.29	4.3	337		J	0.12	1.8
Mercury	2.8	0.67	0.13	**1.9**			0.042	0.52	0.029	J	J	0.007	0.091	0.042	J	J	0.007	0.094	0.028	J	J	0.006	0.086	0.036	J	J	0.006	0.086
Nickel	2000	160	62.8	11.4		J	0.056	2.3	12		J	0.056	2.2	13.6		J	0.056	2.3	11		J	0.057	2.3	12		J	0.059	2.4
Potassium	na	na	na	1630		J	5.6	560	1350		J	5.6	560	1440		J	5.6	560	1260		J	5.7	570	1070		J	5.9	590
Selenium	510	39	na	0.11	U	UL	0.11	5.6	0.14	J	J	0.11	5.6	0.11	U	UJ	0.11	5.6	0.22	J	J	0.11	5.7	0.24	J	J	0.12	5.9
Silver	510	39	na	0.051	U	UL	0.051	0.56	0.05	U		0.05	0.56	0.051	U		0.051	0.56	0.051	U		0.051	0.57	0.053	U		0.053	0.59
Sodium	na	na	na	472	J	L	47	560	482	J	J	46	560	523	J	J	46	560	495	J	J	47	570	399	J	J	49	590
Vanadium	720	55	108	31.6		J	0.034	2.8	31.3		J	0.033	2.8	39.6		J	0.034	2.8	31.5		J	0.034	2.9	26.9		J	0.035	3
Zinc	31000	2300	202	69.5		J	0.073	1.1	39.5		J	0.072	1.1	57.1		J	0.073	1.1	45.9		J	0.074	1.1	43.4		J	0.077	1.2
Dioxins/Furans (ng/kg)																												
2,3,7,8-TCDF	130	37	na	NT					NT					NT					NT					NT				
2,3,7,8-TCDD	18	4.5	na	NT					NT					NT					NT					NT				
1,2,3,7,8-PECDD	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,6,7,8-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,7,8,9-HXCDD	460	100	na	NT					NT					NT					NT					NT				
1,2,3,4,6,7,8-HPCDD	na	na	na	NT					NT					NT					NT					NT				
OCDD	61000	15000	na	NT					NT					NT					NT					NT				
1,2,3,7,8-PECDF	440	120	na	NT					NT					NT					NT					NT				
2,3,4,7,8-PECDF	44	12	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,6,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
2,3,4,6,7,8-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,7,8,9-HXCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,6,7,8-HPCDF	na	na	na	NT					NT					NT					NT					NT				
1,2,3,4,7,8,9-HPCDF	na	na	na	NT					NT					NT					NT					NT				
OCDF	44000	12000	na	NT					NT					NT					NT					NT				
TOTAL TCDD	na	na	na	NT					NT					NT					NT					NT				
TOTAL PECDD	18	4.5	na	NT					NT					NT					NT					NT				
TOTAL HXCDD	180	45	na	NT					NT					NT					NT					NT				
TOTAL HPCDD	1800	450	na	NT					NT					NT					NT					NT				
TOTAL TCDF	na	na	na	NT					NT					NT					NT					NT				
TOTAL PECDF	na	na	na	NT					NT					NT					NT					NT				
TOTAL HXCDF	130	37	na	NT					NT					NT					NT					NT				
TOTAL HPCDF	1300	370	na	NT					NT					NT					NT					NT				

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

Table 4-1
Legend

12	J	Shading and black font indicate an industrial SL exceedance.
12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

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

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

Inorganic results below background UTLs are not indicated as exceedances on the table.

SL = Screening Level (Source: ORNL Regional Screening Table, September 2008).

SL values in table are for the more conservative chromium VI.

SL 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 (USEPA, 1999b).

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
Summary of Analytes Detected in SWMU 43 Soil Samples - 2007 RFI
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Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)											
2-Butanone	19000000	2800000	na	0	0	na	1	30	13.7	13.7	43SB02B
Acetone	61000000	6100000	na	0	0	na	16	30	29.1	95.2	43SB08B
Carbon disulfide	300000	67000	na	0	0	na	5	30	2.1	9	43SB02B
Ethylbenzene	29000	5700	na	0	0	na	1	30	61.8	61.8	43SB09B
m- & p-Xylene	na	na	na	na	na	na	2	30	9.8	12.4	43SB09B
o-Xylene	2300000	530000	na	0	0	na	1	30	8.9	8.9	43SB09B
Toluene	4600000	500000	na	0	0	na	1	30	2.7	2.7	43SB09B
Vinyl chloride	1700	60	na	0	0	na	1	30	6.6	6.6	43SB03B
PAHs (ug/kg)											
1-Methylnaphthalene	99000	22000	na	0	0	na	1	30	95.9	95.9	43SB09B
2-Methylnaphthalene	410000	31000	na	0	0	na	2	30	52.1	152	43SB09B
Acenaphthene	3300000	340000	na	0	0	na	1	30	152	152	43SB09B
Benz(a)anthracene	2100	150	na	0	0	na	4	30	16.4	88.8	43SB09A
Benzo(a)pyrene	210	15	na	0	4	na	4	30	15.2	140	43SB09A
Benzo(b)fluoranthene	2100	150	na	0	0	na	4	30	17.1	80.1	43SB09A
Benzo(g,h,i)perylene	1700000	170000	na	0	0	na	2	30	20.6	65.5	43SB09A
Benzo(k)fluoranthene	21000	1500	na	0	0	na	2	30	21.9	93.5	43SB09A
Chrysene	210000	15000	na	0	0	na	5	30	16.9	81.8	43SB09A
Fluoranthene	2200000	230000	na	0	0	na	2	30	69.4	77.7	43SB09B
Fluorene	2200000	230000	na	0	0	na	1	30	160	160	43SB09B
Indeno(1,2,3-cd)pyrene	2100	150	na	0	0	na	2	30	18.4	72.8	43SB09A
Naphthalene	20000	3900	na	0	0	na	3	30	65.8	92.1	43SB09B
Phenanthrene	1700000	170000	na	0	0	na	2	30	64.5	347	43SB09B
Pyrene	1700000	170000	na	0	0	na	1	30	118	118	43SB09A
SVOCs (ug/kg)											
bis(2-Ethylhexyl)phthalate	120000	35000	na	0	0	na	4	30	366	707	43SB09B
Dibenzofuran	na	na	na	na	na	na	1	30	105	105	43SB09B
Diethylphthalate	49000000	4900000	na	0	0	na	1	30	210	210	43SB09B
Di-n-butylphthalate	6200000	610000	na	0	0	na	3	30	96.4	2350	43SB06B
N-nitrosodiphenylamine	350000	99000	na	0	0	na	4	30	124	856	43SB03B

Table 4-2
Summary of Analytes Detected in SWMU 43 Soil Samples - 2007 RFI

Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Pesticides (ug/kg)											
4,4'-DDD	7200	2000	na	0	0	na	1	30	14.1	14.1	43SB03B
Dieldrin	110	30	na	0	0	na	1	30	0.85	0.85	43SB06B
PCBs (mg/kg)											
PCB-1016	2.1	0.39	na	0	1	na	4	30	0.0493	0.694	43SB03B
PCB-1254	0.74	0.022	na	0	7	na	8	30	0.0094	0.462	43SB03B
PCB-1260	0.74	0.22	na	0	0	na	2	30	0.0174	0.0398	43SB06B
Explosives (mg/kg)											
2,4,6-Trinitrotoluene	7.9	1.9	na	0	1	na	1	30	6.37	6.37	43SB03B
2,4-Dinitrotoluene	120	12	na	0	0	na	1	30	0.727	0.727	43SB03B
2-amino-4,6-Dinitrotoluene	200	15	na	0	0	na	1	30	0.136	0.136	43SB03B
Herbicides (ug/kg)											
Dicamba	1800000	180000	na	0	0	na	1	30	6.7	6.7	43SB01A
Metals (mg/kg)											
Aluminum	99000	7700	40041	0	0	0	30	30	4620	15600	43SB06A
Antimony	41	3.1	na	0	0	na	30	30	0.36	1.5	43SB04B
Arsenic	1.6	0.39	15.8	1	1	1	30	30	1.1	17.7	43SB07A
Barium	19000	1500	209	0	0	0	30	30	21.1	199	43SB09A
Beryllium	200	16	1.02	0	0	3	30	30	0.33	1.3	43SB06A
Cadmium	81	7	0.69	0	0	1	1	30	0.93	0.93	43SB08A
Calcium	na	na	na	na	na	na	30	30	633	95900	43SB02C
Chromium	1400	280	65.3	0	0	0	30	30	8.7	24.3	43SB06A
Cobalt	30	2.3	72.3	0	0	0	30	30	3.8	16.5	43SB10C
Copper	4100	310	53.5	0	0	1	30	30	4	71.9	43SB03B
Iron	72000	5500	50962	0	0	0	30	30	9750	22100	43SB05B
Lead	800	400	26.8	0	0	5	30	30	2.2	95.6	43SB03B
Magnesium	na	na	na	na	na	na	30	30	2130	58700	43SB02C
Manganese	2300	180	2543	0	0	0	30	30	84.2	1710	43SB09A
Mercury	2.8	0.67	0.13	0	2	7	28	30	0.015	1.9	43SB09B
Nickel	2000	160	62.8	0	0	0	30	30	6.4	16.3	43SB03C
Potassium	na	na	na	na	na	na	30	30	757	2120	43SB01B
Selenium	510	39	na	0	0	na	26	30	0.14	6.9	43SB05B
Silver	510	39	na	0	0	na	1	30	0.18	0.18	43SB06B
Sodium	na	na	na	na	na	na	19	30	30.6	557	43SB07C
Vanadium	720	55	108	0	0	0	30	30	11.1	42.4	43SB06A
Zinc	31000	2300	202	0	0	0	30	30	12.3	115	43SB07B

Table 4-2
Summary of Analytes Detected in SWMU 43 Soil Samples - 2007 RFI
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Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Dioxins/Furans (ng/kg)											
2,3,7,8-TCDF	130	37	na	0	0	na	5	6	0.268	5.53	43SB08B
2,3,7,8-TCDD	18	4.5	na	0	0	na	3	6	0.263	0.659	43SB08B
1,2,3,7,8-PECDD	na	na	na	na	na	na	4	6	0.32	0.946	43SB03A
1,2,3,4,7,8-HXCDD	460	100	na	0	0	na	5	6	0.225	1.51	43SB03A
1,2,3,6,7,8-HXCDD	460	100	na	0	0	na	4	6	1.78	7.84	43SB03B
1,2,3,7,8,9-HXCDD	460	100	na	0	0	na	5	6	0.264	3.8	43SB03B
1,2,3,4,6,7,8-HPCDD	na	na	na	na	na	na	6	6	1.65	342	43SB03B
OCDD	61000	15000	na	0	0	na	6	6	32.9	5830	43SB03B
1,2,3,7,8-PECDF	440	120	na	0	0	na	6	6	0.0914	1.33	43SB03B
2,3,4,7,8-PECDF	44	12	na	0	0	na	5	6	0.172	2.62	43SB03B
1,2,3,4,7,8-HXCDF	na	na	na	na	na	na	5	6	0.17	8.87	43SB03B
1,2,3,6,7,8-HXCDF	na	na	na	na	na	na	5	6	0.185	3.11	43SB03B
2,3,4,6,7,8-HXCDF	na	na	na	na	na	na	5	6	0.101	2.73	43SB03B
1,2,3,7,8,9-HXCDF	na	na	na	na	na	na	4	6	0.0892	1.43	43SB03B
1,2,3,4,6,7,8-HPCDF	na	na	na	na	na	na	5	6	0.515	50.4	43SB03B
1,2,3,4,7,8,9-HPCDF	na	na	na	na	na	na	5	6	0.105	4.24	43SB03B
OCDF	44000	12000	na	0	0	na	6	6	1.54	142	43SB03B
TOTAL TCDD	na	na	na	na	na	na	5	6	0.237	7.63	43SB03B
TOTAL PECDD	18	4.5	na	0	2	na	6	6	0.316	12	43SB03B
TOTAL HXCDD	180	45	na	0	1	na	5	6	2.28	68.8	43SB03B
TOTAL HPCDD	1800	450	na	0	1	na	6	6	4.47	865	43SB03B
TOTAL TCDF	na	na	na	na	na	na	6	6	0.268	18.1	43SB03B
TOTAL PECDF	na	na	na	na	na	na	5	6	0.495	17.3	43SB03B
TOTAL HXCDF	130	37	na	0	1	na	6	6	0.0748	48.4	43SB03B
TOTAL HPCDF	1300	370	na	0	0	na	6	6	1.13	174	43SB03B

Dioxins/Furans. Six samples (43SB03A, 43SB03B, 43SB03C, 43SB08A, 43SB08B, and 43SB08C) out of the 30 soil samples were analyzed for dioxins/furans. Four total dioxins/furans (total PECDD, total HXCDD, total HPCDD, and total HXCDF) were detected in soil samples. All four total dioxins/furans were detected in sample 43SB03B above their r-SLs. Only one of them (total PECDD) was detected above its r-SL in sample 43SB03A.

4.1.3 Groundwater Analytical Results

Six groundwater samples (43MW1, 43MW2, 43MW3, 43MW4, 43MW5, and 43MW6) were collected from six existing wells for chemical analysis (see **Table 3-1**). Detected groundwater results for are presented in **Table 4-3** and summarized in **Table 4-4**.

VOCs. One VOC [tetrachloroethene (PCE)] was detected in groundwater samples 43MW1, 43MW4, 43MW5, and 43MW6. PCE concentrations were greater than its tw-SL, but below its MCL in each of these samples. However, well 43MW1 is upgradient of SWMU 43, indicating that PCE may not be originating from SWMU 43.

PAHs. Samples were not tested for this group.

SVOCs. One SVOC (n-nitrosodiphenylamine) was detected in one groundwater sample (43MW6). However, the concentrations were well below the tw-SL.

***Pesticides*.** Pesticides were not detected in the SWMU 43 groundwater samples.

***PCBs*.** PCBs were not detected in the SWMU 43 groundwater samples.

***Explosives*.** Explosives were not detected in the SWMU 43 groundwater samples.

***Herbicides*.** Herbicides were not detected in the SWMU 43 groundwater samples.

TAL Metals. Fifteen (15) metals were detected in the SWMU 43 groundwater samples. Four of these metals (aluminum, arsenic, iron, and manganese) were detected above their respective MCL. Four metals (arsenic, cobalt, iron, and manganese) were found above their respective tw-SLs. However, arsenic, cobalt, and iron were detected above SLs in wells upgradient of the site and in wells downgradient of the site. Aluminum was only detected above SLs in the two upgradient wells (41MW1 and 41MW2). Therefore, these metals may not be originating from SWMU 43.

Misc. Perchlorate was detected in upgradient wells 43MW1 and 43MW2. However, concentrations were not above its tw-SL in any of the samples. It should be noted that perchlorate has consistently been detected at low levels throughout Radford since the adoption of the new LC/MS analytical method.

4.1.4 Soil Screening Level Comparison

Table 4-5 presents the chemical results from all the soil samples collected at SWMU 43 compared with the current (September 2008) ORNL soil transfer to groundwater values, using a dilution attenuation factor of 20 (USEPA, 2008a).

At SWMU 43, two VOCs were detected above their respective SSLs. Ethylbenzene and vinyl chloride were both detected above their SSLs in 1 of 30 soil samples. Two PAHs [benz(a)pyrene and naphthalene] were detected in 1 and 3 out of 30 samples, respectively, above their SSLs. One PCB (PCB-1254) was detected above its soil screening level (SSL) in 4 out of 30 samples. One explosive (2,4,6-TNT) was detected above its SSL in 1 out of 30 samples. Arsenic and

Table 4-3
Analytes Detected in SWMU 43 Groundwater Samples - 2007 RFI
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Analyte	Sample ID		43MW1					43MW2					43MW3				
	Sample Date		8/22/07					8/22/07					8/22/07				
	MCL	tw-SL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																	
Tetrachloroethene	5	0.11	0.45	J	J	*0.25*	*1*	1	U		*0.25*	*1*	1	U		*0.25*	*1*
SVOCs (ug/L)																	
N-nitrosodiphenylamine	na	14	5	U		*1*	*5*	4.9	U		*0.98*	*4.9*	4.9	U		*0.98*	*4.9*
Pesticides (ug/L)	None detected																
PCBs (ug/L)	None detected																
Explosives (ug/L)	None detected																
Herbicides (ug/L)	None detected																
Metals (ug/L)																	
Aluminum	50	3700	198	J	J	*79*	*200*	714			*79*	*200*	79	U		*79*	*200*
Arsenic	10	0.045	3.7	U		*3.7*	*10*	4.4	J	J	*3.7*	*10*	34.9			*3.7*	*10*
Barium	2000	730	63.2	J	J	*5*	*200*	42.6	J	J	*5*	*200*	75.4	J	J	*5*	*200*
Beryllium	4	7.3	1.2	J	J	*1*	*4*	2	J	J	*1*	*4*	1	U		*1*	*4*
Calcium	na	na	51100			*100*	*1000*	94800			*100*	*1000*	152000			*100*	*1000*
Chromium	100	11	6.5	J	J	*0.92*	*10*	10.9			*0.92*	*10*	1.9	J	J	*0.92*	*10*
Cobalt	na	1.1	1.6	J	J	*1*	*50*	1	U		*1*	*50*	2.4	J	J	*1*	*50*
Iron	300	2600	197	J	J	*15*	*300*	11800			*15*	*300*	10200			*15*	*300*
Magnesium	na	na	26000		J	*100*	*5000*	34900		J	*100*	*5000*	64100		J	*100*	*5000*
Manganese	50	88	17.3			*1*	*15*	8.4	J	J	*1*	*15*	9.9	J	J	*1*	*15*
Nickel	na	73	2.8	J	J	*1*	*40*	3.3	J	J	*1*	*40*	4.1	J	J	*1*	*40*
Potassium	na	na	2310	J	J	*100*	*10000*	2940	J	J	*100*	*10000*	3600	J	J	*100*	*10000*
Sodium	na	na	8900	J	J	*500*	*10000*	5350	J	J	*500*	*10000*	11600			*500*	*10000*
Vanadium	na	26	1.3	J	J	*1.1*	*50*	1.7	J	J	*1.1*	*50*	1.1	U		*1.1*	*50*
Zinc	5000	1100	5	U		*5*	*20*	5.7	J	J	*5*	*20*	5	U		*5*	*20*
Misc. (ug/L)																	
Perchlorate	na	2.6	0.203			*0.112*	*0.2*	0.142	J	J	*0.112*	*0.2*	0.2	U		*0.112*	*0.2*

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

Table 4-3
Analytes Detected in SWMU 43 Groundwater Samples - 2007 RFI
Page 2 of 2

Analyte		Sample ID	43MW4					43MW5					43MW6				
		Sample Date	8/22/07					8/22/07					8/22/07				
	MCL	**tw-SL**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																	
Tetrachloroethene	5	0.11	1.9			*0.25*	*1*	0.27	J	J	*0.25*	*1*	2.6			*0.25*	*1*
SVOCs (ug/L)																	
N-nitrosodiphenylamine	na	14	5	U		*0.99*	*5*	4.9	U		*0.98*	*4.9*	4.5	J	J	*0.98*	*4.9*
Pesticides (ug/L)	None detected																
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*	79	U		*79*	*200*	79	U		*79*	*200*
Arsenic	10	0.045	8.2	J	J	*3.7*	*10*	3.7	U		*3.7*	*10*	3.7	U		*3.7*	*10*
Barium	2000	730	226			*5*	*200*	170	J	J	*5*	*200*	181	J	J	*5*	*200*
Beryllium	4	7.3	1.5	J	J	*1*	*4*	1	U		*1*	*4*	1.1	J	J	*1*	*4*
Calcium	na	na	85700			*100*	*1000*	111000			*100*	*1000*	104000			*100*	*1000*
Chromium	100	11	2.2	J	J	*0.92*	*10*	2	J	J	*0.92*	*10*	1.4	J	J	*0.92*	*10*
Cobalt	na	1.1	6.2	J	J	*1*	*50*	1	U		*1*	*50*	2.3	J	J	*1*	*50*
Iron	300	2600	10900			*15*	*300*	15	U		*15*	*300*	3320			*15*	*300*
Magnesium	na	na	32600		J	*100*	*5000*	46000		J	*100*	*5000*	43500		J	*100*	*5000*
Manganese	50	88	835			*1*	*15*	3.1	J	J	*1*	*15*	144			*1*	*15*
Nickel	na	73	2.9	J	J	*1*	*40*	1.2	J	J	*1*	*40*	1	U		*1*	*40*
Potassium	na	na	2370	J	J	*100*	*10000*	2860	J	J	*100*	*10000*	2700	J	J	*100*	*10000*
Sodium	na	na	9790	J	J	*500*	*10000*	6750	J	J	*500*	*10000*	15000			*500*	*10000*
Vanadium	na	26	1.1	U		*1.1*	*50*	1.1	U		*1.1*	*50*	1.1	U		*1.1*	*50*
Zinc	5000	1100	8	J	J	*5*	*20*	5	U		*5*	*20*	5	U		*5*	*20*
Misc. (ug/L)																	
Perchlorate	na	2.6	0.2	U		*0.112*	*0.2*	0.2	U		*0.112*	*0.2*	0.2	U		*0.112*	*0.2*

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

Table 4-3
Legend

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

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

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

The 2-methylnaphthalene tw-SL was used for 1-methylnaphthalene.

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

MCL Action Levels were used for copper and lead.

MCL = Maximum Contaminant Level (Source: 2006 Edition of the Drinking Water Standards and Health Advisories. USEPA, August 2006).

tw-SL = Tap Water Screening Level (Source: ORNL Regional Screening Table, September 2008).

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

tw-SL 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 4-4
Summary of Analytes Detected in SWMU 43 Groundwater Samples - 2007 RFI

Analyte	MCL	tw-SL	# of MCL Exceedances	# of tw-SL Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/L)									
Tetrachloroethene	5	0.11	0	4	4	6	0.27	2.6	43MW6
SVOCs (ug/L)									
N-nitrosodiphenylamine	na	14	na	0	1	6	4.5	4.5	43MW6
Pesticides (ug/L)	None detected								
PCBs (ug/L)	None detected								
Explosives (ug/L)	None detected								
Herbicides (ug/L)	None detected								
Metals (ug/L)									
Aluminum	50	3700	2	0	2	6	198	714	43MW2
Arsenic	10	0.045	1	3	3	6	4.4	34.9	43MW3
Barium	2000	730	0	0	6	6	42.6	226	43MW4
Beryllium	4	7.3	0	0	4	6	1.1	2	43MW2
Calcium	na	na	na	na	6	6	51100	152000	43MW3
Chromium	100	11	0	0	6	6	1.4	10.9	43MW2
Cobalt	na	1.1	na	4	4	6	1.6	6.2	43MW4
Iron	300	2600	4	4	5	6	197	11800	43MW2
Magnesium	na	na	na	na	6	6	26000	64100	43MW3
Manganese	50	88	2	2	6	6	3.1	835	43MW4
Nickel	na	73	na	0	5	6	1.2	4.1	43MW3
Potassium	na	na	na	na	6	6	2310	3600	43MW3
Sodium	na	na	na	na	6	6	5350	15000	43MW6
Vanadium	na	26	na	0	2	6	1.3	1.7	43MW2
Zinc	5000	1100	0	0	2	6	5.7	8	43MW4
Misc. (ug/L)									
Perchlorate	na	2.6	na	0	2	6	0.142	0.203	43MW1

Table 4-5
Overall SSL Transfer Exceedance Summary for SWMU 43 - 2007 RFI
Page 1 of 3

Analyte	Background	SSL Transfer	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)									
2-Butanone	na	30000	na	0	1	30	13.7	13.7	43SB02B
Acetone	na	88000	na	0	16	30	29.1	95.2	43SB08B
Carbon disulfide	na	5400	na	0	5	30	2.1	9	43SB02B
Ethylbenzene	na	38	na	1	1	30	61.8	61.8	43SB09B
m- & p-Xylene	na	na	na	na	2	30	9.8	12.4	43SB09B
o-Xylene	na	32000	na	0	1	30	8.9	8.9	43SB09B
Toluene	na	34000	na	0	1	30	2.7	2.7	43SB09B
Vinyl chloride	na	0.112	na	1	1	30	6.6	6.6	43SB03B
PAHs (ug/kg)									
1-Methylnaphthalene	na	300	na	0	1	30	95.9	95.9	43SB09B
2-Methylnaphthalene	na	18000	na	0	2	30	52.1	152	43SB09B
Acenaphthene	na	540000	na	0	1	30	152	152	43SB09B
Benz(a)anthracene	na	280	na	0	4	30	16.4	88.8	43SB09A
Benzo(a)pyrene	na	92	na	1	4	30	15.2	140	43SB09A
Benzo(b)fluoranthene	na	940	na	0	4	30	17.1	80.1	43SB09A
Benzo(g,h,i)perylene	na	3000000	na	0	2	30	20.6	65.5	43SB09A
Benzo(k)fluoranthene	na	9200	na	0	2	30	21.9	93.5	43SB09A
Chrysene	na	28000	na	0	5	30	16.9	81.8	43SB09A
Fluoranthene	na	4200000	na	0	2	30	69.4	77.7	43SB09B
Fluorene	na	660000	na	0	1	30	160	160	43SB09B
Indeno(1,2,3-cd)pyrene	na	3200	na	0	2	30	18.4	72.8	43SB09A
Naphthalene	na	11	na	3	3	30	65.8	92.1	43SB09B
Phenanthrene	na	3000000	na	0	2	30	64.5	347	43SB09B
Pyrene	na	3000000	na	0	1	30	118	118	43SB09A
SVOCs (ug/kg)									
bis(2-Ethylhexyl)phthalate	na	32000	na	0	4	30	366	707	43SB09B
Dibenzofuran	na	na	na	na	1	30	105	105	43SB09B
Diethylphthalate	na	260000	na	0	1	30	210	210	43SB09B
Di-n-butylphthalate	na	220000	na	0	3	30	96.4	2350	43SB06B
N-nitrosodiphenylamine	na	3400	na	0	4	30	124	856	43SB03B
Pesticides (ug/kg)									
4,4'-DDD	na	1720	na	0	1	30	14.1	14.1	43SB03B
Dieldrin	na	1.8	na	0	1	30	0.85	0.85	43SB06B
PCBs (mg/kg)									
PCB-1016	na	1.04	na	0	4	30	0.0493	0.694	43SB03B
PCB-1254	na	0.102	na	4	8	30	0.0094	0.462	43SB03B
PCB-1260	na	0.28	na	0	2	30	0.0174	0.0398	43SB06B

Table 4-5
Overall SSL Transfer Exceedance Summary for SWMU 43 - 2007 RFI
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Analyte	Background	SSL Transfer	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives (mg/kg)									
2,4,6-Trinitrotoluene	na	0.174	na	1	1	30	6.37	6.37	43SB03B
2,4-Dinitrotoluene	na	1.36	na	0	1	30	0.727	0.727	43SB03B
2-amino-4,6-Dinitrotoluene	na	0.58	na	0	1	30	0.136	0.136	43SB03B
Herbicides (ug/kg)									
Dicamba	na	5600	na	0	1	30	6.7	6.7	43SB01A
Metals (mg/kg)									
Aluminum	40041	1100000	0	0	30	30	4620	15600	43SB06A
Antimony	na	13.2	na	0	30	30	0.36	1.5	43SB04B
Arsenic	15.8	0.026	1	1	30	30	1.1	17.7	43SB07A
Barium	209	6000	0	0	30	30	21.1	199	43SB09A
Beryllium	1.02	1160	3	0	30	30	0.33	1.3	43SB06A
Cadmium	0.69	28	1	0	1	30	0.93	0.93	43SB08A
Calcium	na	na	na	na	30	30	633	95900	43SB02C
Chromium	65.3	42	0	0	30	30	8.7	24.3	43SB06A
Cobalt	72.3	9.8	0	0	30	30	3.8	16.5	43SB10C
Copper	53.5	1020	1	0	30	30	4	71.9	43SB03B
Iron	50962	12800	0	0	30	30	9750	22100	43SB05B
Lead	26.8	na	5	na	30	30	2.2	95.6	43SB03B
Magnesium	na	na	na	na	30	30	2130	58700	43SB02C
Manganese	2543	1140	0	0	30	30	84.2	1710	43SB09A
Mercury	0.13	0.66	7	2	28	30	0.015	1.9	43SB09B
Nickel	62.8	960	0	0	30	30	6.4	16.3	43SB03C
Potassium	na	na	na	na	30	30	757	2120	43SB01B
Selenium	na	19	na	0	26	30	0.14	6.9	43SB05B
Silver	na	32	na	0	1	30	0.18	0.18	43SB06B
Sodium	na	na	na	na	19	30	30.6	557	43SB07C
Vanadium	108	5200	0	0	30	30	11.1	42.4	43SB06A
Zinc	202	13600	0	0	30	30	12.3	115	43SB07B
Dioxins/Furans (ng/kg)									
2,3,7,8-TCDF	na	16.8	na	0	5	6	0.268	5.53	43SB08B
2,3,7,8-TCDD	na	3	na	0	3	6	0.263	0.659	43SB08B
1,2,3,7,8-PECDD	na	na	na	na	4	6	0.32	0.946	43SB03A
1,2,3,4,7,8-HXCDD	na	na	na	na	5	6	0.225	1.51	43SB03A
1,2,3,6,7,8-HXCDD	na	na	na	na	4	6	1.78	7.84	43SB03B
1,2,3,7,8,9-HXCDD	na	na	na	na	5	6	0.264	3.8	43SB03B
1,2,3,4,6,7,8-HPCDD	na	na	na	na	6	6	1.65	342	43SB03B
OCDD	na	82000	na	0	6	6	32.9	5830	43SB03B
1,2,3,7,8-PECDF	na	94	na	0	6	6	0.0914	1.33	43SB03B
2,3,4,7,8-PECDF	na	9.4	na	0	5	6	0.172	2.62	43SB03B
1,2,3,4,7,8-HXCDF	na	na	na	na	5	6	0.17	8.87	43SB03B

Table 4-5
Overall SSL Transfer Exceedance Summary for SWMU 43 - 2007 RFI
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Analyte	Background	SSL Transfer	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
1,2,3,6,7,8-HXCDF	na	na	na	na	5	6	0.185	3.11	43SB03B
2,3,4,6,7,8-HXCDF	na	na	na	na	5	6	0.101	2.73	43SB03B
1,2,3,7,8,9-HXCDF	na	na	na	na	4	6	0.0892	1.43	43SB03B
1,2,3,4,6,7,8-HPCDF	na	na	na	na	5	6	0.515	50.4	43SB03B
1,2,3,4,7,8,9-HPCDF	na	na	na	na	5	6	0.105	4.24	43SB03B
OCDF	na	46000	na	0	6	6	1.54	142	43SB03B
TOTAL TCDD	na	na	na	na	5	6	0.237	7.63	43SB03B
TOTAL PECDD	na	5.4	na	2	6	6	0.316	12	43SB03B
TOTAL HXCDD	na	86	na	0	5	6	2.28	68.8	43SB03B
TOTAL HPCDD	na	1460	na	0	6	6	4.47	865	43SB03B
TOTAL TCDF	na	na	na	na	6	6	0.268	18.1	43SB03B
TOTAL PECDF	na	na	na	na	5	6	0.495	17.3	43SB03B
TOTAL HXCDF	na	48	na	1	6	6	0.0748	48.4	43SB03B
TOTAL HPCDF	na	800	na	0	6	6	1.13	174	43SB03B

SSL = Soil Screening Level (USEPA, September 2008).

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

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

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

NA = not applicable.

mercury were also detected above their SSLs in 1 and 2 out of 30 samples, respectively. Four total dioxins/furans (total PECDD, total HXCDD, total HPCDD, and total HXCDF) were detected above their SSLs.

The low frequency of detection suggests that these compounds are not a concern in soil at SWMU 43. Dioxins/Furans were only detected above residential screening levels in Total dioxins/furans, and not in any individual dioxin/furan congener, which is why they are not deemed a concern. The analytes that were detected above both SLs and SSLs in soil samples were benzo(a)pyrene; PCB-1254; 2,4,6-TNT; arsenic; mercury; total PECDD; and total HXCDF.

4.2 Nature and Extent Summary and Conclusions

4.2.1 Soil

The soil at SWMU 43 was investigated during the 2007 sampling event in support of the RFI. A summary of all analytes detected in soil can be found in **Table 4-2**.

The data indicates that one PAH [benzo(a)pyrene] was detected above its r-SL in 4 out of 30 soil samples collected. Two PCBs were detected above their r-SLs in soil samples. PCB-1016 was detected above its r-SL in 1 out of 30 samples and PCB-1254 was detected above its r-SL in 7 out of 30 soil samples. One explosive (2,4,6-TNT) was detected above its r-SL in 1 out of 30 site soil samples. Two metals were detected above SLs in site soil samples. Arsenic was detected above its r-SL, i-SL, and background level in 1 out of 30 samples. Mercury was detected above its r-SL and background level in 2 out of 30 samples. Four total dioxins/furans were detected above their r-SL in site samples.

Arsenic was the only soil analyte that was above its SLs and background in one soil sample and also detected in 2007 groundwater samples. The constituents found above background and screening levels indicate a potential risk that is evaluated in more detail in the HHRA (*Section 6.0*).

4.2.2 Surface Water

Surface water at SWMU 43 was only investigated during the 1992 investigation. Additional sampling was planned for 2007, but samples were unable to be collected because no seeps were present due to drought conditions. The results of all analytes detected in surface water can be found in **Table 2-2**.

SWMU 43 surface water results from the 1992 sampling event indicated that only four metals (aluminum, arsenic, iron, and manganese) were detected above their screening limits. Aluminum was detected above its MCL in sample 43SP1. Arsenic was found above its tw-SL in sample 43SP2 and above both its MCL and tw-SL in sample 43SP1. Iron was detected above its MCL in both samples, and also above its tw-SL in sample 43SP1. Manganese was detected above both its tw-SL and MCL in both samples. SVOCs, pesticides, and PCBs were not detected in 1992 site surface water samples.

The surface water analytes detected above SLs that were also detected in 2007 groundwater samples were four metals: aluminum, arsenic, iron, and manganese. Sediment and surface water sampling was deemed unnecessary in the future due to the low number of surface soil exceedances found within the landfill cells, on either side, which could be expected to contribute sediment and any possible contaminants to the ditch.

4.2.3 Groundwater

Groundwater at SWMU 43 was investigated during both the 1992 and 2007 investigations. A summary of all analytes detected in the 2007 investigation of SWMU 43's groundwater can be found in **Table 4-4** and all the results can be found in **Table 4-3**.

Although groundwater samples were collected during the 1992 VI, the more recent data from the 2007 investigation was used to assess potential migration of constituents from the landfills, since it is a better representation of current conditions. Groundwater results from the 2007 sampling event indicated that one VOC (PCE) and five metals (aluminum, arsenic, cobalt, iron, and manganese) were detected above their screening limits. PCE was detected above its tw-SL in four out of six samples. Arsenic, iron, and manganese were found above their MCLs and tw-SLs. Aluminum was only detected above its MCL in two samples. Cobalt was only detected above its tw-SL in four samples, but does not have an MCL. However, two wells (43MW1 and 43MW2) of the six groundwater wells are upgradient of the site. Analytes found as exceedances in the upgradient wells may lead one to believe that they are not associated with and/or do not originate from the site. Aluminum, arsenic, cobalt, and iron were detected above SLs in at least one upgradient site. Therefore, of the metals detected above SLs, manganese was the only metal to be found above SLs in a downgradient wells only. Pesticides, PCBs, explosives, and herbicides were not detected in 2007 site groundwater samples. Groundwater samples were not analyzed for dioxins/furans since they are very strongly sorbed in soils and are therefore unlikely to be detected in groundwater.

Although PCE, aluminum, arsenic, cobalt, iron, and manganese were detected above groundwater SLs, arsenic was only analyte detected above SLs in both soil and groundwater.

5.0 CONTAMINANT FATE AND TRANSPORT

This section presents a discussion of the fate and transport mechanisms for chemicals of potential concern (COPCs) at SWMU 43. Physical and chemical properties of the impacted media and of the contaminant(s) affect the fate and persistence of contamination in the environment (Rosenblatt et al., 1975). A general discussion of the physical properties and mechanisms which may govern the fate of contaminants in the environment, and a discussion of contaminant transport is presented in **Appendix D**. A discussion of the physical and chemical properties affecting soil conditions at SWMU 43 is presented as *Section 5.1*.

Of the 30 soil samples collected at SWMU 43, only one PAH [benzo(a)pyrene], two PCBs (PCB-1016 and PCB-1254), one explosive (2,4,6-TNT), two metals (arsenic and mercury), and four dioxins/furans (total PECDD, total HXCDD, total HPCDD, and total HXCDF) were detected above their SLs, most in one or two samples.

A generalized fate and transport discussion for those constituents identified as risk drivers in the HHRA are presented in *Section 5.2*.

5.1 Soil Properties Affecting Fate and Transport

Chemical and physical properties of soil influence the fate and transport of constituents through the environment. Grain size distribution, pH, and TOC are commonly used to assess these chemical and physical characteristics of the soil. A summary of each follows.

Grain Size Distribution. The grain size distribution measures the amount of clay, silt, sand, and gravel in a sample based on the diameter of the material. Soil particles less than 0.002 millimeters are classified as clay and have a very large specific surface area, allowing them a significant capacity to adsorb water and other substances. Clay composition greatly influences soil fertility and the physical conditions of the soil. Clay directly affects the permeability and the plasticity of soil by generally lowering the soil's permeability and increasing the plasticity. Because pores between clay particles are very small and convoluted, movement of both water and air is very slow. Fate and transport of chemical compounds are hindered when passing through a soil with a high composition of clay due to clay's ability to adsorb cations and to retain soil moisture. The U.S. Department of Agriculture has identified the soils underlying SWMU 43 as the Unison-Urban Land Complex. These soils have been highly reworked through activities at RFAAP. A typical profile of Unison-Urban Land Complex has a surface layer of brown loam about 15 inches thick with yellowish-red sticky, plastic clay about 43 inches deep. The substratum is red, sandy clay loam below a depth of 58 inches. The Unison-Urban Land Complex typically has a slope modifier of 2 to 7 percent. Therefore, the site soil beneath SWMU 43 has a high percentage of clay and is a low permeability zone where it is more difficult for constituents to 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. The soils at SWMU 43 appear to be fairly poorly-sorted and therefore aid in a slightly lower permeability rate.

Soil pH. Soil pH is a measure of acidity or alkalinity and is an important chemical property because it is an indication of soil reaction potential. Soil reaction influences the fate of many pollutants, affecting their breakdown and potential movement. For example, hydrolysis is the reaction of a compound with water. It usually involves the introduction of a hydroxyl (-OH) group into an organic compound, usually at a point of unbalanced charge distribution. The hydrolysis reaction can displace halogens and may be catalyzed by the presence of acids, bases, or metal ions. Therefore, the rate of hydrolysis is pH and metal-ion concentration dependent. The transport of some contaminants is also affected by pH. This is less significant for neutral and slightly polarized organic compounds, which are somewhat affected by pH, but is significant for chemicals that tend to ionize (Lyman et al., 1990). When the pH of the groundwater is approximately 1.0 to 1.5 units above the negative log of the acid dissociation constant (pK_a), adsorption becomes significant, retarding transport rates. pH also affects the rate of biodegradation that may occur at a site. Most bacteria find the optimum pH range to be 6.5 to 7.5 and are not able to survive at pH values greater than 9.5 or below 4.0 (Knox et al., 1993).

Soil at RFAAP generally ranges in pH from slightly less than 4.0 to slightly more than 9.61. A review of pH results during the *Facility-Wide Background Study Report* (IT, 2001) across soil types at the MMA did not yield outstanding trends. Higher soil pH results were generally associated with limestone and shale parent material (IT, 2001). pH soil measurements were not taken at SWMU 43.

TOC. 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. In addition, this means that the amount of TOC present in the soil matrix has a large affect on the fate of both organic and inorganic compounds. The degree to which TOC affects the fate of a chemical varies dependent on the properties of the chemical itself. Soil TOC concentrations at RFAAP range from 0.075 to 30.4 percent, with a median value of 0.5 percent.

5.2 Fate and Transport of Analytes Detected Above Screening Levels

As discussed in *Section 4.0*, the analytes that were detected above SLs in 2007 SWMU 43 soil samples were one PAH [benzo(a)pyrene], two PCBs (PCB-1016 and PCB-1254), one explosive (2,4,6-TNT), two metals (arsenic and mercury), and four dioxins/furans (total PECDD, total HXCDD, total HPCDD, and total HXCDF). Of those, the only analyte that was also identified as a soil risk driver in the HHRA for SWMU 43 (*Section 6.0*) was arsenic. However, arsenic was within background concentrations for surface and total soil. Benzo(a) pyrene and the dioxin/furan TCDD TE were also analytes detected above their SLs that were also identified as soil risk drivers.

The analytes detected above SLs in SWMU 43 groundwater from the 1992 sampling event were one VOC (benzene) and three metals (arsenic, iron, and manganese). Benzene was found at a concentration of 0.5 micrograms per liter (µg/L), above its tw-SL of 0.41 µg/L, in one sample, 43MW3 (RDWB*3). The three metals were detected above their MCLs, tw-SLs, and background levels in site samples.

SWMU 43 groundwater results from the 2007 sampling event indicated that one VOC (PCE) and five metals (aluminum, arsenic, cobalt, iron, and manganese) were detected above their screening limits. PCE was detected above its tw-SL in four out of six samples. Arsenic, iron, and manganese were found above their MCLs, tw-SLs, and background levels. Aluminum was only detected above its MCL in two samples. Cobalt was only detected above its tw-SL in four samples, but did not have an MCL.

The analytes detected above SLs that were also identified as groundwater risk drivers in the HHRA for SWMU 43 (*Section 6.0*) were PCE and arsenic.

Specific characteristics of these risk drivers are discussed in more detail in the following sections.

5.2.1 Metals

5.2.1.1 Arsenic

In SWMU 43 2007 soil samples, arsenic was found above both its i-SL [1.6 milligrams per kilogram (mg/kg)] and r-SL (0.39 mg/kg) and background level (15.8 mg/kg) in only one sample (43SB07A) at a concentration of 17.7 mg/kg. However, arsenic was within background concentrations for surface and total soil.

Arsenic is a naturally-occurring element widely distributed in the earth’s crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds (ATSDR, 2007).

Inorganic arsenic compounds are mainly used to preserve wood. Chromated copper arsenate (CCA) is used to make “pressure-treated” lumber. CCA is no longer used in the U.S. for residential uses; it is still used in industrial applications. Organic arsenic compounds are used as pesticides, primarily on cotton fields and orchards (ATSDR, 2007).

Arsenic occurs naturally in soil and minerals and may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching. Arsenic cannot be destroyed in the environment. It can only change its form. Rain and snow remove arsenic dust particles from the air. Many common arsenic compounds can dissolve in water. Most of the arsenic in water will ultimately end up in soil or sediment (ATSDR, 2007).

5.2.2 Polynuclear Aromatic Hydrocarbons

5.2.2.1 Benzo(a)pyrene

In SWMU 43 soil samples, one PAH [benzo(a)pyrene] was detected above its r-SL in four samples, between 0 and 6 ft bgs.

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.

5.2.3 Volatile Organic Compounds

5.2.3.1 PCE

PCE was detected above its tw-SL in four of six SWMU 43 groundwater samples.

PCE is a manufactured chemical used for dry cleaning and metal degreasing. Other names for PCE include perchloroethylene, tetrachloroethene, and tetrachloroethylene. It is a nonflammable liquid at room temperature. It evaporates easily into the air and has a sharp, sweet odor. Most people can smell PCE when it is present in the air at a level of 1 part PCE per million parts of air (1 ppm) or more, although some can smell it at even lower levels (ATSDR, 1997).

5.2.4 Dioxins/Furans

In SWMU 43 soil samples, four total dioxins/furans (Total PECDD, total HXCDD, total HPCDD, and total HXCDF) were detected at concentrations greater than their r-SL values, all in sample 43SB03B and total PECDD also in sample 43SB03A.

Dioxins/furans make up a family of chemicals with related properties and toxicity. There are 75 different forms of dioxins, while there are 135 different furans. Dioxins/furans are not manufactured or used. Instead, these groups of chemicals are formed unintentionally in two ways: (1) as a chemical contaminant of industrial processes involving chlorine or bromine, or (2) by burning organic matter in the presence of chlorine. The principal sources of dioxins/furans in the environment are combustion and incineration, chemical manufacturing, pulp and paper mills, 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 $2.0\text{x}10^{-4}$ milligrams per liter (mg/L) at 25°C. Dioxins/furans also have low vapor pressures (e.g., $1.0\text{x}10^{-6}$ 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., $3.30\text{x}10^{+6}$ for TCDD) indicating that dioxins and furans have high sorption potentials and will not tend to leach into groundwater or surface water runoff.

Chemicals with high K_{ow} values, such as dioxins and furans, are relatively hydrophobic and will tend to sorb to soil rather than partitioning into the polar water phase.

Dioxins and furans with four or more chlorine atoms (i.e., OCDD and HpCDF) are extremely stable, with photolysis as the single significant degradation process. In the photodecomposition process, lower chlorinated congeners are formed (Crosby et al., 1971; Miller et al., 1989). Higher chlorinated congeners will have lower rates of decomposition. In addition, in or on solid phases, photochemical transformation results in a preferential loss of chlorine on the 1, 4, 6, and 9 positions leading to the formation of more toxic compounds (Lamparski et al., 1980; Nestrick et al., 1980). Since sunlight penetration becomes restricted in subsurface soil, photolysis of dioxins and furans will predominantly occur in the top layer of soil.

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 soil most likely did not degrade due to the lack of light at depth.

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, surface water, and groundwater. The HHRA was conducted for SWMU 43 consistent with guidance included in USEPA's *Interim Final Risk Assessment Guidance for Superfund* (RAGS) and other current USEPA/USEPA Region III resources and guidance documents as noted throughout this section and on the RAGS Part D tables provided in **Appendix E-1**. Additional information regarding the site background can be found in *Section 2.0*. This HHRA consists of the following six sections:

- **Section 6.1: Data Summary and Selection of COPCs:** Relevant site data are gathered, examined, and discussed. Basic constituent statistics and SLs 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 compiled 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, 1989a) are discussed.
- **Section 6.6: Summary and Conclusions:** The results of the HHRA are summarized.

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, surface water, and groundwater samples used in the HHRA for SWMU 43. The complete data tables for detected analytes for each media are provided in **Tables 4-1 through 4-4**. Additional information regarding the data used in the HHRAs is summarized below:

- Though several dioxins are known to be toxic, toxicity criteria are limited to 2,3,7,8-TCDD. Therefore, the HHRA uses the method outlined in Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-

Table 6-1
SWMU 43
Sample Groupings

SWMU 43		
SURFACE SOIL[a]		
43SB01A	43SB05A	43SB09A
43SB02A	43SB06A	43SB10A
43SB03A	43SB07A	
43SB04A	43SB08A	
TOTAL SOIL[b]		
43SB01A	43SB04B	43SB07C
43SB01B	43SB04C	43SB08A
43SB01C	43SB05A	43SB08B
43SB02A	43SB05B	43SB08C
43SB02B	43SB05C	43SB09A
43SB02C	43SB06A	43SB09B
43SB03A	43SB06B	43SB09C
43SB03B	43SB06C	43SB10A
43SB03C	43SB07A	43SB10B
43SB04A	43SB07B	43SB10C
SURFACE WATER[c]		
43SP1 (RDWB*7)	43SP2 (RDWB*10)	
GROUNDWATER		
43MW1[d]	43MW3	43MW5
43MW2[d]	43MW4	43MW6

(a) Surface soil samples consist of samples collected at depths of 0 to 0.5 feet.

(b) Total soil sample group includes all surface soil and subsurface soil samples from 0 to 10 feet.

(c) Surface water samples represent water collected in 1992 from seeps along the river bank at SWMU 43.

(d) Samples were collected from monitoring wells located upgradient of SWMU 43.

dioxins and Dibenzofurans (CDDs and CDFs) (USEPA, 1989b, 1994b; Van den Berg et al., 2006) to assess risks due to exposure to dioxins and/or furans. Each congener is assigned a 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 and total soil 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.
- 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, sediment, surface water, and groundwater samples used in the HHRA is provided in *Sections 6.1.1.1 through 6.1.1.4*.

6.1.1.1 Surface Soil and Total Soil

The soil samples used for COPC screening of SWMU 43 were collected during the sampling event in 2007. As presented in **Table 6-1**, the soil samples for SWMU 43 have been divided into surface soil (0 to 0.5 ft bgs) and subsurface soil (4 to 10 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. A total of 10 surface soil samples and 20 subsurface soil samples were used in the HHRA for SWMU 43.

6.1.1.2 Sediment

Because the proposed surface water sample represented springs or seeps, no sediment samples were collected for SWMU 43.

6.1.1.3 Surface Water

Two surface water samples collected during sampling events completed in 1991 were used for the COPC screening for SWMU 43. These surface water samples represented springs or seeps, which occurred on the river bank. Although seep samples were proposed to be collected as part of the 2007 sampling effort, the seep locations were found to be dry in 2007. These sample identifications are listed in **Table 6-1**.

6.1.1.4 Groundwater

Groundwater samples collected during sampling events completed in 2007 were used for the COPC screening for SWMU 43. A total of six groundwater samples were collected. These sample identifications are listed in **Table 6-1**.

6.1.2 Identification of COPCs

COPCs were identified for SWMU 43 by comparing the maximum detected concentration (MDC) with the following risk-based SLs for each media: USEPA r-SLs (surface soil, total soil and sediment) and USEPA tw-SLs (surface water and groundwater) as presented in the September 2008 USEPA Regional Screening Tables (USEPA, 2008a). In accordance with USEPA regional guidance, SLs 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. Although current and future land uses at SWMU 43 are most likely to be industrial in nature, r-SLs (rather than industrial) were used for comparisons with soil concentrations. Because the residential scenario was evaluated for this HHRA, r-SLs were used to screen chemicals in soil as a conservative measure. 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, 1994a).

The maximum concentrations of the four essential human nutrients that do not have SLs (i.e., calcium, magnesium, potassium, and sodium) were compared with 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 SL 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, 1996a).

Analytes detected at a maximum concentration greater than the corresponding adjusted SL or screening values identified above for nutrients and lead were selected as COPCs. Analytes for which no screening criteria exist were also selected as COPCs. COPC screening tables are presented in **Appendix E-1**, **Tables E.1-2** (COPC Determination Detects-Surface Soil), **E.1-4** (COPC Determination Detects-Total Soil), **E.1-6** (COPC Determination Detects-Surface Water), and **E.1-8** (COPC Determination Detects-Groundwater). The COPCs selected for each medium are summarized in **Table 6-2**.

Similarly, the reporting limits for those constituents that were not detected were compared with SLs for each medium. Chemicals that were not detected in at least one medium have not been included in the HHRA. The reporting limits for the non-detected constituents were screened against the SLs to ensure that the range of reporting limits was generally low enough to detect constituents that would be greater than SLs. The maximum reporting limits for these

Table 6-2
Summary of Chemicals of Potential Concern at SWMU 43

Chemical (a)	Surface Soil	Total Soil	Surface Water	Groundwater
Organics				
Aroclor 1016		X		
Aroclor 1254		X		
Benzo(a)pyrene	X	X		
Dibenzofuran		X		
2,4-Dinitrotoluene		X		
p-Chloro-m-cresol[b]		X		
TCDD-Toxicity Equivalent	X	X		
2,4,6-Trinitrotoluene		X		
Inorganics				
Aluminum	X	X		
Arsenic	X	X	X	X
Cobalt	X	X		X
Iron	X	X	X	X
Manganese	X	X	X	X
Sodium			X	
Tetrachloroethene				X
Vanadium	X	X		

(a) Chemicals detected in all media at SWMU 43.

(b) No screening value was available for this compound. Toxicity value for 3-methyl phenol was used as a surrogate for this compound.

Shaded cells indicate that the chemical lacks toxicity criteria and cannot be quantitatively evaluated.

X = Selected as a COPC in this media.

constituents were compared with SLs. The results of these comparisons are shown in **Appendix E-1**, **Tables E.1-3** (Non-Detect Screening- Surface Soil), **E.1-5** (Non-Detect Screening-Total Soil), **E.1-7** (Non-Detect Screening-Surface Water), and **E.1-9** (Non-Detect Screening-Groundwater). Detected constituents identified as COPCs were carried through the quantitative risk assessment. The reporting limits for constituents that were not detected in surface soil, total soil, sediment, surface water, or groundwater are evaluated with respect to their screening criteria and discussed in the uncertainty section (*Section 6.5.2*).

6.2 Exposure Assessment

The objective of the exposure assessment is to estimate "the type and magnitude of exposures to chemicals of potential concern" (USEPA, 1989a). 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 43 are presented on **Figures 6-1 and 6-2** for current and future exposure scenarios, respectively.

SWMU 43 is a closed sanitary landfill consisting of two adjacent 1.5-acre cells located immediately adjacent to the New River in the northeast area of the MMA. The former trench-fill operation repeatedly received paper and refuse over its active life. Borings along the fence to the north encountered sanitary landfill material consisting of paper, rubber, and plastic debris, down to 18 ft bgs.

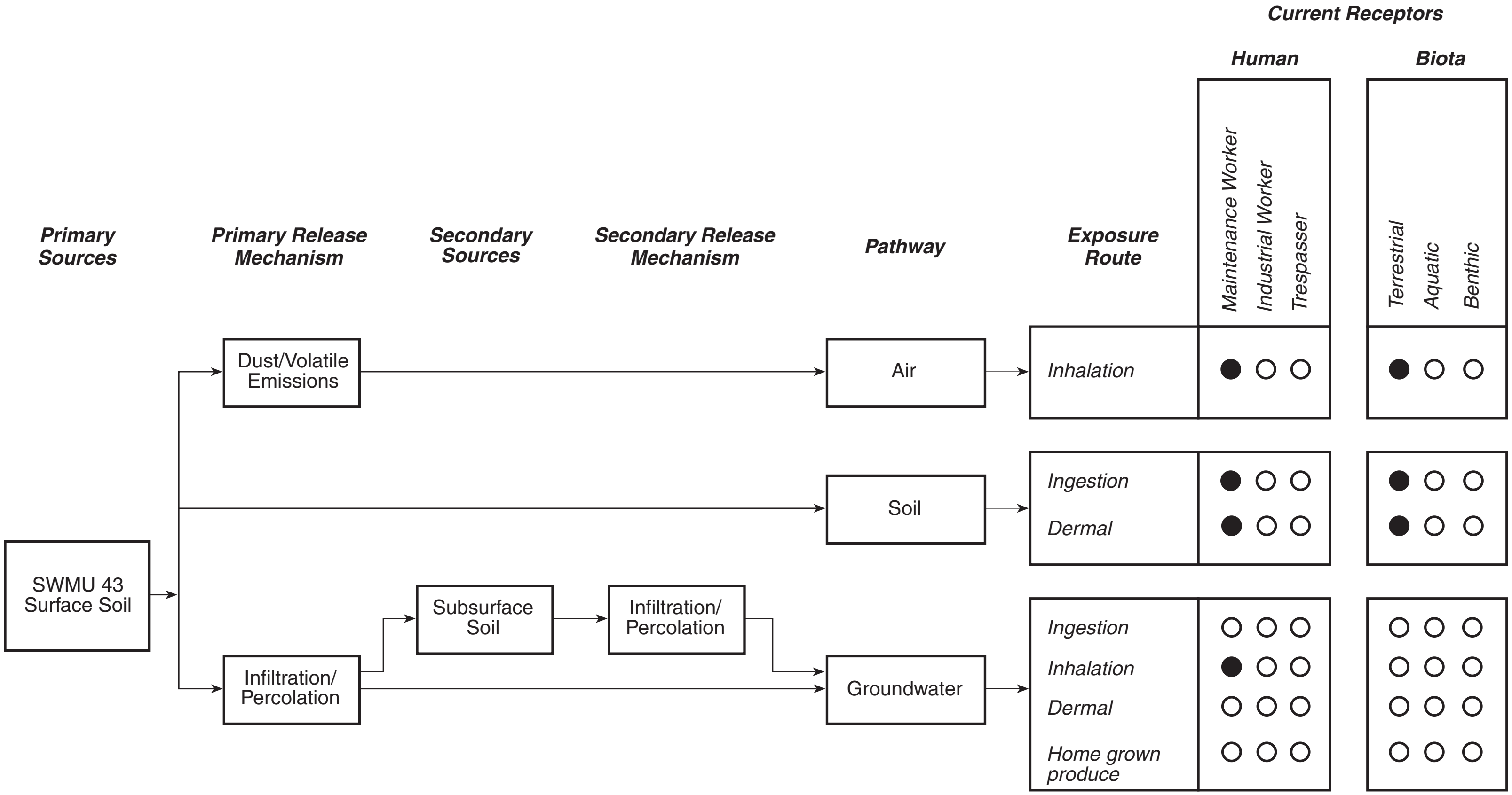
SWMU 43 is a flat level area at an approximate elevation of 1,700 ft msl. A drainage ditch located in the center of the SWMU divides the area into east and west sections. The north-south boundaries are the river bank and paved road way, respectively. The western section is mostly grassy, but has a small concrete pad and a gravel parking area, which are currently used to store office and equipment trailers. The eastern section is covered entirely with grass. Elongated depressions, which corresponded to the disposal trenches, were filled in.

Groundwater at SWMU 43 flows north toward the New River. Several groundwater seeps discharge from the base of the embankment north of SWMU 43 along the New River. Surface water runoff is expected to flow toward the drainage ditch located in the center of the SWMU and is assumed to flow northward to the New River.

It was conservatively assumed that maintenance workers are the most likely receptors at these sites. Due to Installation security, it is unlikely that trespassers could gain access to SWMU 43; 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 soil, subsurface soil, and sediment as a result of disturbing soil during construction/excavation activities. Therefore, maintenance workers and industrial workers were evaluated for exposures to surface soil and total soil at SWMU 43. Excavation workers were evaluated for exposures to total soil only.

The surface water at SWMU 43 currently consists of water from springs or seeps in the river bank. If these seeps would increase in size, these locations would most likely become part of the adjacent New River. No routine exposures would be expected for future workers. Based on the



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

● Indicates pathway/receptor combinations to be evaluated

○ Indicates pathway/receptor combinations incomplete or no source

Figure 6-1. Current Land Use
Conceptual Site Model for SWMU 43
Radford Army Ammunition Plant, Virginia

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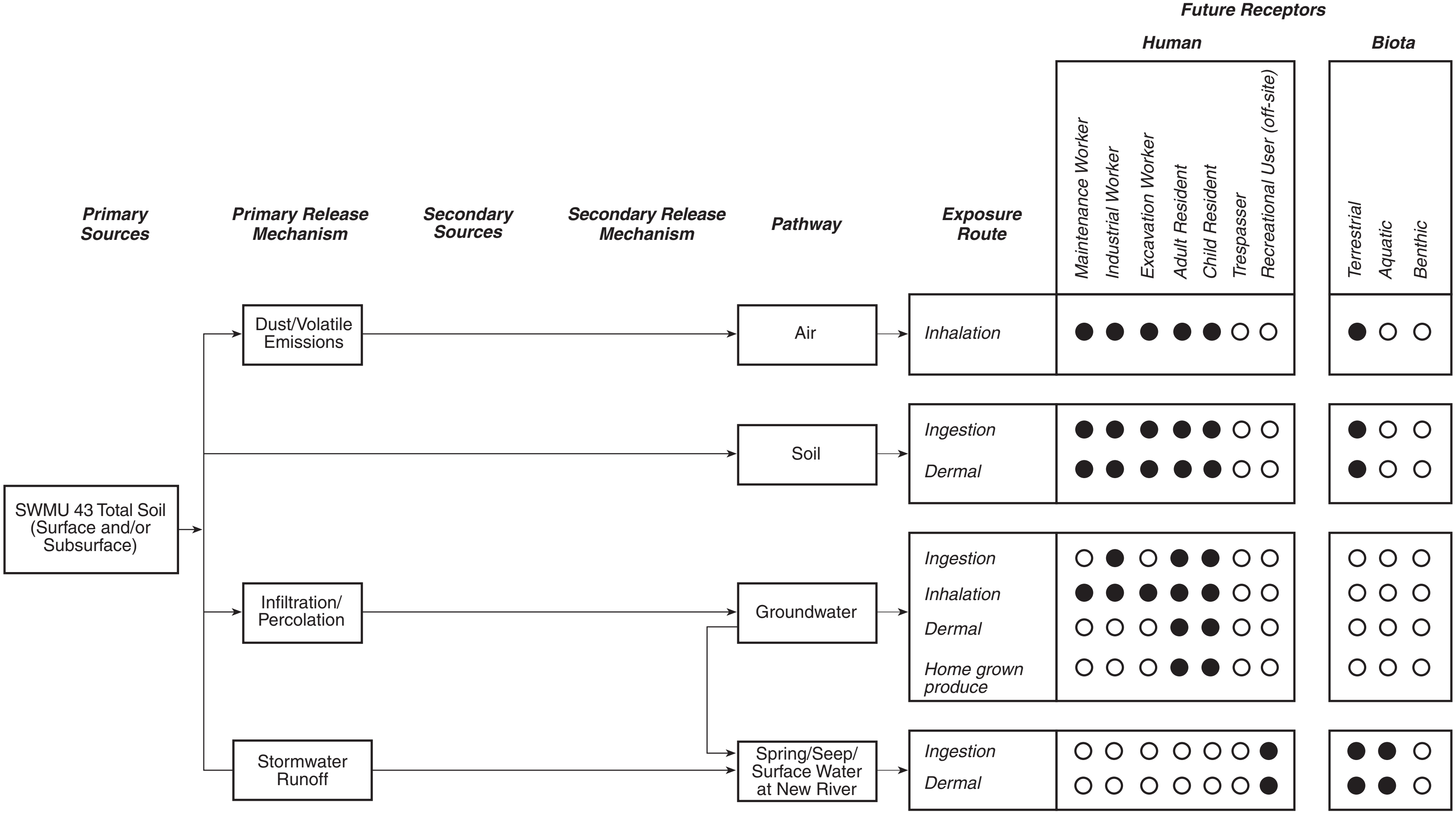

Pathway	Exposure Route	Maintenance Worker	Industrial Worker	Excavation Worker	Adult Resident	Child Resident	Trespasser	Recreational User (off-site)	Terrestrial	Aquatic	Benthic
Air	*Inhalation*	●	●	●	●	●	○	○	●	○	○
Soil	*Ingestion*	●	●	●	●	●	○	○	●	○	○
	Dermal	●	●	●	●	●	○	○	●	○	○
Groundwater	*Ingestion*	○	●	○	●	●	○	○	○	○	○
	Inhalation	●	●	●	●	●	○	○	○	○	○
	Dermal	○	○	○	●	●	○	○	○	○	○
	Home grown produce	○	○	○	●	●	○	○	○	○	○
Spring/Seep/ Surface Water at New River	*Ingestion*	○	○	○	○	○	○	●	●	●	○
	Dermal	○	○	○	○	○	○	●	●	●	○

● Indicates pathway/receptor combinations to be evaluated

○ Indicates pathway/receptor combinations incomplete or no source

Figure 6-2. Future Land Use Conceptual Site Model for SWMU 43 Radford Army Ammunition Plant, Virginia

Shaw™ Shaw Environmental, Inc.

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assumption that surface water from the springs/seeps would migrate to the river, a hypothetical recreational scenario was evaluated for surface water. This scenario involved an adult recreational user at New River. It was assumed that children would not likely be exposed to the river via wading or swimming.

Although groundwater from SWMU 43 is not expected to be used for potable purposes, industrial workers were evaluated for hypothetical exposures to groundwater. Because the groundwater at SWMU 43 flows toward the river and discharges to surface water, adult recreational users of the New River were also evaluated for exposures to surface water at the river.

RFAAP is likely to remain a military installation; therefore, a residential scenario is considered unlikely. However, the residential scenario was evaluated for exposures to total soil, surface water, and groundwater at SWMU 43 to assess clean closeout requirements under RCRA.

6.2.2 Identification of Exposure Pathways

The potential receptors identified for the sites include maintenance workers, industrial workers, excavation workers, child residents, adult residents, lifetime residents, and adult recreational users. **Appendix E-1, Table E.1-1** summarizes the selection of exposure pathways for each receptor listing the rationale for the inclusion or exclusion of each pathway at SWMU 43.

6.2.3 Calculation of EPCs

To calculate intakes, a 95% upper confidence limit of the mean concentration (95% UCL) for each COPC is used as a conservative estimate of the average concentration in a given environmental medium to which a receptor would be exposed. The 95% UCL estimate is referred to as the EPC. The 95% UCL is used rather than the mean concentration, to account for uncertainty when estimating EPCs from sample data (USEPA, 1989a). Methods used to calculate 95% UCLs are based on guidance provided in the documents *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA, 2002a) *and ProUCL Version 4.0 Technical Guide* (USEPA, 2007a).

In general, the method used to calculate a 95% UCL depends on: 1) the prevalence of non-detects, 2) the data distribution (e.g., normal, gamma, or lognormal), and 3) number of samples. Non-detects introduce uncertainty in the data set because the true concentration may be between zero to just below the detection limit. Therefore, distributional assumptions are difficult to ascertain for COPCs with a high rate of non-detects. EPA’s (2007a) ProUCL 4.00.02 statistical program was used to evaluate estimate 95% UCL values for nearly all the soil COPC data sets. For data sets with non-detects, ProUCL uses the Kaplan-Meier estimation method to derive a recommended 95% UCL (USEPA, 2007a). Where ProUCL recommends the results of more than one statistical approach, the most conservative (highest) 95% UCL value was used in the HHRA. Where fewer than 5 percent of samples had detected values, ProUCL does not recommend a 95% UCL value. In these cases, 95% UCL values were derived using a bootstrap-t statistical program, described by Efron (1982) and discussed in USEPA (1997a). Non-detect values are represented in this bootstrap-t program as random numbers between zero and the detection limit that are generated by the iterative process written into the program. EPCs for soil (surface and total) and surface water are presented in **Appendix E-1, Tables E.1-10 through E.1-12**. The output from ProUCL 4.0 is provided in **Appendix E-3**. EPCs were not calculated for groundwater or seep water; therefore, the MDC for COPCs identified for groundwater and seep water were used in the risk assessment. The EPC values for groundwater are shown in **Appendix E-1, Table E.1-13**.

Models were used to estimate concentrations of COPCs in air from soil, concentrations of COPCs in air from groundwater, and concentrations of COPCs in homegrown produce from groundwater. These models are discussed in *Section 6.2.4*.

6.2.4 Quantification of Exposure: Calculation of Daily Intakes

For each receptor and pathway, chronic daily intake (CDI, expressed as milligrams of COPC per kilogram body weight per day) for each COPC is estimated by combining the EPC with exposure parameters such as ingestion rate, frequency of contact, duration, and frequency of exposure. In addition, intake parameters are selected so the combination of intake variables results in an estimate of the reasonable maximum exposure for that pathway (USEPA, 1989a). Intake formulas, exposure parameters, and chemical-specific parameters for each of the receptors are provided in **Appendix E-1**, **Tables E.1-14 through E.1-25**.

The particulate emission factors (PEFs) used to calculate inhalation daily intakes associated with soil were calculated in accordance with the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA, 2002b), as provided in **Appendix E-1, Tables E.1-26 through E.1-28**.

For exposures to groundwater and surface water via dermal contact, the amount of chemical in water absorbed through the skin must be estimated in order to calculate the dose used in the intake formula. The dose absorbed per unit area per event (DA) is a function of chemical concentration in water, the permeability coefficient for that chemical from water through the skin, and exposure time. Following USEPA (2004a) guidance, receptor-specific DA values were calculated for groundwater and surface water using USEPA's worksheet (2001b) and chemical-specific parameters described in **Appendix E-1, Table E.1-29 through E.1-31**.

To evaluate potential inhalation of PCE from groundwater at SWMU 43, an EPC was calculated for each constituent in air using the models depicted in the following sections and provided in **Appendix E-1, Tables E.1-32 through E.1-36**. For this scenario, the volatilization model outlined in American Society for Testing and Materials (ASTM) Risk-Based Corrective Action (RBCA) Guidance (ASTM, 1995) for volatilization from groundwater to ambient air was used. In this case, chemical intake is a result of inhalation of outdoor vapors that originate from dissolved hydrocarbons in groundwater located somewhere below ground surface. The equations used to calculate the volatilization factor to ambient air for PCE in SWMU 43 groundwater are presented in **Appendix E-1**, **Table E.1-32**.

The Johnson and Ettinger model (USEPA, 2004b) is used to estimate indoor air concentrations of volatiles migrating from groundwater through the groundwater and into a structure. The worksheet for this model was used to estimate air concentrations of PCE in office buildings and residences for this HHRA (USEPA, 2004c). The worksheets for PCE at SWMU 43 are found in **Appendix E-4**. The results are given in **Appendix E-1, Table E.1-33**.

In the event that excavation work is performed at SWMU 43, 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, 2008). Two versions of the model have been developed on the basis of depth to groundwater at the site: depths less than or equal to 15 ft and depths greater than 15 ft. The equation and parameters are given in **Appendix E-1, Table E.1-34**.

The EPCs for VOCs in air due to volatilization from SWMU 43 groundwater were estimated for a showering scenario, applicable to the adult resident, using the Foster-Chrostowski (1987, 2003) shower room model. The model is described in **Appendix E-1, Table E.1-35**.

Groundwater-to-air EPCs for VOCs at SWMU 43 are summarized in **Appendix E-1, Table E.1-36**.

The transfer of COPCs in groundwater to vegetables by watering a garden was calculated using two equations based on "exposed produce" developed by Baes et al. (1984), as shown in **Appendix E-1, Table E.1-37**. It is noted that USEPA has determined that sufficient data exists for only arsenic, cadmium, mercury, nickel, selenium, and zinc (USEPA, 1996b). Arsenic was found to be a COPC in the groundwater associated with SWMU 43. The exposure for ingestion of COPCs in home grown produce (vegetables and fruit) by residents was then calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E.1-23**.

6.3 Toxicity Assessment

The methodology used for classifying health effects from exposure to chemicals is recommended by USEPA (2008b). The health effects analysis considers chronic (long-term) exposures. Using the following hierarchy (USEPA, 2003a), the chronic toxicity criteria were obtained from:

- Tier 1 – Integrated Risk Information System (IRIS) (USEPA, 2008b).
- 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, 2003a). Because access to PPRTV is limited, these values were obtained directly from the USEPA Regional Screening Level Table (USEPA, 2008a).
- Tier 3 – Other Toxicity Values – including additional USEPA and non-USEPA sources of toxicity information, such as the Agency for Toxic Substances Disease Registry (ATSDR) Minimum Risk Levels (MRLs), California Environmental Protection Agency, and the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997b).

Toxicity criteria used to quantify non-carcinogenic hazards (risk reference doses - RfDs) and carcinogenic risks (slope factors - CSFs) are presented in **Appendix E-1**, **Tables E.1-38 through E.1-41**.

Benzo(a)pyrene was a COPC in surface and total soil at SWMU 43. USEPA has determined that these compounds have a mutagenic mode of action (USEPA 2005a, 2008a). The lifetime cancer risks for benzo(a)pyrene were calculated in accordance with USEPA guidance concerning carcinogens that act via a mutagenic mode of action (USEPA, 2005a). Risks for these COPCs were estimated by applying age-dependent adjustment factors (ADAFs). The following ADAFs were applied to the following used: 10 for age 0-2, 3 for age 2-16, and 1 (i.e., no adjustment) for years 16 and older. In the following example, cancer risk associated with benzo(a)pyrene in total soil at SWMU 43 is calculated for the ingestion pathway:

Age 0-2

$$\frac{0.0368\ mg/kg\ x\,200\,mg/day\ x\,350\,days/yr\ x\,2\,yr\ x\,1\,x\,1E-6\,kg/mg}{365\,days/yr\ x\,70\,yr\ x\,15\,kg}\ x\,\frac{7.3}{mg/kg/day}\,x\,10 = 9.8\ x\,10^{-7}$$

Age 2-6

$$\frac{0.0368\ mg/kg\ x\,200\,mg/day\ x\,350\,days/yr\ x\,4\,yr\ x\,1E-6\,kg/mg}{365\,days/yr\ x\,70\,yr\ x\,15\,kg}\ x\,\frac{7.3}{mg/kg/day}\,x\,3 = 5.9\ x\,10^{-7}$$

Age 6-16

$$\frac{0.0368\ mg/kg\ x\,100\,mg/day\ x\,350\,days/yr\ x\,10\,yr\ x\,1E-6\,kg/mg}{365\,days/yr\ x\,70\,yr\ x\,70\,kg}\ x\,\frac{7.3}{mg/kg/day}\,x\,3 = 1.6\,x\,10^{-7}$$

Age 16-30

$$\frac{0.0368\ mg/kg\ x\,100\,mg/day\ x\,350\,days/yr\ x\,14\,yr\ x\,1E-6\,kg/mg}{365\,days/yr\ x\,70\,yr\ x\,70\,kg}\ x\,\frac{7.3}{mg/kg/day}\,x\,1 = 7.4\,x\,10^{-8}$$

Total Ingestion Risk

$(9.8 \text{ x } 10^{-7}) + (5.9 \text{ x } 10^{-7}) + (1.6 \text{ x } 10^{-7}) + (7.4 \text{ x } 10^{-8}) = 1.8 \text{ x } 10^{-6}$

Therefore, using ADAFs, the cancer risk for benzo(a)pyrene in total soil at SWMU 43 is ($1.8 \text{ x } 10^{-6}$) for the ingestion pathway. Cancer risks for benzo(a)pyrene associated with the dermal absorption and inhalation pathways were calculated in a similar manner.

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 (1989a).

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 with a value greater than one (1.0) 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 1.0 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 with USEPA's acceptable risk range for Superfund sites of 1E-06 to 1E-04 (USEPA, 1989a). In addition, USEPA's Office of Solid Waste and Emergency Response has issued a directive (USEPA, 1991a) 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 provided in **Appendix E-1**, **Tables E.1-42 through E.1-55**. The risks and HIs for each receptor are presented in **Appendix E-1**, **Tables E.1-56 through E.1-62**. These risks and hazards are summarized in **Table 6-3**. A refinement of the HIs based on target organs is conducted by calculating HIs on a target organ-specific basis. In addition, **Appendix E-1, Tables E.1-63 through E.1-69,** 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 1.0).

6.4.1 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 43, a "margin of exposure evaluation" was conducted. 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 via the route of ingestion is 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, 1996a).

The calculated intake of iron via ingestion of groundwater was 0.75 mg/kg-day and ingestion of total soil was 0.24 mg/kg-day. Therefore, the total estimated intake of iron by ingestion was 0.99 mg/kg-day. The intakes calculated for groundwater and total soil at SWMU 43 were within the allowable range (0.36 to 1.11 mg/kg-day).

6.4.2 Background

Statistical evaluations were conducted to compare metals concentrations in soil at SWMU 43 with 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. Statistical 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 data sets or the 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. Unless otherwise noted, Gehans test was conducted for each metal with background data sets to evaluate whether site concentrations were consistently higher or lower than the background data set. Gehans test was used because it was found to handle data sets with multiple detection limits better than the Wilcoxon Mann Whitney test. There is no background data set for groundwater.

Table 6-3
Summary of Risks and Hazards
SWMU 43

Timeframe/Receptor	Risk	Risk Drivers	HI	Target Organ Segregation HI>1[a]
Current maintenance worker	**2E-06**	**Surface Soil** Arsenic	5E-02	N/A
Future maintenance worker	**2E-06**	**Surface Soil** Arsenic	5E-02	N/A
Future industrial worker	**2E-04**	**Surface Soil** Arsenic **Groundwater** Tetrachloroethene Arsenic	**2E+00**	**Skin** (1.1) - Groundwater [Arsenic - Ing (1.0)] **Vascular Effects** (1.1) - Groundwater [Arsenic - Ing (1.0)]
Future excavation worker	3E-07	N/A	6E-01	N/A
Future adult resident	N/A	N/A	**6E+00**	**Skin** (3.2) - Groundwater [Arsenic - Ing (3.2)] **Vascular Effects** (3.2) - Groundwater [Arsenic - Ing (3.2)] **CNS** (1.1) - Groundwater [Manganese - Ing (0.95)]
Future child resident	**3E-04**	**Total Soil** TCDD TE Arsenic **Groundwater** Tetrachloroethene Arsenic	**1E+01**	**Skin** (7.7) - Total Soil [Arsenic - Ing (0.24)] Groundwater [Arsenic - Ing (7.4)] **Vascular Effects** (7.7) - Total Soil [Arsenic - Ing (0.24)] Groundwater [Arsenic - Ing (7.4)] **CNS** (3.0) - Total Soil [Aluminum - Ing (0.15); Manganese - Ing (0.32), Derm (0.22)] Groundwater [Manganese - Ing (2.2)] **Liver** (1.5) - Total Soil [Iron - Ing (0.34)] Groundwater [Iron - Ing (1.1)] **Blood** (1.4) - Total Soil [Iron - Ing (0.34] Groundwater [Iron - Ing (1.1)] **GI Tract** (1.4) - Total Soil [Iron - Ing (0.34)] Groundwater [Iron - Ing (1.1)]
Future lifetime resident	**8E-04**	**Total Soil** TCDD TE Benzo(a)pyrene Arsenic **Groundwater** Tetrachloroethene Arsenic	N/A	N/A
Future off-site recreational user	**3E-06**	**Surface Water** [b] Tetrachloroethene Arsenic	2E-02	N/A

NA = Not Applicable
HI = Hazard Index
HQ = Hazard Quotient
Bold = Exceeds USEPA Risk or Hazard Range.
Ing = Ingestion; Inh = Inhalation; Derm = Dermal
CNS = Central Nervous System
GI = Gastrointestinal
TCDD TE = Dioxin Toxicity Equivalent

NOTE: Arsenic is within background concentrations for surface and total soil. Aluminum, arsenic, cobalt, and iron are within background concentrations for total soil.

(a) Cumulative HIs and individual HQs are rounded to the nearest tenth. HIs > 1 and HQs > 0.1 are listed.

(b) Surface water concentrations are based on the maximum concentrations of COPCs in SWMU 43 groundwater and spring/seep samples, assuming migration to surface water at New River.

Notes on the methodology and the results of the background evaluation are summarized in **Tables 6-4 and 6-5**. The ProUCL 4.0 output is provided in **Appendix E-5**. One inorganic COPC risk driver (arsenic) was identified for surface and total soil SWMU 43. Based on the background evaluation, concentrations of arsenic were within background for both surface and total soil. Although no individual COPCs had HIs above 1, the total HI for the child resident exceeded 1. Aluminum, arsenic, cobalt, iron, and vanadium contributed to the total soil HI; however, these constituents are within background. Manganese concentrations in soil were above the background range, but manganese in soil did not exceed an HI of 1.

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 43, 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 SWMU 43, 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 SWMU 43, 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. Although B-qualified were eliminated, however, the amount of B-qualified data in the data set was low.

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, PAHs, such as benzo(a)pyrene, and dioxins are considered ubiquitous in soil from anthropogenic sources, such as combustion and incineration of municipal waste, coal, wood,

Table 6-4
Background Comparison for Surface Soil at SWMU 43

Soil COPC	Gehan Test [a, b] Site > Background?	Considered to be Background?
Arsenic [c]	No	Yes

[a] Gehan test used unless otherwise noted. See Appendix for backup statistics.
[b] If both Site and Background data sets had normal distribution with 100% detects, the t-test was used (note: this did not occur for SWMU 43 surface soil vs. background comparisons).
[c] Wilcoxon-Mann-Whitney test used (for 100% detect data sets).

Table 6-5
Background Comparison for Total Soil at SWMU 43

Soil COPC	Gehan Test [a, b] Site > Background?	Considered to be Background?
Aluminum [c]	No	Yes
Arsenic	No	Yes
Cobalt	No	Yes
Iron	No	Yes
Manganese [c]	Yes	No

[a] Gehan test used unless otherwise noted. See Appendix for backup statistics.
[b] If both Site and Background data sets had normal distribution with 100% detects, the t-test was used (note: this only occurred for iron in SWMU 43 total soil vs. background comparisons).
[c] If both data sets were 100 % detect, then Wilcoxon Mann Whitney test used.

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.

Finally, it is noted that the surface water samples from the seeps and springs were collected in October 1991. Although additional samples were proposed to be taken at the previous seep sample locations for this investigation, the seeps were dry during the field sampling event due to drought conditions. Given the available data were collected nearly 17 years ago, the surface water risks and hazards calculated for this HHRA are likely to be over-estimated.

6.5.2 Selection of Chemicals for Evaluation

A comparison of maximum detected chemical concentrations to USEPA Regional SLs was conducted for surface soil, total soil, surface water, and groundwater. Chemicals with maximum concentrations below their respective SLs 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 SLs. 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 SLs) 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, the maximum MDL exceeded the adjusted SLs for several chemicals in soil, surface water, and groundwater; therefore, the site-related risks and hazards could be underestimated for the risk assessments due to inadequate detection limits. The results for the evaluations of non-detects at SWMU 43 are discussed in the following sections.

The reporting limits for chemicals that were not detected in surface soil, total soil, surface water, and groundwater at SWMU 43 were compared with SLs in **Appendix E-1, Tables E.1-3, E.1-5, E.1-7, and E.1-9**, respectively. As shown in **Appendix E-1, Table E.1-3**, reporting limits in surface soil exceeded SLs for 5 of 113 constituents (4 percent). These constituents include: bis(2-chloroethyl)ether, dibenz(a,h)anthracene, nitroglycerin, n-nitroso-di-n-propylamine, and thallium. Several PAHs, including benzo(a)pyrene, were detected in surface soil. Therefore, dibenz(a,h)anthracene could also be present at SWMU 43. Nitroglycerin has been detected elsewhere on the Installation. Although thallium could be background-related, thallium was not statistically evaluated due to the high percentage of non-detects in the background data set. If these constituents are actually present, risk and hazard could be underestimated. However, the reporting limits exceed SLs that are based on a cancer risk of 1E-06 or HQ of 0.1. With the exception of thallium, the reporting limits for these compounds would not exceed if they were compared with SLs based on 1E-05 and HQ of 1. For 13 of 113 constituents (11.5 percent) in surface soil, there were no SLs for comparison. These constituents include: 2-hexanone, 2-nitroaniline, 2-nitrophenol, 4-bromophenyl phenylether, 4-chlorophenyl phenylether, 4-nitrophenol, carbazole, dibenzofuran, dichloroprop, dimethylphthalate, di-octylphthalate, p-chloro-m-cresol, and pentaerythritol tetranitrate. These chemicals are not known to be associated with past disposal at SWMU 43.

As shown in **Appendix E-1, Table E.1-5**, reporting limits in total soil exceeded SLs for 10 of 116 constituents (9 percent). These constituents include: 4,6-dinitro-o-cresol, Aroclor 1221, Aroclor 1232, bis(2-chloroethyl)ether, dibenz(a,h)anthracene, hexachlorobenzene, nitroglycerin, n-nitroso-di-n-propylamine, thallium, and toxaphene. One PAH, dibenz(a,h)anthracene, slightly exceeded screening criteria. This compound could be associated with other PAHs detected at SWMU 43. Similarly, Aroclor 1221and Aroclor 1232 slightly exceeded screening criteria and could be associated with other Aroclor compounds detected at the site. Nitroglycerin has been detected elsewhere on the Installation. Although thallium could be background-related, thallium was not statistically evaluated due to the high percentage of non-detects in the background data set. If these constituents are actually present, risk and hazard could be underestimated. The reporting limits exceed SLs that are based on a cancer risk of 1E-06 or HQ of 0.1. With the exception of thallium, the reporting limits for these compounds would not exceed if they were compared with SLs based on 1E-05 and HQ of 1. For 11 of 116 constituents (9 percent) in total soil, there were no SLs for comparison. These constituents were similar to those identified for surface soil. These chemicals are not known to be associated with past disposal at SWMU 43.

As shown in **Appendix E-1, Table E.1-7**, reporting limits in surface water exceeded SLs for 44 of 147 constituents (30 percent). These constituents include: 1,1,2,2-tetrachloroethane, 1,2-diphenylhydrazine, 2,4-dinitrotoluene, 3,3’-dichlorobenzidine, 4,4’-DDD, 4,4’-DDE, 4,4’-DDT, 4,6-dinitro-o-cresol, acraldehyde, acrylonitrile, aldrin, alpha-BHC, alpha-chlordane, Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260, benzidine, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, beta-BHC, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, cobalt, delta-BHC, dibenz(a,h)anthracene, dieldrin, gamma-BHC, gamma-chlordane, heptachlor, heptachlor epoxide, hexachlorobenzene, indeno(1,2,3-cd)pyrene, n-nitrosodimethylamine, n-nitroso-di-n-propylamine, pentachlorophenol, PCE, thallium, toxaphene, and vinyl chloride. Some of these compounds, such as PAHs and Aroclors, were selected as COPCs in other media at SWMU 43. Vinyl chloride is a breakdown product of PCE, which was detected in groundwater at SWMU 43. Nitroglycerin has been detected elsewhere on the Installation. If these constituents are actually present, risk and hazard could be underestimated. However, the reporting limits exceed SLs that are based on a cancer risk of 1E-06 or HQ of 0.1. If the reporting limits were compared with SLs based on 1E-05 and HQ of 1, some of them would not exceed. For 12 of 147 constituents (8 percent) in surface water, there were no SLs for comparison. These constituents include: 2-chloroethyl-vinyl ether, 2-hexanone, 2-nitroaniline, 2-nitrophenol, 4-bromophenyl phenylether, 4-chlorophenyl phenylether, 4-nitrophenol, dibenzofuran, dimethylphthalate, di-octylphthalate, lead, and p-chloro-m-cresol. The remaining chemicals are not known to be associated with past disposal at SWMU 43.

As shown in **Appendix E-1, Table E.1-9**, reporting limits in groundwater exceeded SLs for 58 of 159 constituents (36 percent). For 15 of 159 constituents (9 percent) in groundwater, there were no SLs for comparison. Some of these constituents could potentially be site-related. For example, vinyl chloride is a degradation product of PCE, which was identified as a COPC in groundwater. Several of these constituents were Aroclors and PAHs, which were identified as COPCs in other media at SWMU 43. It is assumed, however, groundwater exposures at SWMU 43 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 43 groundwater will be used for residential purposes in the future.

In general, these chemicals, if present in surface soil, total soil, surface water, sediment, and groundwater, could contribute additional risk and hazard at SWMU 43. Therefore, risks and hazards associated with the site may be underestimated. Even if the risk and hazard were underestimated for groundwater, however, it is noted that the risk estimate already exceeds 1E-04 and the HI is above 1.

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 43 are consistently higher or lower than background. However, the background data obtained may not fully characterize naturally-occurring metals levels in the landfill material at SWMU 43. 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 potentially toxic at very high doses (i.e., calcium, magnesium, potassium, and sodium). None of these elements were selected as COPCs in soil. Omitting these essential human nutrients from further evaluation is expected to have a low effect on risk and hazard estimates. However, sodium was identified as a COPC in SWMU 43 surface water. This essential nutrient was retained in the HHRA.

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.

SWMU 43 is 2.977 acres in size and the sampling plan was based on this acreage. The PEF for the residents, however, was based on a 0.5-acre residential lot per EPA guidance. As a result, the risks and hazards for the inhalation pathway could be underestimated for SWMU 43. However, this potential uncertainty would not affect the conclusions for the site.

The non-cancer hazard estimates for the inhalation of dust emissions by the construction worker receptor are based on the construction worker PEF calculation. Because future plans for construction or excavation at SWMU 43 are not known, assumptions regarding the duration of construction activities and type and number of construction vehicles were based on the acreage of the site. Although the inhalation cancer risk/non-cancer hazard estimates could be overestimated, the calculated risks and hazards were below the acceptable risk range and HI. 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 overestimate or underestimate risks, based on the degree of chemical transport to other media or the rate and extent a chemical degrades over time. For example, the biodegradation of PCE could result in the formation of vinyl chloride over time. Vinyl chloride is classified as a known human carcinogen. Therefore, the cancer risks associated with future exposures to groundwater may be underestimated.

When calculating EPCs from sample data using ProUCL, non-detect samples are coded as "zeros." As indicated in the ProUCL output for SWMU 43 and the toxicity equivalents (**Appendices E-3 and E-5**), summary statistics, such as the arithmetic mean, are based on the detected values only. For the calculation of the 95% UCL of the mean, the program substitutes surrogate values for the detection limits. 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 (1991b) 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, 2004a). 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 ATSDR (1992, 2000, 2004, 2006, 2007) indicate that metals such as aluminum, arsenic, cobalt, 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, 2004a) 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). The permeability coefficients for halogenated compounds, such as PCE, are likely to be underestimated. Because halogenated chemicals have a lower ratio of molar volume relative to their molecular weight than hydrocarbons (due to the relatively weighty halogen atom), the K_p correlation based on molecular weight of hydrocarbons will tend to underestimate permeability coefficients for halogenated organic chemicals (USEPA, 2004a). In determining whether the dermal absorption pathway warrants assessment, USEPA's dermal guidance considers the risks and hazards of dermal exposure relative to those of drinking water exposures. In cases where dermal exposure was less than 10 percent of drinking water exposure, the COPC was not included in the dermal risk assessment. As shown in **Appendix E-1, E.1-29 through E.1-31** for groundwater at SWMU 43, several metals were not included in the assessment. For surface water, however, all COPCs were included in the dermal assessment because exposures via ingestion were very low. Given the uncertainty associated with the dermal absorption of metals, the risks and hazards calculated for the surface water are likely to 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 RBCA Guidance (ASTM, 1995) was used to estimate the concentrations of VOCs in ambient or outdoor air at SWMU 43 that originate from dissolved hydrocarbons in groundwater located some distance below ground surface (**Appendix E-1, Table E.1-32**). This model calculates a representative concentration in air based on the following assumptions:

- A constant dissolved concentration in groundwater.
- Linear equilibrium partitioning between the dissolved chemicals and groundwater and chemical vapors in the groundwater table.

- Steady-state vapor- and liquid-phase diffusion through the capillary fringe and vadose zones to ground surface.
- No loss of chemical as it diffuses toward 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 over-estimate risk and hazard. Second, it is assumed that there is no loss of chemical due to biodegradation over time. This assumption is especially conservative with respect to exposure for the industrial worker scenario, which is based on an exposure duration of 25 years. Third, it is assumed that vapor concentrations remain constant over the duration of exposures and that all inhaled chemicals are absorbed.

The ASTM model also considers wind speed, mixing height, depth to groundwater, and diffusion coefficients in air and water. Uncertainty based on mechanisms such as partitioning, diffusion, and dispersion would be dependent on chemical-specific and site-specific conditions and could result in either over- or underestimation of chemical concentrations at both sites. The depth to groundwater at SWMU 43 ranges from 13 to 32 ft. In areas of SWMU 43 where the depth to groundwater is at the deeper end of the range, exposure to PCE in trench air is likely to be negligible.

The Johnson and Ettinger model (1991; USEPA, 2004b) 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.1-33**). As acknowledged in the *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings* (USEPA, 2004b), the Johnson and Ettinger model "…was developed for use as an SL 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, 2004b). These include:

<u>Contaminant Distribution and Occurrence</u>

- 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 43 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 the chemical 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. Vinyl chloride is a possible byproduct of biodegradation over time. Potential future cancer risks associated with vinyl chloride could result in an underestimation of risk. On balance, however, the risk and hazard associated with inhalation of COPCs 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.

The soil type at SWMU 43 above the water table was not found to be homogeneous. Eighteen (18) ft of landfill material was encountered during the drilling of two downgradient borings drilled along the fence bordering the SWMU. Under the landfill material, a relatively thin layer of undisturbed fine grain silt to silty sand over weathered limestone rock was encountered. Depth to groundwater in this area was found just above bedrock. In the upgradient borings, silty gravel or silty clay was present above the weathered limestone bedrock. Therefore, at SWMU 43, the soil and the soil properties in any horizontal plane are not homogeneous. The *User's Guide* (USEPA, 2004b) 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 less documented model was used.

Transport Mechanisms

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

- Significant convective transport only occurs in the vapor phase.
- All contaminant vapors originating from directly below the basement will enter the basement, unless the floor and walls are perfect barriers. Contaminant vapors enter structures primarily through cracks and openings in the walls and foundation.

Because most of the inputs to the model are not collected during a typical site characterization, conservative inputs were estimated or inferred from available data and other non-site-specific sources of information. In addition, because there are currently no structures at or near SWMU 43, the default values for a typical residential building were used to represent the building characteristics in the model. The depth to groundwater (approximately 21.5 ft) was based on the average depth to groundwater in the area most suitable for construction. If a structure were to be constructed at a depth shallower than 21.5 ft, the modeled concentrations for air in the building would potentially be underestimated. Finally, it is assumed that vapor velocities decrease rapidly with increasing distance from a structure. These assumptions contribute to a conservative estimate of the VOC concentrations in building air at SWMU 43.

As stated in *Section 6.2.3*, EPA has not developed a standardized model for estimating concentrations of airborne VOCs released from groundwater during construction or excavation activities. Therefore, VDEQ’s VRP trench model was used in this HHRA (**Appendix E-1, Table E.1-34**). Due to several conservative assumptions used in VDEQ’s trench model, risks and hazards due to potential exposures to groundwater during the hypothetical excavation of a construction/utility trench are likely to be overestimated. The uncertainties associated with this model include:

- The maximum concentration of PCE in SWMU 43 groundwater was used to estimate exposures to VOCs 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 range of depths to groundwater at SWMU 43 was 13 to 32 ft. Given this range, the modeled concentrations of VOCs in trench air could be either under- or overestimated.
- To be consistent with the other excavation/construction exposures in this HHRA, an exposure frequency of 250 days/year and exposure duration 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 either site for 4 hours each day for 1 year.

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

There are several factors that contribute to the potential uncertainty of the results of the shower model (Foster and 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 PCE in indoor air from all potential household uses, risk and hazard are likely to be underestimated.

To address potential discharge of springs/seeps and groundwater from SWMU 43 to surface water in the New River, it was conservatively assumed that adult receptors could be exposed to COPCs from discharge from seeps/springs and groundwater during recreational activities at the river. As noted in *Section 6.5.1*, surface water samples from the seeps and springs were collected in October 1991. No additional samples could be collected for this investigation because the seeps were dry due to drought conditions. In addition, concentrations of COPCs in SWMU 43 spring/seeps and groundwater were conservatively used in the risk and hazard calculations without adjustment for dilution. For the future adult recreational user at SWMU 43, the total cancer risk for exposures to off-site surface water (3E-06) was within the acceptable risk range, primarily due to PCE and arsenic. The total HI was below 1. Considering the conservative dilution factor of 100 assumed in the SLERA (*Section 7.1.10*), the risk associated with discharge from SWMU 43 is likely overestimated and below the acceptable risk range of 1E-06 to 1E-04.

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 by 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 forestomach, 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.

The lack of toxicity values for the inhalation pathway could result in an underestimation of risk or hazard. With the exception of the excavation workers, however, risks and hazards associated with dusts and particulates are typically small relative to the ingestion and dermal pathways.

For chemicals without IRIS toxicity criteria, provisional toxicity criteria were used where available (**Appendix E-1, Tables E.1-38 through E.1-41**). 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 or other oral toxicity provisional values were used for Aroclor 1016, Aroclor 1254, 2,3,7,8-TCDD toxicity equivalents, PCE, aluminum, cobalt, iron, and vanadium at SWMU 43. Provisional inhalation toxicity values were used for Aroclor 1016, Aroclor 1254, benzo(a)pyrene, 2,3,7,8-TCDD toxicity equivalents, PCE, aluminum, arsenic, and cobalt at SWMU 43. In particular, the provisional oral RfD for 2,3,7,8-TCDD (1E-09 mg/kg-day) is based on an MRL established by the ATSDR (USEPA, 2008a; ATSDR, 2009). An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration and route of exposure. The substance-specific estimates are intended to be used as SLs. Based on a review of more recent literature, ATSDR acknowledged that the MRL is approximately two orders of magnitude below the noncancer health effect levels observed in more recent studies (DeRosa et al., 1997). Therefore, the HQs for 2,3,7,8-TCDD are likely to be over-estimated. 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 and hazards calculated using these toxicity criteria.

For some chemicals, toxicity criteria were unavailable (**Appendix E-1, Tables E.1-38 through E.1-41**). Sodium was identified as a COPC in surface water at SWMU 43 at a maximum concentration (20.8 mg/L, which slightly exceeded the screening criterion (20 mg/L). The screening criterion was based on USEPA's drinking water advisory for sodium of 20 mg/L (USEPA, 2006a). This advisory is intended for individuals on a 500 mg/day restricted sodium diet. Although lack of published toxicity data could result in an underestimation of risk and hazard in this HHRA, this uncertainty is likely to be balanced by the conservative nature of the verified toxicity values that were available for use.

It is noted that the Supplemental SSL Guidance (USEPA, 2002b) recommends that toxicity values for subchronic exposures be used to calculate the HQs for exposures by the construction worker. Although subchronic values for some chemicals are included in USEPA's database of PPRTVs, this web site cannot be accessed without authorization. The overall lack of subchronic toxicity values for the COPCs at these sites contributes to the uncertainty of 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 hazards are likely to be overestimated. For SWMU 43, however, hazards associated with individual COPCs for this pathway were below the target HI.

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 results in differences between summed risk and hazard values, depending on how the summing is performed. For example, the RAGS Table 7 and 8 spreadsheets in **Appendix E-1**,**Tables E.1-42 through E.1-55** present risks and hazards that are summed for exposure route, exposure point, exposure medium, and medium total. The individual chemical-specific risks and hazards are summed only for the initial exposure route in deriving 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**, **Tables E.1-56 through E.1-69**.

6.6 HHRA Summary and Conclusions

This HHRA was performed to evaluate the potential human health effects associated with previous activities at SWMU 43. 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. Because it was found that groundwater at SWMU 43 flows toward the New River, off-site residential exposure due to migration of groundwater downgradient of SWMU 43 was no longer a relevant pathway. Recreational users were evaluated as the most likely potential future receptors downgradient of SWMU 43.

As presented in *Section 6.4*, the total cancer risk for current maintenance worker exposures to surface soil (2E-06) was within the acceptable risk range of 1E-06 to 1E-04 due to arsenic. Arsenic in surface soil was found to be within background concentrations. The total HI for surface soil was less than 1. The total cancer risk associated with groundwater (8E-12) was below the acceptable risk range. The total HI for groundwater was below 1.

For the future maintenance worker, the total cancer risk for exposures to surface soil (2E-06) was within the acceptable risk range of 1E-06 to 1E-04 due to arsenic. The total HI for surface soil was less than 1. The total cancer risk for exposures to total soil (9E-07) was below the acceptable risk range due to arsenic. The total HI for total soil was less than 1. The total cancer risk associated with groundwater (8E-12) was below the acceptable risk range. The total HI for groundwater was below 1.

For future industrial worker exposures to surface soil, the total cancer risk for exposures to surface soil (7E-06) was within the acceptable risk range of 1E-06 to 1E-04 due to arsenic. Arsenic in surface soil was found to be within background concentrations. The total HI for surface soil was less than 1. The total cancer risk for exposures to total soil (4E-06) was within the acceptable risk range due to arsenic. Arsenic in total soil was found to be within background concentrations. The total HI for total soil was less than 1. The total cancer risk associated with groundwater (2E-04) was above the acceptable risk range due to PCE and arsenic. The total HI for groundwater (2E+00) was above 1, due to arsenic.

For the future excavation worker, the total cancer risk for exposures to total soil (3E-07) was below the acceptable risk range. The total HI for total soil was below 1. The total cancer risk associated with groundwater (8E-9) was below the acceptable risk range. The total HI for groundwater was below 1.

For the future lifetime resident, the total cancer risk for exposures to total soil (2E-05) was within the acceptable risk range of 1E-06 to 1E-04 due to dioxins/furans, benzo(a)pyrene, and arsenic. Arsenic in total soil was found to be within background concentrations. The total HI for total soil was less than 1. The total cancer risk associated with groundwater (8E-04) was above the acceptable risk range, primarily due to PCE and arsenic. The total HI (5E+00) was above 1, primarily due to arsenic. When calculated by target organ, the following organs exceeded 1: CNS (1.1), skin (3.2), and vascular effects (3.2).

For the child resident, the total cancer risk for exposures to total soil (1E-05) was within the acceptable risk range of 1E-06 to 1E-04 due to dioxins/furans and arsenic. Arsenic in total soil was found to be within background concentrations. The total HI for total soil (2E+00) was above 1, although no individual HQ exceeded 1. Aluminum, arsenic, cobalt, and iron were found to be within background concentrations. If HQs for background-related metals were excluded, the total HI for total soil would be 1. The total cancer risk associated with groundwater (3E-04) was above the acceptable risk range, due to PCE and arsenic. The total HI (1E+01) was above 1, due to arsenic, cobalt, iron, and manganese. When recalculated by target organ, the following organs exceeded 1: CNS (3.0), blood (1.4), liver (1.5), skin (7.7), vascular system (7.7), and GI tract (1.4). It is noted that chemicals with a critical endpoint of harm to the developing fetus may have other less sensitive effects on other organs in children. The margin-of-exposure evaluation for iron indicated that the iron intake was within the allowable range.

Off-site recreational users were evaluated to address potential future migration of COPCs in groundwater and springs/seeps at SWMU 43 to surface water at the New River. For the future adult recreational user, the total cancer risk for exposures to off-site surface water (3E-06) was within the acceptable risk range, primarily due to PCE and arsenic. It is noted, however, that concentrations of COPCs in SWMU 43 spring/seeps and groundwater were conservatively used in the risk and hazard calculations without adjustment for dilution. Considering the dilution factor of 100 assumed in the SLERA (*Section 7.1.10*), the risk associated with discharge from SWMU 43 is expected to be below the acceptable risk range of 1E-06 to 1E-04. The total HI was below 1.

7.0 SCREENING LEVEL 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 43. Common methods and procedures are presented in *Section 7.1*, and individual results are presented in *Section 7.2*, respectively.

7.1 SLERA Methods and Procedures

This section provides the rationale for the methods and procedures used during the evaluation of the data collected at SWMU 43 and performance of the SLERA.

A SLERA was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at SWMU 43. The results of the SLERA contribute to the overall characterization of the site and the scientific/management decision point (SMDP) reached for the SLERA includes one of the following:

- There is adequate information to conclude that ecological risks are negligible and therefore there is no need for further action at the site on the basis of ecological risk.
- The information is not adequate to make a decision at this point and further refinement of data is needed to augment the ecological risk screening.
- The information collected and presented indicates that a more thorough assessment is warranted.

The SLERA was performed following the *RFAAP Final MWP* (URS, 2003), the *RFAAP Site Screening Process* (USEPA, 2001c), the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al., 1996), and Steps 1, 2 and 3a of the *Ecological Risk Assessment Guidance for Superfund (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 43, 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 43.

Concentrations of chemicals were measured in surface soil, sediment, surface water, and groundwater which were the relevant environmental media at SWMU 43.

Using available concentration data, the 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 an SL preliminary exposure estimate and risk calculation. The SLERA is organized as follows: General Site Characterization (*Section 7.1.1*); Methodologies for the Identification of Chemicals of Potential Ecological Concern (COPECs) and Concentration Statistics (*Section 7.1.2*); Identification of Exposure Pathways and Potential

Receptors for Analysis (*Section 7.1.3*); Identification of Assessment and Measurement Endpoints (*Section 7.1.4*); Exposure Estimation (*Section 7.1.5*); Ecological Effects Assessment (*Section 7.1.6*); Risk Characterization (*Section 7.1.7*); Direct Contact Toxicity (*Section 7.1.8*); Background Metals Evaluation (*Section 7.1.9*); and General Uncertainty Analysis (*Section 7.1.11*).

7.1.1 General Site Characterization

This section includes a general discussion of the Installation, vegetative communities, a species inventory, and a discussion on threatened and endangered species. SWMU 43 is located in the northeast section of the MMA at RFAAP (**Figure 1-1**), immediately adjacent to the New River. **Figures 2-1** shows the layout of the site. SWMU 43 is a closed sanitary landfill that is approximately 3.04 acres consisting of east and west cells divided by a drainage ditch.

7.1.1.1 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 43 during the Installation-wide biological survey of 1999. Five state-listed rare plants were observed at RFAAP during this survey: *Clematis coattails, Cystoptris tennesseensis, Hasteola suaveolens, Sagittaria rigida,* and *Eleocharis intermedia*. State threatened animals located at RFAAP include the invertebrate *Speyeria idalia* and the birds *Ammodramus henslowii* (Henslow’s sparrow) and *Lanius ludovicianus* (loggerhead shrike).

An earlier comprehensive inventory of the mammals, birds, reptiles, aquatic invertebrates, trees, and plants found on the Installation, and of fish inhabiting the New River where it flows through the Installation, was conducted in 1976 during the RFAAP Installation Assessment (USATHAMA, 1976). Information from that assessment was summarized in previous documents (Dames and Moore, 1992). The summarized information was updated for the RFI through personal communication with RFAAP biologists and is presented in the following paragraphs (from URS, 2003).

Many of the reptiles, mammals, and birds listed in the assessment (USATHAMA, 1976) are believed to breed on the Installation. Migratory waterfowl are found throughout the spring and winter near the New River because the Installation is on the Atlantic Flyway. Public fishing occurs in the New River where it flows through RFAAP.

The Virginia Department of Game and Inland Fisheries identified the following terrestrial flora and fauna as endangered or threatened for Pulaski and Montgomery Counties:

- Plant species - six endangered, three threatened.
- Insect species - one endangered, four threatened.
- Bird species - three endangered.
- The locally endangered mountain lion.

In addition, a fish, salamander, four additional bird species, and the river otter are identified as species of concern in the two counties in which RFAAP is located.

Tree species at RFAAP include the shortleaf pine, loblolly pine, eastern white pine, yellow poplar, and black walnut. There are 2,537 acres of managed woodland on site (personal communication with T. Thompson, RFAAP Conservation Specialist 1995, as cited in URS, 2003).

RFAAP is located at the boundary of the central Appalachian Ridges and Valleys Ecoregion and the central Appalachian Ecoregion (Omernik, 1986). These two Ecoregions are characterized in **Table 7-1**.

Table 7-1
Ecoregions of RFAAP

Ecoregion	Land Surface Form	Potential Natural Vegetation	Land Use
Central Appalachian Ridges and Valleys	Open low hills to open low mountains	Appalachian oak in undisturbed areas	Mosaic of cropland and pasture with some woodland and forest
Central Appalachian	Open low to high hills, open mountains	Mixed mesophytic forest[1], Appalachian oak, northern hardwoods[2]	Forest and woodland mostly ungrazed

[1] maple, buckeye, beech, tuliptree, oak, linden
[2] maple, birch, beech, hemlock

Based on previous site visits and investigations, the available photographic record was compiled (**Appendix F-1, Photos F-1 through F-5**). A Shaw ecologist performed site reconnaissance activities in 2008. Prior to the reconnaissance, relevant information was obtained, including topographic maps, township, county, or other appropriate maps. This information was used to identify the location of potential ecological units such as streams, creeks, ponds, grasslands, forest, and wetlands on or near many of the RFAAP SWMUs. 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 sites 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.

7.1.1.2 Surface Water

SWMU 43 is located adjacent to the New River at an elevation of approximately 1,700 ft msl. Surface water runoff from the SWMU is expected to flow towards a drainage ditch located in the center of the SWMU and is assumed to flow northward to the New River. Groundwater seeps also discharge from the base of the embankment north of SWMU 43 along the New River during average or above average precipitation.

7.1.1.3 Groundwater

Water samples were collected from groundwater seeps at the northern embankment of SWMU 43 in 1992. Surface water and sediment from these sources are the likely exposure points for ecological receptors; however, due to the proximity of the sites to the New River and the potential for groundwater discharge to river, groundwater was evaluated further in *Section 7.2.6*.

Site groundwater is also being evaluated separately under the Horseshoe Area Groundwater Study.

7.1.1.4 Wetlands

According to the information presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, and confirmed during a review of site photographs, there are no wetlands at SWMU 43. There are also no wetlands close enough to the site that could potentially be impacted or receive surface water drainage from the sites.

7.1.1.5 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 using the photographs in **Appendix F-1**. As shown in **Appendix F-1, Photos F-1 through F-3**, the area surrounding SWMU 43 is primarily maintained grass with some trees and the New River located along the northern edge. There are also several dilapidated truck beds and/or trailers at SWMU 43 (**Appendix F-1, Photos F-4 and F-5**).

The two primary habitat types (grass and riparian edge) can be expected to support different wildlife species assemblages; however, given the close proximity of the habitats to each other, many species would be expected to spend some amount of time within each community type for foraging and resting activities, depending on the season.

Based on information from the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, and confirmed during a review of available site information, the following community description is presented for typical grassland communities at RFAAP.

The grassland communities at RFAAP are an aggregation of several community types that are so intermingled that delineation is impractical. Grassland may conveniently be subdivided into old field, meadow, and cultivated field. The term old field is used here to denote areas that were formerly open and subsequently abandoned, but are still open. In most cases, these areas were formerly pasture or hayfield. Small trees or shrubs may be present individually or in small groups, but a canopy is lacking. There is a small riparian habitat just beyond the northern edge of the sites. Old fields, in most cases, are dominated by native, warm-season species with a wide variety of other grasses, sedges, and herbs mixed in. The two dominants are little bluestem

(*Schizachyrium scoparium*) and broomsedge (*Andropogon virginicus*) with others such as *Tridens flavus, Panicum oligosanthes, Panicum anceps, Eragrostis spectabilis, Setaria glauca, Sorghastrum nutans,* and *Paspalum* being frequent. Much of the old-field community is mowed (on an infrequent basis) to help keep woody plants maintained.

Meadows are areas that are mowed regularly and, in most cases, have been planted in forage grasses for haying. These are typically non-native, cool-season species such as *Festuca elatior, Poa pratensis, Phleum pratense, Agrostis gigantea, Bromus inermis, Dactylis glomerata,* and *Arrhenatherum elatius*. These species may also be mixed with native species characteristic of old fields.

Cultivated fields are areas that have been plowed and seeded with various cover crops. These areas have a major ruderal component that persists after abandonment. Principal weed species are *Cirsium arvense, Carduus acanthoides, Carduus nutans, Erechtites hieracifolia, Hypochaeris radicata, Verbascum thapsus, Hieracium pilosella,* and *Datura stramonium*.

Grassland communities at RFAAP comprise 4,379 acres, or about 63 percent of the 6,901-acre total [Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey].

7.1.1.6 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 that may be within or near the grassland community type.

Table 7-2
Species Inventory within RFAAP's Grassland Community Type

Taxa	Number of Species	Typical Examples
Plants	24	little bluestem, broomsedge, panic grass, orchard grass, foxtail, timothy, thistle, fireweed, hawkweed
Invertebrates	~250 in 17 taxonomic orders	millipedes, beetles, flies, springtails, seed bugs, bees, ants, moths, butterflies, dragonflies, mantis, caddisflies, isopods, pill bugs, amphipods
Reptiles and amphibians	24	salamanders, toads, frogs, turtles, snakes
Fish	12	sunfish, minnows, trout (not expected at the site)
Birds	83	robin, swift, dove, sparrow, warbler, wren, hawk
Mammals	13	red fox, white-tailed deer, shrew, meadow vole

7.1.1.7 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 sites, it is possible these species could also occur at the sites, however, as mentioned in *Section 7.1.1.1,* no threatened, rare, or endangered species have been documented at SWMU 43.

Table 7-3
Threatened, Rare, and Endangered Species in RFAAP's Grassland Community

Common Name	Scientific Name	Federal Status	State Status
Midland sedge	*Carex mescochorea*	not available	Watchlist
Shaggy false gromwell	*Onosmodium hispidissimum*	not available	Watchlist
Regal fritillary butterfly	*Speyeria idalia*	not available	State threatened
Henslow's sparrow	*Ammodramus henslowii*	not available	State threatened
Loggerhead shrike	*Lanius ludovicianus*	not available	State threatened

Although a unique community type (calcareous fen) exists within the RFAAP grassland community type, it is not found at or near SWMU 43.

7.1.2 Methodologies for the Identification of COPECs and Concentration Statistics

Using the chemical results from environmental media samples collected at SWMU 43, a subset of the chemicals detected having data of good quality and that were not a result of non-site sources are identified. The COPEC selection process is described in more detail in the following subsections; however, screening results are presented in *Section 7.2.2*.

Lists of samples are presented in *Sections 7.2.1*. A general discussion of comparing non-detected constituent concentrations with ecotoxicity screening values is presented in the General Uncertainty Analysis section (*Section 7.1.11*).

7.1.2.1 Data Organization

The data for each chemical have been sorted by medium. To assess potential ecological impacts, soil data from 0 to 2 ft bgs, as well as sediment and surface water data, have been considered. The 0 to 2 ft soil depth interval was selected for three primary reasons: 1) to maintain consistency with other RFAAP ecological risk assessment documents that used 0 to 2 ft, or a similar depth interval (e.g., *Ecological Risk Assessment Approach*, IT, 1998; *Screening Ecological Risk Assessment*, IT, 1999); 2) to address the most important ecological soil depth exposure interval, as soil depths below 2 ft would be infrequently contacted; and 3) to focus on the soil depth interval expected to have the highest COPEC concentrations, as discharges at SWMU 43 were primarily surficial; although the former landfill at SWMU 43 is expected to contain subsurface COPECs. Although some burrowing wildlife (e.g., the red fox) may actually burrow to depths greater than 2 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 to 2 ft depth range.

Chemicals that were not detected at least once in a medium are not included in the risk assessment, although non-detected constituents are discussed in the Uncertainty Analysis section (*Section 7 2.7*).

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 from USEPA (1989a) are discussed, along with other data issues in **Appendix A-2**, **QA/QC Evaluation**. Besides taking into account the ecological depth of interest, the methodology for data summary was identical for the SLERA and the HHRA.

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

7.1.2.3 Frequency of Detection

Chemicals that are detected infrequently (<5%) have been included in the risk evaluation as a conservative approach. Therefore, a low frequency of detection was not used to exclude COPECs.

7.1.2.4 Natural Site Constituents (Essential Nutrients)

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

7.1.2.5 Selection of COPECs

Comparison of the MDCs of chemicals with available toxicity benchmarks was not performed based on USEPA Region 3 Biological Technical Assistance Group (BTAG) comments prohibiting a “prescreening” during the SLERA process (USEPA, 2005b). Therefore, all detected chemicals in an environmental medium were assessed for the direct contact exposure pathway, and important bioaccumulative constituents (USEPA, 2000c) and explosives were selected for assessment using food chain modeling (as per USEPA Region 3 BTAG requirements). COPEC selection for SWMU 43 is detailed in *Section 7.2.2*.

Dioxin-like compounds (PCDDs and PCDFs) were detected in sediment at SWMU 43. For the SWMU 43 SLERA, dioxin-like compounds were treated according to procedures provided by USEPA and the World Health Organization (WHO) (Van den Berg et al., 2006; USEPA, 1989b, 1994b; WHO, 1998). Dioxin-like compounds 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 the 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. No soil samples collected at SWMU 43 were analyzed for pH, but an analysis of five surface soil samples collected at nearby Area P ranged from 7.46 to 7.82. Since the pH values from these soil samples are estimated to be greater than 5.5, aluminum was not evaluated for direct contact exposure at SWMU 43.

7.1.3 Identification of Exposure Pathways and Potential Receptors for Analysis

RFAAP terrestrial and aquatic wildlife may be exposed to COPECs by several pathways, including: 1) the ingestion of impacted soil, sediment, surface water, or food while foraging; 2) dermal absorption of chemicals from soil, sediment, or surface water; and 3) inhalation of chemicals that have been wind-eroded from soil or have volatilized from soil or water. Among these potential exposure pathways, the greatest potential for exposure to chemicals is likely to result from the ingestion of chemicals in food and surface water. The incidental ingestion of impacted soil or sediment (while foraging) is typically a less important exposure route. The ingestion of food, soil, sediment, and surface water, however, are viable exposure pathways and were considered in the SLERA.

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 SLERA. In order to narrow the exposure characterization portion of the SLERA on species or components that are the most likely to be affected, the SLERA has focused the selection process on species, groups of species, or functional groups, rather than higher organization levels such as communities or ecosystems. Site biota are organized into major functional groups. For terrestrial communities, the major groups are plants and wildlife, including terrestrial invertebrates, mammals, and birds. For aquatic and/or wetland communities, the major groups are flora and fauna, including vertebrates (waterfowl and fish), aquatic invertebrates, and semi-aquatic mammals and birds. Species presence was assessed during a literature review and during the site reconnaissance prior to identification of target receptor species.

Primary criteria for selecting appropriate assessment receptors included, but were not limited to, the following:

- The assessment receptor will have a relatively high likelihood of contacting chemicals via direct or indirect exposure.
- The assessment receptor will exhibit marked sensitivity to the COPECs given their mode of toxicity, propensity to bioaccumulate, etc.
- The assessment receptor will be a key component of ecosystem structure or function (e.g., importance in the food web, ecological relevance).

7.1.3.1 Terrestrial Receptors

Five representative receptor species that are expected or possible in the area of SWMU 43 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 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-1**.

The meadow vole, shrew, and robin represent the prey base for the larger predators of the area (represented by the red-tailed hawk and the red fox). A terrestrial food web is presented 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 (cm) 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 the SLERA (**Appendix F-2, Table F-1**).

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 cm in size, have a body weight range of 63 to 103 grams, and an average home range of 1.2 acres (USEPA, 1993).

Red-Tailed Hawk. The red-tailed hawk is a common predator in the mixed landscapes typifying RFAAP. The wooded habitats and riverside trees within RFAAP are considered ideal foraging and nesting habitats for these raptors. This hawk is one of the most common and widespread members of the genus *Buteo* in the continental United States and Canada (Brown and Amadon, 1968). Red-tailed hawks live in a variety of habitats, such as farmlands, woodlands, mountains, and deserts, as long as there is open country interspersed with woods, bluffs, or streamside trees. They are primarily carnivorous, feeding on small rodents, as well as fish. Other prey items include amphibians, reptiles, crayfish, and other birds (Adamcik et al., 1979;

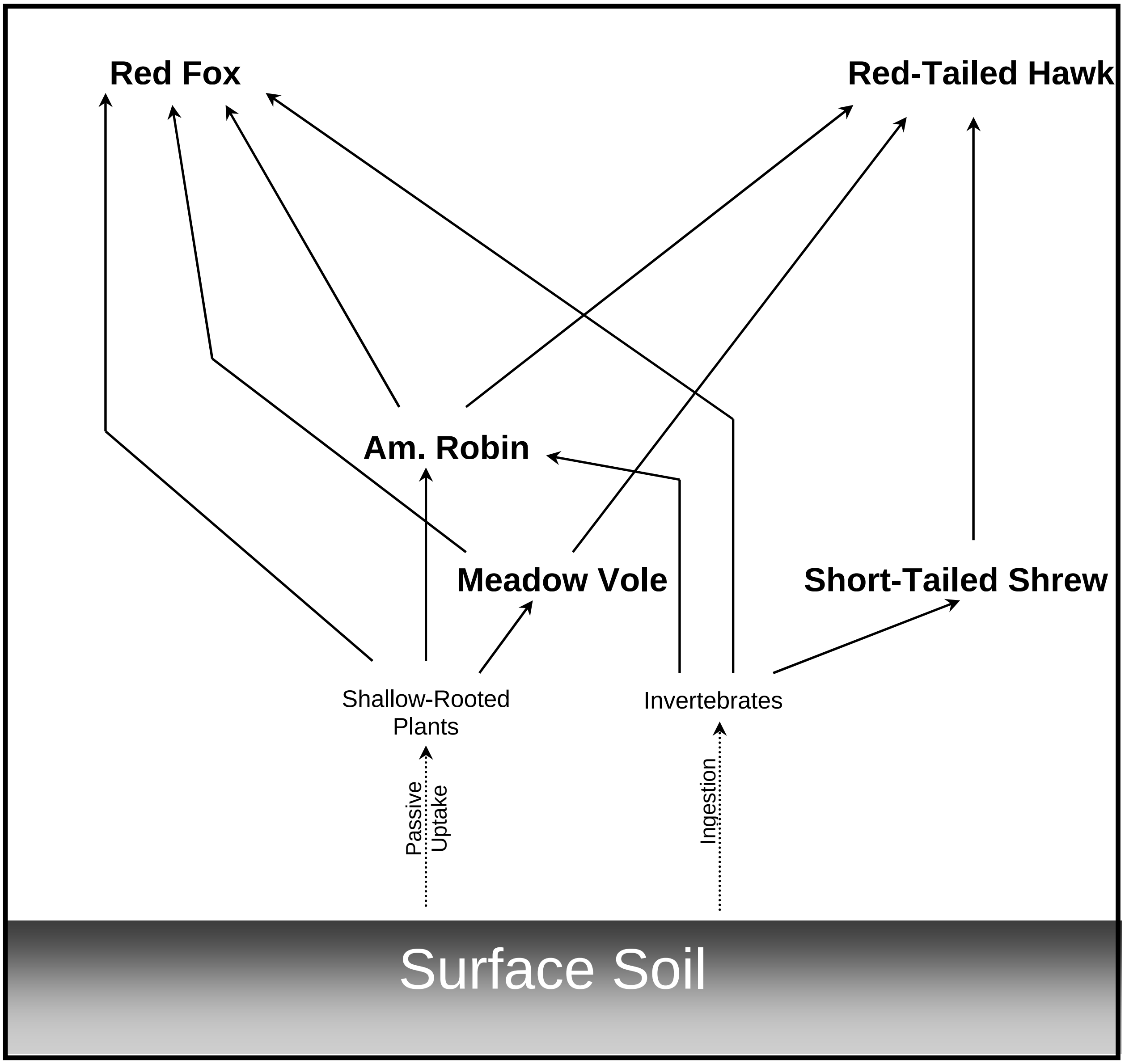


Figure 7-1. Simplified Terrestrial Food Web Conceptual Site Exposure Model (CSEM)

Ehrlich et al., 1988). Home range has been reported as small as 66.8 acres, with a population density of 0.16 pairs per acre (Janes, 1984), although USEPA (1993) reports an average territory size of 2,081 acres. Breeding population density is one nest per 0.009 acre or one individual per 0.004 acre. Body weight for male red-tails is 1,028.6 to 1,142.9 grams, and for females 1,371.4 to 1,600 grams (Brown and Amadon, 1968), although USEPA (1993) reports an average body weight of 1,134 grams. More northerly populations are migratory, while the more southerly are year-round residents.

Red Fox. The red fox is a carnivorous predator that occurs in a wide range of habitats typical of RFAAP. Red fox use many types of habitat, including cropland, rolling farmland, brush, pastures, hardwood stands, and coniferous forests. They are present throughout the United States and Canada, and are the most widely distributed carnivore in the world. These foxes have a length of 56 to 63 cm, with a 35 to 41 cm tail and an average weight of 4,530 grams. They do not undergo hibernation, and most often occupy abandoned burrows or dens of other species.

One fox family per 100 to 1,000 hectares is typical, and the average home range is 892 hectares (2,204 acres) (USEPA, 1993). Fecundity is higher in areas of high mortality and low population density.

A pictorial representation of potential exposure has been prepared and is presented as **Figure 7-1**. This food web pictorial clarifies the conceptual site exposure model (CSEM). The CSEM traces the contaminant pathways through both abiotic components and biotic food web components of the environment. The CSEM presents potentially complete exposure pathways.

7.1.3.2 Aquatic Receptors

Two representative aquatic receptor species that are expected or possible in SWMU 43 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 aquatic plants and other aquatic biota were assessed by comparing measured surface water and sediment COPEC concentrations with available direct contact criteria. The two animal species selected include the great blue heron (*Ardea herodias*) (medium, piscivorous bird) and the mink, (small, omnivorous mammal). Data used to model exposure for these species are summarized in **Appendix F-2, Table F-1**.

An aquatic food web is presented on **Figure 7-2**. The selected aquatic receptor species have a potential for high abundance at the sites that have adequate aquatic habitat; also, sufficient toxicological information (with the exception of some COPECs for the bird species) is available in the literature for comparative and interpretive purposes. Both of the species are considered important to the stability of the local ecological food chain and biotic community. Finally, the selected species have readily-available exposure data, as summarized in the *Wildlife Exposure Factors Handbook* (USEPA, 1993).

Receptor profiles for these two selected species are presented in the following paragraphs.

Great Blue Heron. The great blue heron is the largest member of its group in North America (99 to 132 cm) (Bull and Farrand, 1995), with body weights ranging from 2.2 to 2.58 kilograms (kg) (USEPA, 1993). It ranges from coastal Alaska, and Nova Scotia south to Mexico (Bull and Farrand, 1995). Habitat of this heron includes both fresh and marine waters, including freshwater lakes and rivers, brackish marshes, lagoons, mangroves, and coastal wetlands,

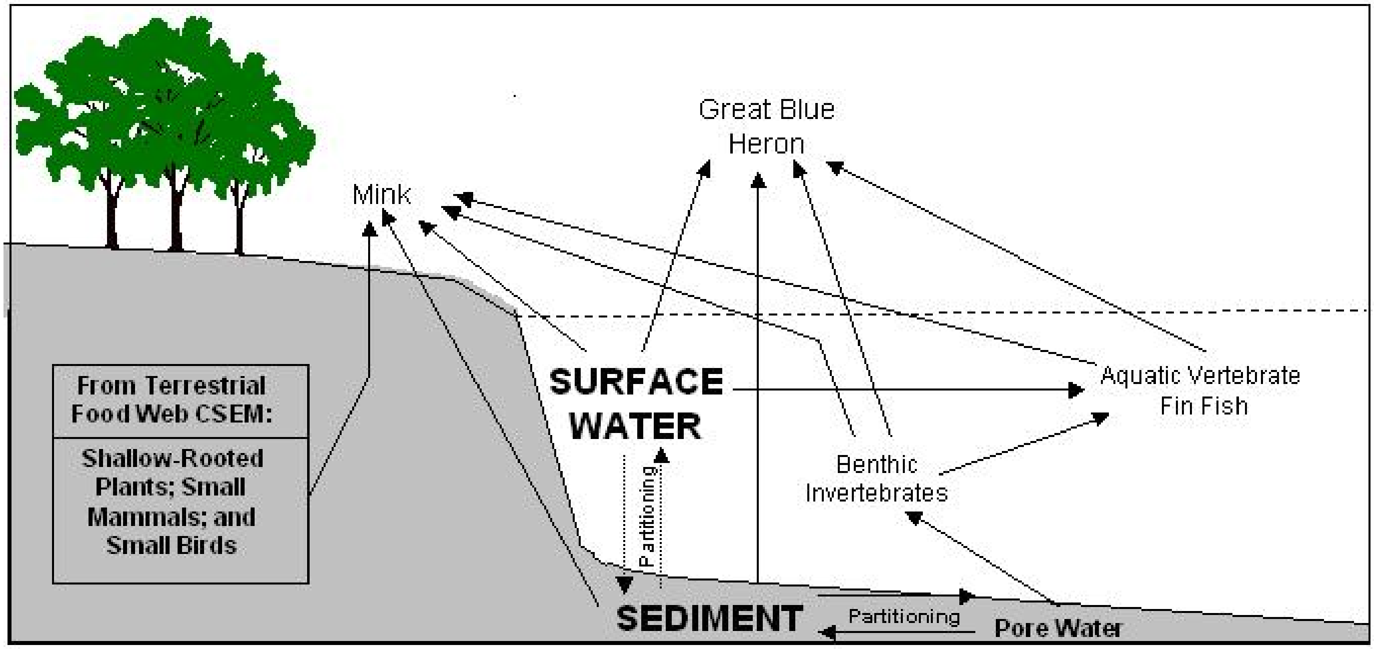


Figure 7-2. Simplified Aquatic Food Web Conceptual Site Exposure Model (CSEM)

particularly where small fish are plentiful (USEPA, 1993). Great blues tend to nest in dense colonies, or heronries. The location of the heronry is generally close to foraging grounds, and tall trees are preferred over shorter trees or bushes for nest sites. Fish are the preferred prey, but the heron will also eat crustaceans, amphibians, reptiles, insects, birds, and mammals. Foraging home range may be as great as 24 kilometers; however, an average home range of 21 acres is used in the current assessment. Population densities along streams and rivers range from 2.3 to 3.6 birds per kilometer (USEPA, 1993). Once a year the female will lay 2 to 7 eggs (Bull and Farrand, 1995), and the first year mortality rate is approximately 64 percent (USEPA, 1993).

Mink. The mink is the most abundant and widespread carnivorous mammal in North America. Mink are distributed throughout North America, except in the extreme north of Canada, Mexico, and arid areas of the southwestern United States. Mink do not undergo hibernation and are active year-round. Mink are particularly sensitive to PCBs and similar chemicals. Mink body size varies greatly throughout its range, with males weighing markedly more than females. Males measure from 33 to 43 cm with an 18 to 23 cm tail, and females measure from 30 to 36 cm, with a 13 to 20 cm tail. An average body weight of 1.02 kg has been used for purposes of the current assessment, and body weights range from 0.55 to 1.73 kg (USEPA, 1993).

Mink are found associated with aquatic habitats of every kind, including waterways such as rivers, streams, lakes, and ditches, as well as swamps, marshes, and backwater areas. Mink prefer irregular shorelines to more open exposed banks. They also tend to use brushy or woody cover adjacent to the water, where cover for prey is abundant and where downfall and debris provide den sites. Mink are predominantly nocturnal hunters. Shorelines and emergent vegetation are the mink's principal hunting areas. Mink are opportunistic feeders, taking whatever is abundant. Mammals can be the mink's most important prey year-round, but mink also hunt aquatic prey such as fish, amphibians, and crustaceans and other terrestrial prey such as birds, reptiles, and insects, depending on the season. In winter, mink often supplement their diet with fish.

The home range of mink encompasses both their foraging areas around waterways and their dens. Home range depends mostly on food abundance, but also on the age and sex of the mink, season, and social stability. In winter, mink spend more time near dens and use a smaller portion of their range than in summer. Adult male home ranges are generally larger than female home ranges, particularly during the mating season when males may range over 1,000 hectares. For the purposes of this assessment an average home range of 35 acres was used (USEPA, 1993).

7.1.4 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, a SLERA focuses on populations or groups of interbreeding nonhuman, non-domesticated 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 the SLERAs 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.

7.1.4.1 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 43 are stated as the protection of long-term survival and reproductive capabilities for populations of herbivorous, insectivorous, and carnivorous mammals, and omnivorous, piscivorous, and carnivorous birds. The corresponding null hypothesis (H_o) for each of the assessment endpoints is stated as: the presence of site contaminants within soil, surface water, sediment, vegetation, and prey will have no adverse 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/sediment dwelling invertebrates.

The food web CSEMs were developed to illustrate how the selected terrestrial and aquatic species are ecologically linked. For terrestrial and aquatic invertebrates, small prey items, fish, and plants, partitioning coefficients and simple empirical uptake models were employed to estimate COPEC concentrations within tissues (*Section 7.1.5*). These tissue concentrations were then used as input values for exposure to higher trophic level receptors through the dietary route of exposure.

7.1.4.2 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.

7.1.5 Exposure Estimation

This section includes a discussion of how COPEC exposures were quantified, including intake (*Section 7.1.5.1*) and bioaccumulation (*Section 7.1.5.2*).

An estimate of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the sites was developed, considering both current and reasonably plausible future use scenarios.

Ecological routes of exposure for biota may be direct (bioconcentration) or through the food web via the consumption of contaminated organisms (bioaccumulation). Food web exposure can occur when terrestrial or aquatic fauna consume contaminated biota. Direct exposure routes include dermal contact, absorption, inhalation, and ingestion. Examples of direct exposure include animals incidentally ingesting contaminated soil or sediment; animals ingesting surface water; plants absorbing contaminants by uptake from contaminated soil or sediment; and the dermal contact of aquatic organisms with contaminated surface water or sediment. In addition, as discussed in *Section 7.1.3*, 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. For purposes of the SLERA, bioavailability is conservatively assumed to be 100 percent.

For terrestrial and aquatic faunal receptors, calculation of exposure rates relies upon determination of an organism's exposure to COPECs found in surface soil, surface water, or sediment, and on transfer factors used for food chain exposure. Exposure rates for terrestrial and aquatic wildlife receptors in this SLERA are based solely upon ingestion of contaminants from these media and from consumption of other organisms.

7.1.5.1 Intake

The first step in estimating exposure rates for terrestrial and aquatic wildlife involves the calculation of food ingestion and drinking water intake rates for site receptors. USEPA (1993) includes a variety of exposure information for a number of avian and mammalian species. Information regarding feeding rates, watering rates and dietary composition are available for many species, or may be estimated using allometric equations (Nagy, 1987). Data have also been gathered on incidental ingestion of soil and/or sediment, and are incorporated for the receptor species. This information is summarized in **Appendix F-2**, **Table F-1**. For the SLERA, conservative Tier 1 exposures are based on maximum dietary intake, maximum incidental soil intake, minimum body weight, 100 percent site exposure [i.e., area use factor (AUF) set equal to unity], and the use of COPEC MDCs as EPCs. Less conservative Tier 2 exposures are based on average dietary and incidental soil intake, average body weight, calculated AUF based on site area and home range of the receptor species, and COPEC EPCs set equal to 95% UCLs. 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. Results for these algorithms are presented in **Appendix F-2, Tables F-2 through F-15.**

The basic equation for estimating dose through the dietary pathway is:

$$D_p = \sum_{k=1}^{m} (C_k \times F_k \times I_k) / W$$

where:

D_p = the potential average daily dose (mg/kg-day),
C_k = the average COPEC concentration in the k^{th} food type (mg/kg dry weight)
F_k = the fraction of the k^{th} food type that is contaminated
I_k = the ingestion rate of the k^{th} food type (kg dry weight/day)
W = the body weight of the receptor (kg wet weight).

Literature values for animal-specific sediment ingestion have been used if available. However, such values generally are not available in the literature. Where sediment ingestion rates could not be found, the animal-specific incidental soil ingestion rate is used for sediment ingestion as well, if the receptors life history profile suggests a significant aquatic component, and if sediment is a medium of concern at the site.

The estimated chemical intakes for the exposed receptors for the relevant pathway and scenario are presented in the risk characterization spreadsheets referenced in *Section 7.2.3*.

7.1.5.2 Bioaccumulation and Bioconcentration Factors

For the current SLERA, bioaccumulation factors (BAFs) and bioconcentration factors (BCFs) for soil-to-plants, soil-to-earthworms, soil-to-small mammals and birds, sediment-to-aquatic invertebrates, and surface water-to-fish are presented in **Appendix F-2**, **Tables F-17, F-18, F-19, F-20, and F-21**, respectively. BAFs and/or BCFs were not available for every COPEC, but were estimated as described in the footnotes to these tables. For each BAF/BCF pathway, both a Tier 1 and Tier 2 value is presented, as recommended in the *Site Screening Process* (USEPA, 2001c) and the *RFAAP Final MWP* (URS, 2003). The Tier 1 BAF/BCF is 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-17**) are based on information from Bechtel Jacobs (1998a), USEPA (2008c), Efroymson (2001), Baes et al. (1984), International Atomic Energy Agency (IAEA) (1994), and Travis and Arms (1988). 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. It should be noted that as the regression equation predicts COPEC concentrations in plants, the actual BAF/BCF value is estimated by dividing the estimated plant COPEC concentration by the soil COPEC concentration. For organic COPEC without available BAF/BCF values, the K_{ow} regression equation from Travis and Arms (1988) is used, as shown as follows:

$$Log\ BAF / BCF = -0.578 \times Log\, K_{ow} + 1.588$$

where:

Log Kow = log octanol-water partition coefficient (see **Appendix F-2, Table F-17**)

In order to estimate Tier 1 and Tier 2 BAF/BCF plant uptake values using the Travis and Arms (1988) regression equation, the log K_{ow} value from the USEPA Estimation Programs Interface (EPI) Suite program (USEPA, 2007b) was used. BAF/BCF values estimated for organics using the Travis and Arms (1988) equation ranged from 0.0036 (for Aroclor 1254) to 0.0039 (for TCDD) for the Tier 1 and Tier 2 approaches (**Appendix F-2**, **Table F-17**).

Soil-to-earthworm BAF/BCF values (**Appendix F-2**, **Table F-18**) are based on information from USEPA (2008c), Sample et al. (1998a), and Sample et al. (1999). Earthworms are used as a surrogate species to represent terrestrial invertebrates including insects. Values are based on Ecological Soil Screening Level (EcoSSL) uptake values or regression equations, if available. If a regression equation or recommended uptake value is not available 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-19**) are based on information from USEPA (2008c) and Sample et al. (1998b). Values are based on regression equations (USEPA, 2008c) or upperbound BAF/BCF values if no regression equation is available. If no organic surrogate soil uptake value was available, a conservative default BAF/BCF of 1 was used for the Tier 1 assessment, while a default BAF/BCF of 0.5 was used for the Tier 2 assessment.

Sediment-to-aquatic invertebrate BAF/BCF values (**Appendix F-2**, **Table F-20**) are based on information from Bechtel Jacobs (1998b). If no uptake value was available for inorganic COPECs, geometric means of the available inorganic uptake values from Bechtel Jacobs (1998b) were used: the geometric mean of the 90th percentile values (2.1) was used for the Tier 1 BAF/BCF value and the geometric mean of the median values (0.42) was used for the Tier 2 BAF/BCF value. If no uptake value was available for organic COPECs, a soil-to-terrestrial invertebrate BAF/BCF value was used (from **Appendix F-2**, **Table F-18**).

Water-to-fish BAF/BCF values (**Appendix F-2, Table F-21**) are based on information from IAEA (1994), Bintein and Devillers (1993), USEPA (1999a), and USEPA (1989c). The Tier 1 value was the maximum BAF/BCF value available from the literature, while the Tier 2 value used represents a conservative, yet more realistic uptake value.

For surface water organic COPECs that did not have available literature uptake values from IAEA (1994), the following equation from Bintein and Devillers (1993) with the log K_{ow} value from the USEPA EPI Suite program (USEPA, 2007b), was used to estimate the BAF/BCF, along with the COPEC-specific K_{ow}:

$$Log BAF/BCF = 0.910 \times Log K_{ow} - 1.975 \times Log(6.8 \times 10^{-7} \times K_{ow} + 1) - 0.786$$

where:

Log Kow = log octanol-water partition coefficient (see **Appendix F-2, Table F-21**)

However, since the only aquatic food chain COPEC was arsenic, no Fish BAF/BCF values were estimated using the Bintein and Devillers (1993) equation (**Appendix F-2**, **Table F-21**).

7.1.6 Ecological Effects Characterization

This ecological effects characterization section presents the selection of literature benchmark values and the development of reference toxicity values.

7.1.6.1 Selection of Literature Benchmark Values

Appropriate sources for literature benchmark values have been consulted, such as Toxicological Benchmarks for Wildlife (Sample et al., 1996); EcoSSLs (USEPA, 2008c); Ecorisk Database, Release 2.2 (LANL, 2005); Toxicological Profile for Silver, U.S. Public Health Service (ATSDR, 1990); Toxicological Profile for 1,1,2,2-Tetrachloroethane, U.S. Public Health Service (ATSDR, 1996); PAH Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review (Eisler, 1987); TERRETOX, http://www.epa.gov/ecotox; Terrestrial Toxicity Database (USACHPPM, 2002); SLERA Protocol for Hazardous Waste Combustion Facilities (USEPA, 1999a); OPP (Office of Pesticide Programs) Environmental Effects Database (USEPA, 2000d); and IRIS (USEPA, 2008b). Some values were extrapolated to chronic no-observed-adverse-effect level (NOAEL) or lowest-observed-adverse-effect level (LOAEL) values using recommended Tri-Service (Wentsel et al., 1996) uncertainty factors (UFs).

7.1.6.2 Development of Toxicity Reference Values

Toxicity reference values (TRVs) were selected from available data for use in the SWMU 43 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 and the values are presented in **Appendix F-2, Tables F-22 and F-23** for NOAEL and LOAEL TRVs, respectively.

Toxicity information pertinent to identified receptors has been gathered for those analytes identified as COPECs. Because the measurement endpoint ranges from the NOAEL to the LOAEL, preference was given to chronic studies noting concentrations at which no adverse effects were observed and ones for which the lowest concentrations associated with adverse effects were observed.

Using the relevant toxicity information, TRVs have been calculated for each of the COPECs. TRVs represent NOAELs and LOAELs with safety factors incorporated for toxicity information derived from studies other than no-effects or lowest-effects studies.

TRVs have been calculated from LD_{50} values, when required, using safety factors specified in Ford et al. (1992) and reported in Wentsel et al. (1996) and summarized in the footnotes to **Appendix F-2, Tables F-22 and F-23**. 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 UFs 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-24** for the receptors used in the SLERAs. 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 7.1.7.* 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.

7.1.7 Risk Characterization

The risk characterization phase integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is a determination of the likelihood, severity, and characteristics of adverse effects to environmental stressors present at a site. Qualitative and semi quantitative approaches have been taken to estimate the likelihood of adverse effects occurring as a result of exposure of the selected site receptors to COPECs.

For this assessment, TRVs and exposure rates have been calculated and are used to generate HQs (Wentsel et al., 1996), by dividing the receptor exposure rate for each contaminant by the calculated TRV. Environmental effects quotients (EEQs) or HQs are a means of estimating the potential for adverse effects to organisms at a contaminated site, and for assessing the potential that toxicological effects will occur among site receptors.

7.1.7.1 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 or via reviewing site photographs. The overall health of the plant community at the sites was comparable to the plant communities in the surrounding areas. Plants were not quantitatively evaluated in the 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 sites (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, terrestrial plant impacts are discussed further in *Section 7.2.4*.

7.1.7.2 Predictive Risk Estimation for Terrestrial Wildlife

The potential wildlife risks associated with SWMU 43 are estimated in the SLERA. The risk estimation has been performed through a series of quantitative HQ calculations that compare receptor-specific exposure doses 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. Whether or not HQ summation was appropriate and scientifically defensible is based on whether the chemicals have a similar mode of toxicological action (see *Section 7.2.3.2*). 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.

Tier 1 and Tier 2 individual COPEC EEQs and HIs (summed EEQs) for terrestrial and aquatic receptors at SWMU 43 are presented in risk characterization tables for the seven selected receptor species.

7.1.8 Approach for the Evaluation of Direct Contact Toxicity

For direct contact exposure for soil invertebrates to COPECs in surface soil, sediment, and surface water; measured COPEC concentrations were simply compared with direct contact benchmarks appropriate for these communities. COPEC media concentrations are compared with BTAG-approved 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, sediment, and surface water. The results are summarized in *Section 7.2.4*.

7.1.8.1 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, 2008c), or if an EcoSSL was not available, with the lowest BTAG (USEPA, 1995b) soil screening value. A chemical was only retained as a COPEC if the MDC exceeded the EcoSSL, or in the absence of an EcoSSL, if the MDC exceeded the BTAG soil screening value. If no EcoSSL or BTAG value was available, the value was also carried forward for comparison to other available screening values (listed below). The results are summarized in *Section 7.2.4.1*.

In the second step, the MDCs of the chemicals carried-forward were compared with up to five individual soil screening values (in addition to the BTAG screening value, if one was available and relevant):

- Dutch intervention values (Netherlands Ministry of Housing, Spatial Planning and Environment, 2000), Circular on Target Values and Intervention Values for Soil Remediation.
- Canadian Council of Ministers of the Environment, Canadian Environmental Quality Guidelines, December 2003.
- Lowest EcoSSL value for direct contact toxicity for either plants or terrestrial invertebrates (USEPA, 2008c).
- ORNL (1997a, ES/ER/TM-85/R3), screening benchmarks for plants.
- ORNL (1997b, ES/ER/TM-126/R2), screening benchmarks for earthworms.

7.1.8.2 Surface Water

For aquatic organisms potentially exposed to COPECs in surface water collected from SWMU 43, comparison of the EPC to promulgated water quality criteria or a weight-of-evidence approach (for constituents without promulgated criteria) was used. The results are summarized in *Section 7.2.4.2*. It should be noted that because of the nature of various benchmark sources, promulgated water quality criteria [e.g., National Ambient Water Quality Criteria (NAWQC) and Virginia Water Quality Standards] were determined to be more critical during the evaluation than non-promulgated benchmarks. COPEC selection was based on whether or not promulgated criteria were exceeded or when no promulgated criteria were available, whether more than half of the available surface water benchmarks were exceeded. As some aquatic biota are relatively non-mobile, maximum detected surface water concentrations are used, in addition to a more realistic exposure concentration expressed as the 95% UCL. Surface water benchmarks used to assess direct contact exposure include the following:

- USEPA Region 3 BTAG SLs (July 2006). Values are for freshwater.
- USEPA (2006a) - 4304T. National Recommended Water Quality Criteria.
- Virginia Water Quality Standards, 9 VAC 25-260, October 2008.
- ORNL. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision, ES/ER/TM-96/R2.
- USEPA Region 4 Ecological Benchmark Screening Values for Surface Water (2000e).

7.1.9 Background Metals Considerations

A background evaluation was conducted on the surface soil analytical results to determine if any inorganic COPECs were potentially related to naturally-occurring soil concentrations. Inorganics with MDCs that are not statistically different based on appropriate population statistical tests are considered background related (*Section 6.4.2*). Individual results are discussed in *Section 7.2.5*.

7.1.10 Groundwater/Seep Discharge to New River

Determination of a Dilution Factor.

In order to evaluate concentrations of groundwater COPECs in the New River resulting from groundwater discharge at SWMU 43, a dilution factor was estimated using the following equation:

$$DF = \frac{Q_{NewRiver}}{Q_{gw}}$$

where:

DF = dilution factor (unitless)
$Q_{\text{New River}}$ = volumetric low flow in the New River (cfs)
Q_{gw} = average volumetric discharge rate for groundwater (cfs).

Volumetric Flow in the New River. Compared with the flow in the New River, groundwater discharge from SWMU 43 to the New River is relatively low; therefore, considerable dilution of the groundwater COPECs is expected. As shown on **Figure 7-3**, average monthly flows in the New River adjacent to the site range from a low of approximately 2,400 cubic feet per second (cfs) in August-September to a high of approximately 6,000 cfs in March. Considering the low-flow value minus one standard deviation and the high-flow value plus one standard deviation (for the 64-year period of record) the average August-September and March monthly flows could range from approximately 800 to 8,400 cfs (**Figure 7-3**). The flow in the New River near the site is controlled by discharges from the Claytor Reservoir located approximately eight miles upstream (Appalachian Power Company, 2006). Due to hydroelectric power needs for the Claytor Hydroelectric Project and agreements with downstream users, the Claytor Hydroelectric Project is operated to provide a minimum average daily flow of 750 cfs (Appalachian Power Company, 2006). The Little River provides additional flow to the New River between the Claytor Reservoir spillway and the site. As shown on **Figure 7-4**, average monthly flows in the Little River range from a low of approximately 251 cfs in August to a high of approximately 538 cfs in March. Considering the low-flow value minus one standard deviation and the high-flow value plus one standard deviation (for the 76-year period of record), the average August and March Little River monthly flows could range from approximately 51 to 760 cfs (**Figure 7-4**). Based on this information, the 7-day average low flow expected with a recurrence interval of 10 years (7Q10) is estimated to be approximately 50 cfs for the Little River. The 7Q10 value is a conservative low flow value typically used to assess possible adverse impacts to aquatic life during the critical low flow period. According to Nelms et al. (1997), a 75th percentile 7Q10 flow can be estimated using a drainage area base-flow factor of 0.16 cfs per square mile for streams and rivers in the south Valley and Ridge Region of Virginia. As the Little River has a drainage area of 300 square miles, use of a drainage area base-flow factor of 0.16 cfs translates into an estimated 7Q10 of 48 cfs that is very close to the estimate of 50 cfs.

Adding the Little River estimated 7Q10 flow of 50 cfs to the minimum Claytor Reservoir discharge flow of 750 cfs results in an estimated total low flow of 800 cfs for the New River near the site.

Average Volumetric Flow of Contaminated Groundwater. The average volumetric discharge rate for the contaminated groundwater is defined by the following equation:

$$Q_{gw} = T \bullet I \bullet w$$

where:

Q_{gw} = volumetric discharge rate [ft^3/s]
T = transmissivity [ft^2/s]
I = hydraulic gradient [dimensionless]
w = width of groundwater plume[ft]

The estimated groundwater transmissivity used in this evaluation is based on the maximum transmissivity for flood plain monitoring wells (31MW1 and 54MW4) in the Horseshoe Area of RFAAP. Based on short-term pumping test results presented in the *Current Conditions Report* (Shaw, 2005), groundwater transmissivities from two wells, 31MW1 and 54MW4, were estimated at 1.2E-3 square feet per minute (ft^2/min) and 6.8E-3 ft^2/min, respectively. The

Figure 7-3. New River Mean Monthly Flow at Radford Virgina (1939-2003)

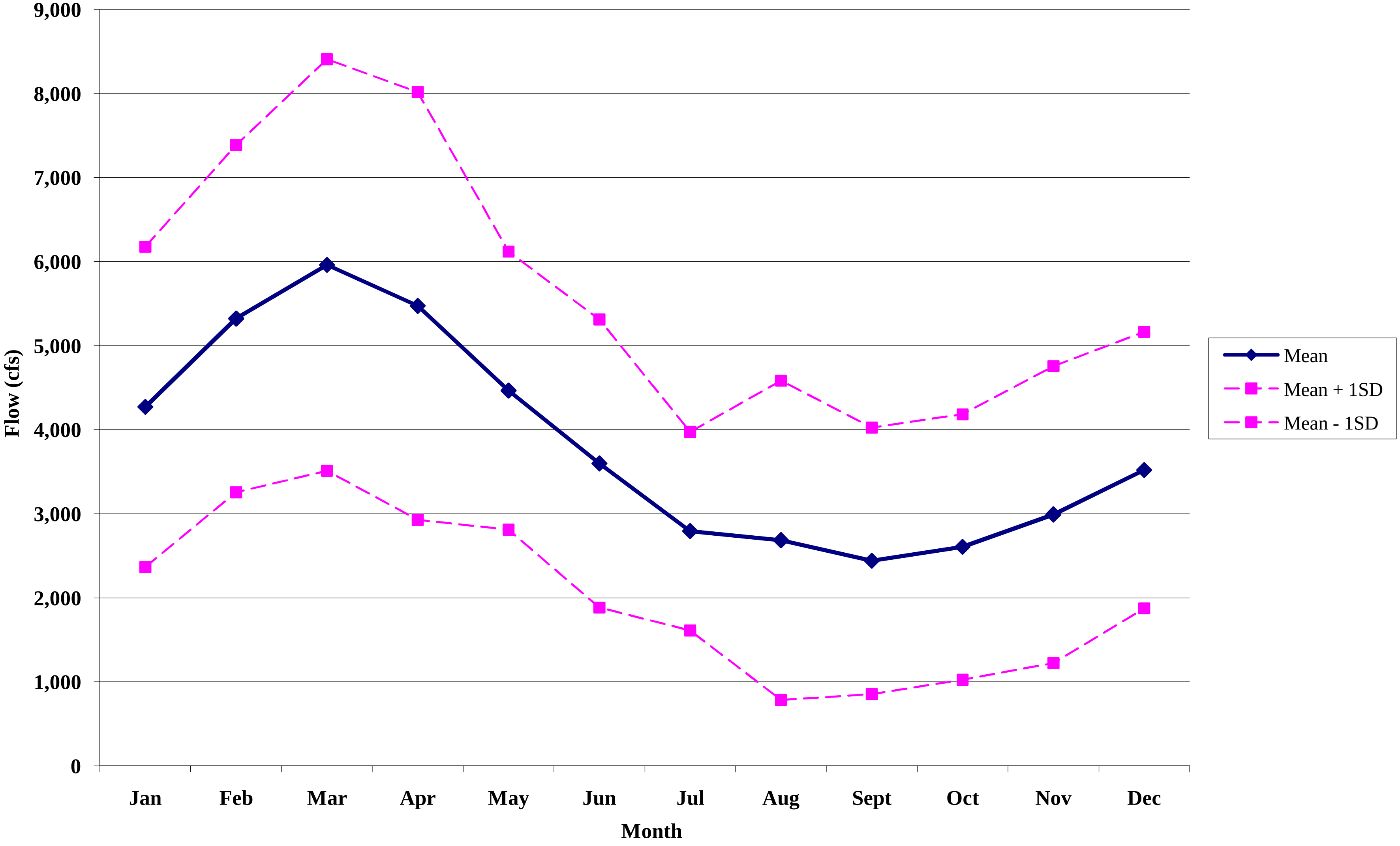
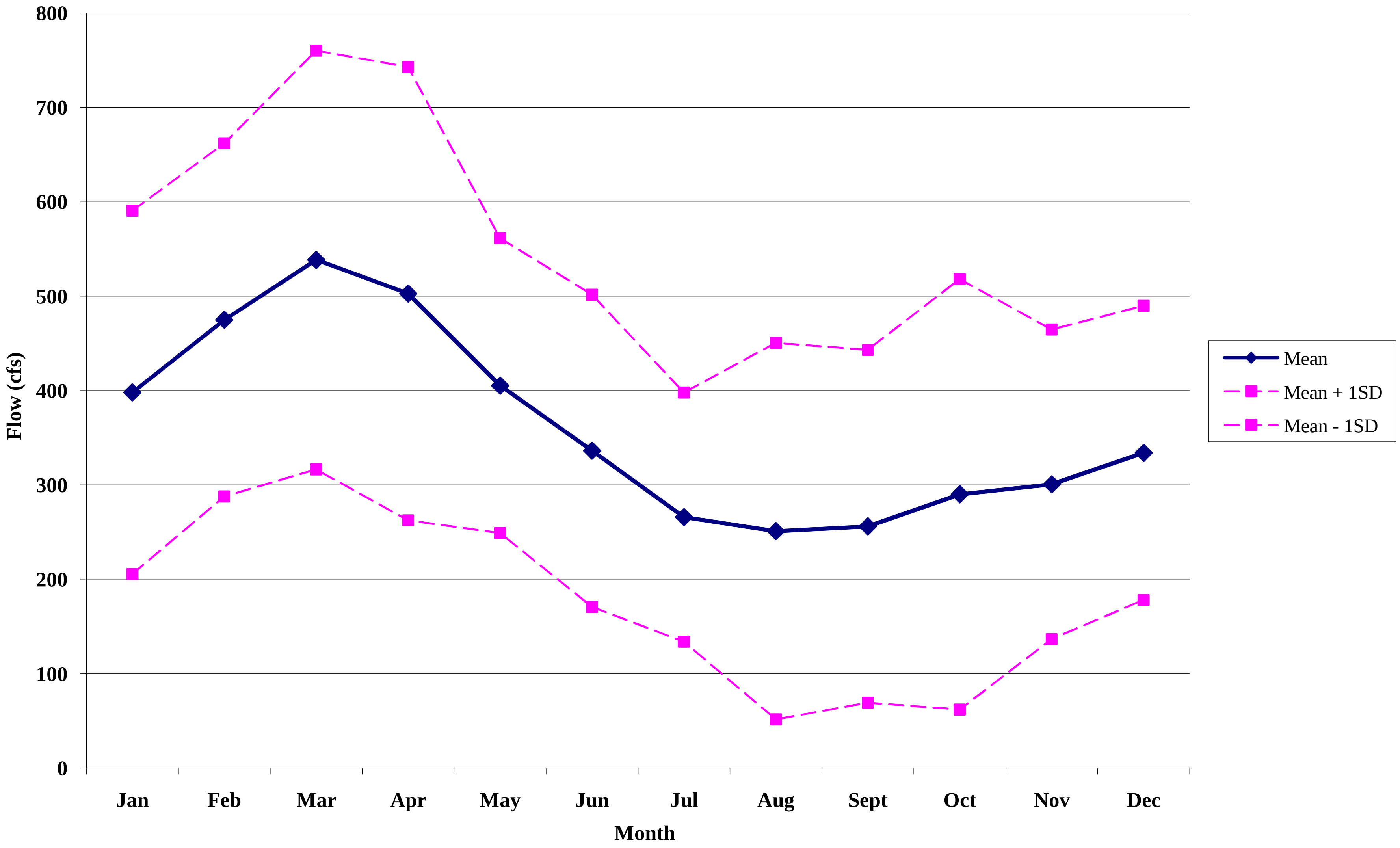


Figure 7-4. Little River Mean Monthly Flow near Radford Virginia (1929-2005)



maximum groundwater transmissivity (6.8E-03 ft^2/min, or 1.13E-4 ft^2/s) was used in this analysis. Groundwater gradients were estimated at SWMU 43 to range from 0.005 ft/ft to 0.0105 ft/ft. The maximum groundwater gradient (0.0105 ft/ft) was used in this analysis. The width of the potentially contaminated groundwater plume was estimated by the width of the landfill areas (Shaw, 2007), parallel to the direction of the river flow, or 1375 ft. Using this information, the average volumetric groundwater discharge rate at SWMU 43 is 1.64E-3 cfs. Dividing the SWMU 43 groundwater discharge rate (1.64E-3 cfs) into the estimated New River low flow rate of 800 cfs results in a dilution factor of 4.88E+5 (e.g., 800/1.64E-3 = 4.88E+5). Since this dilution factor is large and mixing of the groundwater with the flow in the New River is not instantaneous, a conservative dilution factor of 100 is assumed for SWMU 43.

7.1.11 General 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).

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 numerous chemical constituents not detected in surface soil, sediment, and/or surface water samples. The uncertainty associated with these constituents' detection limits for SWMU 43 was evaluated by presenting a comparison of the maximum detection limit for each non-detect constituent with a conservative ecological toxicity screening value (see *Section 7.2.7*).

Some of the non-detect constituents had maximum detection limits that exceeded the screening criteria. This finding is not unexpected, given the conservative and numerically low screening values.

The general uncertainty analysis is presented in **Table 7-4** 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, 1997a).

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 the 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.

Table 7-4
General Uncertainty Analysis

Component	Bias	Magnitude	Ways to Minimize Uncertainty	Additional Comments
Use of 95% UCL as source-term concentration	Overestimates Risk	Medium	Use central tendency	Easy to implement, but may not be acceptable to Agency.
Use of representative receptor species for site ecological community	Underestimates Risk	Low	Select additional receptor species	Easy to implement, but unlikely to change conclusions.
Use of conservative foraging factors (i.e., 100%) for some species	Overestimates Risk	Medium	Use more site-specific foraging factors, i.e., less than 100%	May be difficult to obtain site-specific foraging factors.
Assumption that COPECs are 100% bioavailable	Overestimates Risk	Medium to High	Obtain medium- and COPEC-specific bioavailability factors	Would be very difficult and costly to obtain these bioavailability factors.
Discounting of dermal and inhalation exposure routes	Underestimates Risk	Low	Include dermal and inhalation routes of exposure	Would be difficult to quantify these routes of exposure.
Use of partitioning and transfer factors to estimate COPEC concentrations in plants, invertebrates, and prey items.	Overestimates Risk	Medium to High	Measure COPEC concentrations in site plants, invertebrates, and/or other prey species	Would be costly to implement, but could significantly reduce EEQs.
Use of safety factors to convert LOAEL and LD_{50} toxicity data to NOAELs	Overestimates Risk	Medium	Obtain COPEC-specific NOAEL data	Would be costly to implement, unless data available in the literature.
Use of uncertainty factor of 8 to extrapolate TRVs between most species within the same class	Overestimates Risk	Medium	1) Assume TRVs similar for species in the same genus, family, or order; or 2) obtain species-specific NOAEL data	1) May not be accepted by Agency. 2) Would be very difficult to obtain species-specific NOAEL data.
Use of surrogate constituents to estimate toxicity for those COPECs without available toxicity data	Overestimates Risk	Low to Medium	Obtain COPEC-specific toxicity data	Would be very costly to obtain COPEC-specific toxicity data, unless available in the literature.
Use of hazard quotient method to estimate risks to populations or communities may be biased	Overestimates Risk	High	Perform population or community studies	Would be very costly to perform.

7.2 Screening Level Ecological Risk Assessment

This section presents the SLERA for SWMU 43 (Sanitary Landfill No. 2). The detailed methodology used for performance of the SLERA is presented in *Section 7.1*. This section includes a Site Characterization (*Section 7.2.1*); Summary of COPEC Selection (*Section 7.2.2*); Risk Characterization (*Section 7.2.3*); Direct Contact Assessment (*Section 7.2.4*); Background Evaluation (*Section 7.2.5*); Groundwater Evaluation (*Section 7.2.6*); Uncertainty Analysis (*Section 7.2.7*); and Results and Conclusions (*Section 7.2.8*).

7.2.1 Site Characterization

SWMU 43 is a closed unlined sanitary landfill consisting of two adjacent approximately 1.5-acre cells located immediately adjacent to the New River in the northeast section of the MMA (**Figure 1-1**). SWMU 43 is a flat level area that is approximately 3.04 acres located at an approximate elevation of 1,700 ft msl. A drainage ditch located in the center of the SWMU divides the area into east and west sections. Based on geophysics and aerial photography, the landfill apparently extends east-west approximately 700 ft on either side of the drainage ditch. The north-south boundaries are the riverbank and paved roadway, respectively. The western section is mostly grassy but has a small concrete pad and a gravel parking area, which are currently used to store office and equipment trailers. Former descriptions of the site noted a pile of soil located adjacent to the roadway at the western end of the site that is no longer present. The eastern section is covered entirely with grass. Elongated depressions, which corresponded to the disposal trenches, were filled in and the site was regarded in accordance with the 1992 VI recommendation for the site. The former trench-fill operation reportedly received at least 300 tons of paper and refuse over its active life. Sanitary landfill material, consisting of paper, rubber, and plastic debris down to 18 ft bgs, was encountered when monitoring well borings were advanced along the fence to the north during the 1992 VI. These same materials were encountered during the advancement of soil borings in both cells during the 2007 RFI. It was reported by RFAAP personnel that this landfill was operated from about 1967 through the early 1970s. A previous report (USATHAMA, 1976) described a sanitary landfill in the same location as having operated from 1958 to 1969.

Surface soil, surface water, and groundwater samples collected from the site and utilized in the SLERA are listed in **Table 7-5**; note that subsurface soil samples were not used in the SLERA (see *Section 7.1.2.1* for discussion).

Table 7-5
SWMU 43 Sample Groupings

Surface Soil	Surface Water	Groundwater (On Site)	Upgradient Groundwater (Off Site)
43SB01A	43SP1 (RDWB*7)	43MW3	43MW1
43SB02A	43SP2 (RDWB*10)	43MW4	43MW2
43SB03A		43MW5	
43SB04A		43MW6	
43SB05A			
43SB06A			
43SB07A			
43SB08A			
43SB09A			
43SB10A			

7.2.2 Summary of COPEC Selection

Tables 7-6 and 7-7 (surface soil) and **Tables 7-8 and 7-9** (surface water) have been prepared for detected constituents 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.

COPECs were selected as shown in **Tables 7-6 through 7-9**. In general, COPECs were selected as a concern for the direct contact exposure pathway if the constituent was detected in an environmental medium (**Tables 7-6 and 7-8**). For food chain exposure pathways, detected COPECs were selected if they were important bioaccumulative constituents (USEPA, 2000c) or explosive compounds (**Tables 7-7 and 7-9**).

Thirty-four (34) COPECs (14 organic and 20 inorganic COPECs) have been selected for surface soil direct contact exposure (**Table 7-6**).

Twenty (20) COPECs (11 organic and 9 inorganic COPECs) have been selected for surface soil food chain exposure (**Table 7-7**).

Eleven (11) COPECs (1 organic and 10 inorganic COPECs) have been selected for surface water direct contact exposure (**Table 7-8**).

One COPEC (organic) has been selected for surface water food chain exposure (**Table 7-9**).

EPCs based on the statistical procedures discussed in *HHRA Section 6.2.3* are presented in **Tables 7-10** (surface soil) and **7-11** (surface water). Arithmetic mean concentrations are presented for informational purposes.

Groundwater COPECs are discussed in *Section 7.2.6*.

7.2.3 Risk Characterization

This section presents the SLERA risk characterization results, following the detailed methods and procedures presented in *Section 7.1.7*.

7.2.3.1 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 and review of the site photographs was performed and no obvious signs of vegetative stress were noted. The overall health of the grassland/field communities at the site was comparable to those of the surrounding area. As allowed in the *RFAAP Final MWP* (URS, 2003), that states “owing to the invasive and

Table 7-6
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at SWMU 43
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Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
	NA	2,3,7,8-TCDD-TE	2.20E-06	6.40E-06	mg/kg	43SB03A	2/2	N/A	Yes	DET
Surface Soil	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.48E-05	2.48E-05	mg/kg	43SB03A	1/2	5.19E-07 - 5.19E-07	No	TEQ
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	4.28E-05 J	1.62E-04	mg/kg	43SB03A	2/2	N/A	No	TEQ
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	5.02E-07 J	1.94E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	9.34E-07 B	1.26E-06 B	mg/kg	43SB03A	2/2	N/A	No	TEQ
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	5.21E-07 J	1.51E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	4.17E-07 B	6.00E-07 B	mg/kg	43SB03A	2/2	N/A	No	TEQ
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1.78E-06 J	4.82E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	4.12E-07 J	4.12E-07 J	mg/kg	43SB03A	1/2	5.19E-07 - 5.19E-07	No	TEQ
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.25E-06 J	3.77E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	1.78E-07 J	2.39E-07 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	3.20E-07 J	9.46E-07 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	5.62E-07 J	8.63E-07 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	3.69E-07 J	3.72E-07	mg/kg	43SB03A	2/2	N/A	No	TEQ
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	2.63E-07 J	2.63E-07 J	mg/kg	43SB03A	1/2	1.80E-07 - 1.80E-07	No	TEQ
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	4.15E-07 J	4.23E-07 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Heptachlorodibenzofuran	2.55E-05	9.89E-05 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Heptachlorodibenzo-p-dioxin	9.13E-05	3.52E-04	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Hexachlorodibenzofuran	8.52E-06	1.97E-05 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Hexachlorodibenzo-p-dioxin	8.90E-06	3.20E-05 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Pentachlorodibenzofuran	1.20E-06	2.66E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Pentachlorodibenzo-p-dioxin	1.05E-06	9.21E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Tetrachlorodibenzofuran	8.53E-07	1.71E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Tetrachlorodibenzo-p-dioxin	2.37E-07	3.48E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	3268-87-9	Octachlorodibenzodioxin	7.64E-04 J	4.42E-03 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	39001-02-0	Octachlorodibenzofuran	2.11E-05 B	7.97E-05	mg/kg	43SB03A	2/2	N/A	No	TEQ
	67-64-1	Acetone	2.91E-02 J	4.05E-02 J	mg/kg	43SB01A	2/10	4.80E-02 - 7.20E-02	Yes	DET
	11097-69-1	Aroclor 1254	9.40E-03 J	7.12E-02	mg/kg	43SB07A	2/10	1.70E-02 - 1.90E-02	Yes	DET
	56-55-3	Benzo(a)anthracene	1.79E-02 J	8.88E-02	mg/kg	43SB09A	3/10	5.50E-02 - 6.20E-02	Yes	DET
	50-32-8	Benzo(a)pyrene	1.89E-02 J	1.40E-01	mg/kg	43SB09A	3/10	5.50E-02 - 6.20E-02	Yes	DET
	205-99-2	Benzo(b)fluoranthene	1.71E-02 J	8.01E-02	mg/kg	43SB09A	3/10	5.50E-02 - 6.20E-02	Yes	DET
	191-24-2	Benzo(g,h,i)perylene	2.06E-02 J	6.55E-02	mg/kg	43SB09A	2/10	5.50E-02 - 6.20E-02	Yes	DET
	207-08-9	Benzo(k)fluoranthene	2.19E-02 J	9.35E-02	mg/kg	43SB09A	2/10	5.50E-02 - 6.20E-02	Yes	DET
	75-15-0	Carbon disulfide	2.10E-03 J	2.10E-03 J	mg/kg	43SB01A	1/10	4.60E-03 - 7.20E-03	Yes	DET
	218-01-9	Chrysene	1.69E-02 J	8.18E-02	mg/kg	43SB09A	3/10	5.50E-02 - 6.20E-02	Yes	DET

Table 7-6
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at SWMU 43
Page 2 of 2

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

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
	1918-00-9	Dicamba	6.70E-03 J	6.70E-03 J	mg/kg	43SB01A	1/10	6.90E-03 - 7.60E-03	Yes	DET
	206-44-0	Fluoranthene	6.94E-02 J	6.94E-02 J	mg/kg	43SB09A	1/10	2.70E-01 - 3.10E-01	Yes	DET
	193-39-5	Indeno(1,2,3-cd)pyrene	1.84E-02 J	7.28E-02	mg/kg	43SB09A	2/10	5.50E-02 - 6.20E-02	Yes	DET
	129-00-0	Pyrene	1.18E-01 J	1.18E-01 J	mg/kg	43SB09A	1/10	2.70E-01 - 3.10E-01	Yes	DET
	7429-90-5	Aluminum	8.69E+03 J	1.56E+04 J	mg/kg	43SB06A	10/10	N/A	Yes	DET
	7440-38-2	Arsenic	1.20E+00 L	1.77E+01 J	mg/kg	43SB07A	10/10	N/A	Yes	DET
	7440-39-3	Barium	9.89E+01 J	1.99E+02 J	mg/kg	43SB09A	10/10	N/A	Yes	DET
	7440-41-7	Beryllium	7.50E-01	1.30E+00	mg/kg	43SB06A	10/10	N/A	Yes	DET
	7440-43-9	Cadmium	9.30E-01 L	9.30E-01 L	mg/kg	43SB08A	1/10	5.40E-02 - 5.50E-01	Yes	DET
	7440-70-2	Calcium	1.06E+03 J	1.59E+04 J	mg/kg	43SB08A	10/10	N/A	Yes	DET
	7440-47-3	Chromium	1.44E+01 J	2.43E+01 J	mg/kg	43SB06A	10/10	N/A	Yes	DET
	7440-48-4	Cobalt	6.60E+00 J	1.26E+01 J	mg/kg	43SB09A	10/10	N/A	Yes	DET
	7440-50-8	Copper	9.20E+00 J	1.68E+01 J	mg/kg	43SB07A	10/10	N/A	Yes	DET
	7439-89-6	Iron	1.26E+04 J	2.01E+04 J	mg/kg	43SB09A	10/10	N/A	Yes	DET
	7439-92-1	Lead	7.00E+00 J	3.62E+01 J	mg/kg	43SB01A	10/10	N/A	Yes	DET
	7439-95-4	Magnesium	2.13E+03 J	8.18E+03 J	mg/kg	43SB08A	10/10	N/A	Yes	DET
	7439-96-5	Manganese	3.49E+02 J	1.71E+03 J	mg/kg	43SB09A	10/10	N/A	Yes	DET
	7439-97-6	Mercury	3.50E-02 J	3.10E-01	mg/kg	43SB07A	10/10	N/A	Yes	DET
	7440-02-0	Nickel	9.10E+00 J	1.36E+01 J	mg/kg	43SB10A	10/10	N/A	Yes	DET
	7440-09-7	Potassium	8.56E+02 J	1.44E+03 J	mg/kg	43SB10A	7/7	N/A	Yes	DET
	7782-49-2	Selenium	3.10E-01 L	5.80E+00 J	mg/kg	43SB05A	8/10	1.10E-01 - 1.20E-01	Yes	DET
	7440-23-5	Sodium	3.13E+02 J	5.23E+02 J	mg/kg	43SB10A	5/9	2.60E+01 - 2.80E+01	Yes	DET
	7440-62-2	Vanadium	2.04E+01 J	4.24E+01 J	mg/kg	43SB06A	10/10	N/A	Yes	DET
	7440-66-6	Zinc	4.87E+01 J	1.05E+02 J	mg/kg	43SB01A	10/10	N/A	Yes	DET

COPEC Selection Rationale Codes

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

Notes/Definitions:

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

Table 7-7
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at SWMU 43
Page 1 of 2

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

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
Surface Soil	NA	2,3,7,8-TCDD-TE	2.20E-06	6.40E-06	mg/kg	43SB03A	2/2	N/A	Yes	IBC
	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.48E-05	2.48E-05	mg/kg	43SB03A	1/2	5.19E-07 - 5.19E-07	No	TEQ
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	4.28E-05 J	1.62E-04	mg/kg	43SB03A	2/2	N/A	No	TEQ
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	5.02E-07 J	1.94E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	9.34E-07 B	1.26E-06 B	mg/kg	43SB03A	2/2	N/A	No	TEQ
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	5.21E-07 J	1.51E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	4.17E-07 B	6.00E-07 B	mg/kg	43SB03A	2/2	N/A	No	TEQ
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1.78E-06 J	4.82E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	4.12E-07 J	4.12E-07 J	mg/kg	43SB03A	1/2	5.19E-07 - 5.19E-07	No	TEQ
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.25E-06 J	3.77E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	1.78E-07 J	2.39E-07 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	3.20E-07 J	9.46E-07 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	5.62E-07 J	8.63E-07 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	3.69E-07 J	3.72E-07	mg/kg	43SB03A	2/2	N/A	No	TEQ
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	2.63E-07 J	2.63E-07 J	mg/kg	43SB03A	1/2	1.80E-07 - 1.80E-07	No	TEQ
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	4.15E-07 J	4.23E-07 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Heptachlorodibenzofuran	2.55E-05	9.89E-05 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Heptachlorodibenzo-p-dioxin	9.13E-05	3.52E-04	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Hexachlorodibenzofuran	8.52E-06	1.97E-05 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Hexachlorodibenzo-p-dioxin	8.90E-06	3.20E-05 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Pentachlorodibenzofuran	1.20E-06	2.66E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Pentachlorodibenzo-p-dioxin	1.05E-06	9.21E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Tetrachlorodibenzofuran	8.53E-07	1.71E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	NA	Total Tetrachlorodibenzo-p-dioxin	2.37E-07	3.48E-06 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	3268-87-9	Octachlorodibenzodioxin	7.64E-04 J	4.42E-03 J	mg/kg	43SB03A	2/2	N/A	No	TEQ
	39001-02-0	Octachlorodibenzofuran	2.11E-05 B	7.97E-05	mg/kg	43SB03A	2/2	N/A	No	TEQ
	67-64-1	Acetone	2.91E-02 J	4.05E-02 J	mg/kg	43SB01A	2/10	4.80E-02 - 7.20E-02	No	NIBC
	11097-69-1	Aroclor 1254	9.40E-03 J	7.12E-02	mg/kg	43SB07A	2/10	1.70E-02 - 1.90E-02	Yes	IBC
	56-55-3	Benzo(a)anthracene	1.79E-02 J	8.88E-02	mg/kg	43SB09A	3/10	5.50E-02 - 6.20E-02	Yes	IBC
	50-32-8	Benzo(a)pyrene	1.89E-02 J	1.40E-01	mg/kg	43SB09A	3/10	5.50E-02 - 6.20E-02	Yes	IBC
	205-99-2	Benzo(b)fluoranthene	1.71E-02 J	8.01E-02	mg/kg	43SB09A	3/10	5.50E-02 - 6.20E-02	Yes	IBC
	191-24-2	Benzo(g,h,i)perylene	2.06E-02 J	6.55E-02	mg/kg	43SB09A	2/10	5.50E-02 - 6.20E-02	Yes	IBC
	207-08-9	Benzo(k)fluoranthene	2.19E-02 J	9.35E-02	mg/kg	43SB09A	2/10	5.50E-02 - 6.20E-02	Yes	IBC
	75-15-0	Carbon disulfide	2.10E-03 J	2.10E-03 J	mg/kg	43SB01A	1/10	4.60E-03 - 7.20E-03	No	NIBC
	218-01-9	Chrysene	1.69E-02 J	8.18E-02	mg/kg	43SB09A	3/10	5.50E-02 - 6.20E-02	Yes	IBC
	1918-00-9	Dicamba	6.70E-03 J	6.70E-03 J	mg/kg	43SB01A	1/10	6.90E-03 - 7.60E-03	No	NIBC

Table 7-7
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at SWMU 43
Page 2 of 2

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

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
	206-44-0	Fluoranthene	6.94E-02 J	6.94E-02 J	mg/kg	43SB09A	1/10	2.70E-01 - 3.10E-01	Yes	IBC
	193-39-5	Indeno(1,2,3-cd)pyrene	1.84E-02 J	7.28E-02	mg/kg	43SB09A	2/10	5.50E-02 - 6.20E-02	Yes	IBC
	129-00-0	Pyrene	1.18E-01 J	1.18E-01 J	mg/kg	43SB09A	1/10	2.70E-01 - 3.10E-01	Yes	IBC
	7429-90-5	Aluminum	8.69E+03 J	1.56E+04 J	mg/kg	43SB06A	10/10	N/A	No	NIBC
	7440-38-2	Arsenic	1.20E+00 L	1.77E+01 J	mg/kg	43SB07A	10/10	N/A	Yes	IBC
	7440-39-3	Barium	9.89E+01 J	1.99E+02 J	mg/kg	43SB09A	10/10	N/A	No	NIBC
	7440-41-7	Beryllium	7.50E-01	1.30E+00	mg/kg	43SB06A	10/10	N/A	No	NIBC
	7440-43-9	Cadmium	9.30E-01 L	9.30E-01 L	mg/kg	43SB08A	1/10	5.40E-02 - 5.50E-01	Yes	IBC
	7440-70-2	Calcium	1.06E+03 J	1.59E+04 J	mg/kg	43SB08A	10/10	N/A	No	NIBC
	7440-47-3	Chromium	1.44E+01 J	2.43E+01 J	mg/kg	43SB06A	10/10	N/A	Yes	IBC
	7440-48-4	Cobalt	6.60E+00 J	1.26E+01 J	mg/kg	43SB09A	10/10	N/A	No	NIBC
	7440-50-8	Copper	9.20E+00 J	1.68E+01 J	mg/kg	43SB07A	10/10	N/A	Yes	IBC
	7439-89-6	Iron	1.26E+04 J	2.01E+04 J	mg/kg	43SB09A	10/10	N/A	No	NIBC
	7439-92-1	Lead	7.00E+00 J	3.62E+01 J	mg/kg	43SB01A	10/10	N/A	Yes	IBC
	7439-95-4	Magnesium	2.13E+03 J	8.18E+03 J	mg/kg	43SB08A	10/10	N/A	No	NIBC
	7439-96-5	Manganese	3.49E+02 J	1.71E+03 J	mg/kg	43SB09A	10/10	N/A	No	NIBC
	7439-97-6	Mercury	3.50E-02 J	3.10E-01	mg/kg	43SB07A	10/10	N/A	Yes	IBC
	7440-02-0	Nickel	9.10E+00 J	1.36E+01 J	mg/kg	43SB10A	10/10	N/A	Yes	IBC
	7440-09-7	Potassium	8.56E+02 J	1.44E+03 J	mg/kg	43SB10A	7/7	N/A	No	NIBC
	7782-49-2	Selenium	3.10E-01 L	5.80E+00 J	mg/kg	43SB05A	8/10	1.10E-01 - 1.20E-01	Yes	IBC
	7440-23-5	Sodium	3.13E+02 J	5.23E+02 J	mg/kg	43SB10A	5/9	2.60E+01 - 2.80E+01	No	NIBC
	7440-62-2	Vanadium	2.04E+01 J	4.24E+01 J	mg/kg	43SB06A	10/10	N/A	No	NIBC
	7440-66-6	Zinc	4.87E+01 J	1.05E+02 J	mg/kg	43SB01A	10/10	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]
Explosives (EXP)
Deletion Reason: Not Important Bioaccumulative Compound (NIBC)
Dioxins and furans will be analyzed by the toxicity equivalent provided by the TCDD-TE (TEQ)

Notes/Definitions

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

Table 7-8
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Water Direct Contact Exposure at SWMU 43

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

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 Water	75-15-0	Carbon disulfide	3.30E-03	3.30E-03	mg/l	43SP1 (RDWB*7)	1/2	5.00E-04 - 5.00E-04	Yes	DET
	7429-90-5	Aluminum	4.03E-01	4.03E-01	mg/l	43SP1 (RDWB*7)	1/2	1.41E-01 - 1.41E-01	Yes	DET
	7440-38-2	Arsenic	3.94E-03	1.52E-02	mg/l	43SP1 (RDWB*7)	2/2	N/A	Yes	DET
	7440-39-3	Barium	8.40E-02	1.94E-01	mg/l	43SP1 (RDWB*7)	2/2	N/A	Yes	DET
	7440-70-2	Calcium	7.23E+01	9.20E+01	mg/l	43SP1 (RDWB*7)	2/2	N/A	Yes	DET
	7439-89-6	Iron	1.73E+00	3.23E+01	mg/l	43SP1 (RDWB*7)	2/2	N/A	Yes	DET
	7439-95-4	Magnesium	2.83E+01	4.11E+01	mg/l	43SP1 (RDWB*7)	2/2	N/A	Yes	DET
	7439-96-5	Manganese	9.81E-02	1.30E+00	mg/l	43SP1 (RDWB*7)	2/2	N/A	Yes	DET
	7440-09-7	Potassium	8.56E-01	1.51E+00	mg/l	43SP2 (RDWB*10)	2/2	N/A	Yes	DET
	7440-23-5	Sodium	9.17E+00	2.08E+01	mg/l	43SP1 (RDWB*7)	2/2	N/A	Yes	DET
	7440-62-2	Vanadium	1.32E-02	1.32E-02	mg/l	43SP1 (RDWB*7)	1/2	1.10E-02 - 1.10E-02	Yes	DET

COPEC Selection Rationale Codes

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

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

Table 7-9
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Water Food Chain Exposure at SWMU 43

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

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 Water	75-15-0	Carbon disulfide	3.30E-03	3.30E-03	mg/l	43SP1 (RDWB*7)	1/2	5.00E-04 - 5.00E-04	No	NIBC
	7429-90-5	Aluminum	4.03E-01	4.03E-01	mg/l	43SP1 (RDWB*7)	1/2	1.41E-01 - 1.41E-01	No	NIBC
	7440-38-2	Arsenic	3.94E-03	1.52E-02	mg/l	43SP1 (RDWB*7)	2/2	N/A	Yes	IBC
	7440-39-3	Barium	8.40E-02	1.94E-01	mg/l	43SP1 (RDWB*7)	2/2	N/A	No	NIBC
	7440-70-2	Calcium	7.23E+01	9.20E+01	mg/l	43SP1 (RDWB*7)	2/2	N/A	No	NIBC
	7439-89-6	Iron	1.73E+00	3.23E+01	mg/l	43SP1 (RDWB*7)	2/2	N/A	No	NIBC
	7439-95-4	Magnesium	2.83E+01	4.11E+01	mg/l	43SP1 (RDWB*7)	2/2	N/A	No	NIBC
	7439-96-5	Manganese	9.81E-02	1.30E+00	mg/l	43SP1 (RDWB*7)	2/2	N/A	No	NIBC
	7440-09-7	Potassium	8.56E-01	1.51E+00	mg/l	43SP2 (RDWB*10)	2/2	N/A	No	NIBC
	7440-23-5	Sodium	9.17E+00	2.08E+01	mg/l	43SP1 (RDWB*7)	2/2	N/A	No	NIBC
	7440-62-2	Vanadium	1.32E-02	1.32E-02	mg/l	43SP1 (RDWB*7)	1/2	1.10E-02 - 1.10E-02	No	NIBC

COPEC Selection Rationale Codes

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

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

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

Table 7-10
Medium-Specific Exposure Point Concentration Summary for SWMU 43 Surface Soil
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Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No)[1]	95% UCL (Distribution)[2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic[3]	Rationale[4]
Surface Soil	2,3,7,8-TCDD-TE	mg/kg	4.30E-06	N/A	N/A	6.40E-06	6.40E-06	mg/kg	Max	Test (7)
	Acetone[5]	mg/kg	3.48E-02	N/A	4.01E-02 (NP)	4.05E-02	4.01E-02	mg/kg	95% UCL-Bst	Test (8)
	Aroclor 1254[5]	mg/kg	4.03E-02	N/A	2.18E-02 (NP)	7.12E-02	2.18E-02	mg/kg	95% UCL-Bst	Test (8)
	Benzo(a)anthracene	mg/kg	4.33E-02	Yes	4.24E-02 (N)	8.88E-02	4.24E-02	mg/kg	95% KM-t	Test (1)
	Benzo(a)pyrene	mg/kg	6.34E-02	Yes	6.27E-02 (N)	1.40E-01	6.27E-02	mg/kg	95% KM-t	Test (1)
	Benzo(b)fluoranthene	mg/kg	4.24E-02	Yes	8.01E-02 (N)	8.01E-02	8.01E-02	mg/kg	95% KM-% Btstrp	Test (1)
	Benzo(g,h,i)perylene[5]	mg/kg	4.31E-02	N/A	4.09E-02 (NP)	6.55E-02	4.09E-02	mg/kg	95% UCL-Bst	Test (8)
	Benzo(k)fluoranthene[5]	mg/kg	5.77E-02	N/A	4.44E-02 (NP)	9.35E-02	4.44E-02	mg/kg	95% UCL-Bst	Test (8)
	Carbon disulfide[5]	mg/kg	2.10E-03	N/A	3.82E-03 (NP)	2.10E-03	2.10E-03	mg/kg	Max	Test (2)
	Chrysene	mg/kg	4.28E-02	Yes	4.46E-02 (N)	8.18E-02	4.46E-02	mg/kg	95% KM-t	Test (1)
	Dicamba[5]	mg/kg	6.70E-03	N/A	4.92E-03 (NP)	6.70E-03	4.92E-03	mg/kg	95% UCL-Bst	Test (8)
	Fluoranthene[5]	mg/kg	6.94E-02	N/A	1.88E-01 (NP)	6.94E-02	6.94E-02	mg/kg	Max	Test (2)
	Indeno(1,2,3-cd)pyrene[5]	mg/kg	4.56E-02	N/A	4.10E-02 (NP)	7.28E-02	4.10E-02	mg/kg	95% UCL-Bst	Test (8)
	Pyrene[5]	mg/kg	1.18E-01	N/A	1.91E-01 (NP)	1.18E-01	1.18E-01	mg/kg	Max	Test (2)
	Aluminum	mg/kg	1.20E+04	No	1.32E+04 (N)	1.56E+04	1.32E+04	mg/kg	95% Student's-t	Test (4)
	Arsenic	mg/kg	3.79E+00	No	1.06E+01 (NP)	1.77E+01	1.06E+01	mg/kg	95% Cheby, Mean, Sd	Test (3)
	Barium	mg/kg	1.38E+02	No	1.59E+02 (N)	1.99E+02	1.59E+02	mg/kg	95% Student's-t	Test (4)
	Beryllium	mg/kg	9.55E-01	No	1.07E+00 (N)	1.30E+00	1.07E+00	mg/kg	95% Student's-t	Test (4)
	Cadmium[5]	mg/kg	9.30E-01	N/A	3.53E-01 (NP)	9.30E-01	3.53E-01	mg/kg	95% UCL-Bst	Test (8)
	Calcium	mg/kg	3.20E+03	No	9.42E+03 (NP)	1.59E+04	9.42E+03	mg/kg	95% Cheby, Mean, Sd	Test (3)
	Chromium	mg/kg	1.91E+01	No	2.09E+01 (N)	2.43E+01	2.09E+01	mg/kg	95% Student's-t	Test (4)
	Cobalt	mg/kg	9.61E+00	No	1.06E+01 (N)	1.26E+01	1.06E+01	mg/kg	95% Student's-t	Test (4)
	Copper	mg/kg	1.18E+01	No	1.31E+01 (N)	1.68E+01	1.31E+01	mg/kg	95% Student's-t	Test (4)
	Iron	mg/kg	1.78E+04	No	1.93E+04 (NP)	2.01E+04	1.93E+04	mg/kg	95% Student's-t	Test (3)
	Lead	mg/kg	1.47E+01	No	1.98E+01 (G)	3.62E+01	1.98E+01	mg/kg	95% Approx. Gamma	Test (6)
	Magnesium	mg/kg	3.31E+03	No	4.42E+03 (NP)	8.18E+03	4.42E+03	mg/kg	95% Modified-t	Test (3)
	Manganese	mg/kg	6.54E+02	No	8.96E+02 (L)	1.71E+03	8.96E+02	mg/kg	95% Modified-t	Test (5)
	Mercury	mg/kg	9.16E-02	No	2.17E-01 (NP)	3.10E-01	2.17E-01	mg/kg	95% Cheby, Mean, Sd	Test (3)

Table 7-10
Medium-Specific Exposure Point Concentration Summary for SWMU 43 Surface Soil
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Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No) [1]	95% UCL (Distribution) [2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale [4]
	Nickel	mg/kg	1.11E+01	No	1.19E+01 (N)	1.36E+01	1.19E+01	mg/kg	95% Student's-t	Test (4)
	Potassium	mg/kg	1.19E+03	No	1.35E+03 (N)	1.44E+03	1.35E+03	mg/kg	95% Student's-t	Test (4)
	Selenium	mg/kg	3.66E+00	Yes	8.17E+00 (NP)	5.80E+00	5.80E+00	mg/kg	Max	Test (2)
	Sodium	mg/kg	3.87E+02	Yes	4.07E+02 (N)	5.23E+02	4.07E+02	mg/kg	95% KM-% Btstrp	Test (1)
	Vanadium	mg/kg	3.20E+01	No	3.60E+01 (N)	4.24E+01	3.60E+01	mg/kg	95% Student's-t	Test (4)
	Zinc	mg/kg	7.12E+01	No	8.25E+01 (N)	1.05E+02	8.25E+01	mg/kg	95% Student's-t	Test (4)

Notes: N/A = Not applicable

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

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

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

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

Test (1): Kaplan-Meier method recommended by ProUCL due to multiple detection limits.
Test (2): The 95% UCL exceeds the 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.
Test (8): 95% UCL estimated by a non-Pro-UCL bootstrap method.

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

Table 7-11
Medium-Specific Exposure Point Concentration Summary for SWMU 43 Surface Water

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

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No) [1]	95% UCL (Distribution) [2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale [4]
Surface Water	Carbon disulfide	mg/l	3.30E-03	N/A	N/A	3.30E-03	3.30E-03	mg/l	Max	Test (7)
	Aluminum	mg/l	4.03E-01	N/A	N/A	4.03E-01	4.03E-01	mg/l	Max	Test (7)
	Arsenic	mg/l	9.57E-03	N/A	N/A	1.52E-02	1.52E-02	mg/l	Max	Test (7)
	Barium	mg/l	1.39E-01	N/A	N/A	1.94E-01	1.94E-01	mg/l	Max	Test (7)
	Calcium	mg/l	8.22E+01	N/A	N/A	9.20E+01	9.20E+01	mg/l	Max	Test (7)
	Iron	mg/l	1.70E+01	N/A	N/A	3.23E+01	3.23E+01	mg/l	Max	Test (7)
	Magnesium	mg/l	3.47E+01	N/A	N/A	4.11E+01	4.11E+01	mg/l	Max	Test (7)
	Manganese	mg/l	6.99E-01	N/A	N/A	1.30E+00	1.30E+00	mg/l	Max	Test (7)
	Potassium	mg/l	1.18E+00	N/A	N/A	1.51E+00	1.51E+00	mg/l	Max	Test (7)
	Sodium	mg/l	1.50E+01	N/A	N/A	2.08E+01	2.08E+01	mg/l	Max	Test (7)
	Vanadium	mg/l	1.32E-02	N/A	N/A	1.32E-02	1.32E-02	mg/l	Max	Test (7)

Notes: N/A = Not applicable

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

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

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

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

Test (1): Kaplan-Meier method recommended by ProUCL due to multiple detection limits.
Test (2): The 95% UCL exceeds the 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.
Test (8): 95% UCL estimated by a non-Pro-UCL bootstrap method.

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

successive nature of plant communities, plants as receptors do not typically warrant a detailed examination of effects," plants were not quantitatively evaluated in this SLERA. As there were no unique or site-specific terrestrial plant issues discovered at SWMU 43, a qualitative evaluation was deemed adequate. However, a terrestrial plant impact screening assessment is discussed in *Section 7.2.4*. It should also be noted that plants (and invertebrates) are included in the SLERAs as media through which the wildlife receptors may be exposed indirectly to COPECs in the soil by means of the food chain.

7.2.3.2 Predictive Risk Estimation for Terrestrial Wildlife

The potential wildlife risks associated with SWMU 43 are estimated in this section. 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. Whether or not HQ summation was appropriate and scientifically defensible is based on whether the chemicals 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 1 to 733 (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 43 are presented in risk characterization tables (**Appendix F-2, Tables F-2 through F-15**) for the seven selected receptor species. These summed EEQs are presented in **Table 7-12** (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 7-12**, Tier 1 total EEQs ranged from approximately 1.6 to 733 for the seven receptor species, using TRVs based on either NOAEL or LOAEL values. The short-tailed shrew was predicted to be the most impacted, followed by the mink, the American robin, the meadow vole, the red fox, the red-tailed hawk, and the great blue heron. The inorganic constituents arsenic, mercury, selenium, and zinc; and the organic constituent TCDD were the COPECs contributing the most to the total EEQs for each of the receptors. Exposure pathways of most concern, based on the results of the Tier 1 food chain modeling, were fish, plant, terrestrial invertebrate, and small mammal ingestion.

More realistic Tier 2 total EEQs were also elevated, especially values based on NOAEL TRVs, which ranged from 0.002 to 90. However, Tier 2 total EEQs were much lower than Tier 1 total EEQs, and both the NOAEL and LOAEL Tier 2 total EEQs for the red-tailed hawk, red fox, and great blue heron were below 1. For the mink, the Tier 2 total NOAEL-based EEQ was above 1, but below 1 for the Tier 2 total LOAEL-based EEQ. Tier 2 total EEQs based on LOAEL values were 23 for the short-tailed shrew, 12 for the American robin, and 11 for the meadow vole (**Table 7-12**).

The specific results of the Tier 2 risk estimation for the meadow vole, short-tailed shrew, American robin, and mink are discussed below. The specific results for the red-tailed hawk, red fox, and great blue heron are not discussed because the summed EEQs are below 1.

Meadow Vole. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (23 and 11, respectively). Two COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): selenium (15.9) and arsenic (4.5). Only selenium (10) had a LOAEL-based EEQ that exceeded 1 (EEQ in parenthesis) when rounded to one significant figure. The primary exposure pathway was the ingestion of plants. The results of the Tier 2 risk evaluation for meadow voles are presented in **Appendix F-2, Table F-3**.

Short-tailed Shrew. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (90 and 23, respectively). Six COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): TCDD (30.6), selenium (23.3), arsenic (22.3), cadmium (4.3), zinc (2.7), and lead (1.6). Three COPECs had individual LOAEL-based EEQs that exceeded 1 (EEQ in parenthesis) when rounded to one significant figure: selenium (14), TCDD (3), and arsenic (2). The primary exposure pathway was the ingestion of terrestrial invertebrates and soil. The results of the short-tailed shrew Tier 2 risk evaluation are presented in **Appendix F-2, Table F-5**.

American Robin. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (42 and 12, respectively). Seven COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): zinc (20.1), selenium (12.3), chromium (2.4), lead (2.2), cadmium (1.8), mercury (1.3), and TCDD (1.2). Three COPECs had individual LOAEL-based EEQs that exceeded 1 (EEQ in parenthesis) when rounded to one significant figure: selenium (6), chromium (2), and zinc (2). The primary exposure pathway was the ingestion of terrestrial invertebrates. The results of the Tier 2 risk evaluation for American robins are presented in **Appendix F-2, Table F-7**.

Mink. The total EEQs for NOAEL TRVs exceeded 1 (3). Only arsenic (2.4) had an individual NOAEL-based EEQ that exceeded 1 (EEQ in parenthesis). No COPECs had individual LOAEL-based EEQs that exceeded 1. The primary exposure pathway was the ingestion of fish. The results of the Tier 2 risk evaluation for mink are presented in **Appendix F-2, Table F-13**.

7.2.4 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-approved direct contact screening values, and secondarily, a variety of additional appropriate direct contact benchmarks. Surface soil, sediment, and surface water were the exposure media at SWMU 43. Intake is not calculated because potential adverse effects are assessed by evaluating the COPEC concentrations in the specific medium. Detailed procedures are presented in *Section 7.1.8* and the results are summarized in **Tables 7-13** (surface soil) and **7-14** (surface water).

Table 7-12
Wildlife EEQ Hazard Summary for Food Chain Exposure at SWMU 43

Receptor	Tier 1[a]		Tier 2[b]	
	NOAEL-Based EEQ	LOAEL-Based EEQ	NOAEL-Based EEQ	LOAEL-Based EEQ
Meadow vole	72	31	23	11
Hazard Driver(s)[c]:	Se - plant ingestion		Se - plant ingestion	
Short-tailed shrew	733	107	90	23
Hazard Driver(s)[c]:	TCDD - terrestrial invertebrate ingestion		TCDD, Se, and As - terrestrial invertebrate ingestion	
American robin	136	36	42	12
Hazard Driver(s)[c]:	Hg and Se - terrestrial invertebrate ingestion		Zn and Se - terrestrial invertebrate ingestion	
Red-tailed hawk	7.9	2.1	0.01	0.002
Hazard Driver(s)[c]:	Zn- small mammal ingestion		--	
Red fox	40	9.6	0.02	0.005
Hazard Driver(s)[c]:	TCDD and Se - small mammal ingestion		--	
Mink	327	45	3.0	0.5
Hazard Driver(s)[c]:	As - fish ingestion		--	
Great blue heron	4.7	1.6	0.2	0.1
Hazard Driver(s)[c]:	As - fish ingestion		--	

[a] Tier 1 = Max EEQ using max EPC, max BAF/BCF (unless regression equation is used), max Intake Rates, min BW, and FHR =1.

[b] Tier 2 = EEQ using 95% EPC, non-max BAF/BCF BCF (unless regression equation is used), avg Intake Rates, avg BW and calculated FHR less than or equal to 1.

[c] Hazard drivers are those chemicals contributing the most to the total estimated EEQ, and the primary route of exposure associated with this driver.

Notes:

EEQ = Ecological Effects Quotient.

LOAEL = Lowest-Observed-Adverse-Effect Level

NOAEL = No-Observed-Adverse-Effect Level

Table 7-13
Direct Toxicity Evaluation for Surface Soil at SWMU 43

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	Dutch Intervention Value (3)	CCME Value (4)	USEPA EcoSSL Direct Contact Value (5)	ORNL Screening Benchmark for Plants (6)	ORNL Screening Benchmark for Invertebrates (7)	COPEC Weight of Evidence Summary - Number of Direct Contact Benchmarks Exceeded Using MDC	Comment
2,3,7,8-TCDD-TE	2/2	6.40E-06	6.40E-06	2.20E-06	1.00E-02	No								
Acetone	2/10	4.05E-02	4.01E-02	2.91E-02	NVA	Yes		NVA	NVA	NVA	NVA	NVA	NVA	
Aroclor 1254	2/10	7.12E-02	2.18E-02	9.40E-03	1.00E-01	No								
Benzo(a)anthracene	3/10	8.88E-02	4.24E-02	1.79E-02	1.1E+00 (HMW)	No								
Benzo(a)pyrene	3/10	1.40E-01	6.27E-02	1.89E-02	1.1E+00 (HMW)	No								
Benzo(b)fluoranthene	3/10	8.01E-02	8.01E-02	1.71E-02	1.1E+00 (HMW)	No								
Benzo(g,h,i)perylene	2/10	6.55E-02	4.09E-02	2.06E-02	1.1E+00 (HMW)	No								
Benzo(k)fluoranthene	2/10	9.35E-02	4.44E-02	2.19E-02	1.1E+00 (HMW)	No								
Carbon disulfide	1/10	2.10E-03	2.10E-03	2.10E-03	NVA	Yes		NVA	NVA	NVA	NVA	NVA	NVA	
Chrysene	3/10	8.18E-02	4.46E-02	1.69E-02	1.1E+00 (HMW)	No								
Dicamba	1/10	6.70E-03	4.92E-03	6.70E-03	NVA	Yes		NVA	NVA	NVA	NVA	NVA	NVA	
Fluoranthene	1/10	6.94E-02	6.94E-02	6.94E-02	1.1E+00 (HMW)	No								
Indeno(1,2,3-cd)pyrene	2/10	7.28E-02	4.10E-02	1.84E-02	1.1E+00 (HMW)	No								
Pyrene	1/10	1.18E-01	1.18E-01	1.18E-01	1.1E+00 (HMW)	No								
Aluminum	10/10	1.56E+04	1.32E+04	8.69E+03	---	No	pH > 5.5	NVA	NVA	NVA	---	NVA	---	pH = 7.87
Arsenic	10/10	1.77E+01	1.06E+01	1.20E+00	1.80E+01	No								
Barium	10/10	1.99E+02	1.59E+02	9.89E+01	3.30E+02	No								
Beryllium	10/10	1.30E+00	1.07E+00	7.50E-01	2.10E+01	No								
Cadmium	1/10	9.30E-01	3.53E-01	9.30E-01	**3.60E-01**	Yes		12	1.4	32	4	20	0/5	No exceedences
Calcium	10/10	1.59E+04	9.42E+03	1.06E+03	NVA	Yes		NVA	NVA	NVA	NVA	NVA	NVA	
Chromium (Cr III tox)	10/10	2.43E+01	2.09E+01	1.44E+01	2.60E+01	No								
Chromium (Cr VI tox)	10/10	2.43E+01	2.09E+01	1.44E+01	1.30E+02	No								
Cobalt	10/10	1.26E+01	1.06E+01	6.60E+00	1.30E+01	No								
Copper	10/10	1.68E+01	1.31E+01	9.20E+00	2.80E+01	No								
Iron	10/10	2.01E+04	1.93E+04	1.26E+04	5 ≤ pH ≤ 8	No								
Lead	10/10	3.62E+01	1.98E+01	7.00E+00	**1.10E+01**	Yes	Bird tox	530	70	120	50	500	0/5	No exceedences
Magnesium	10/10	8.18E+03	4.42E+03	2.13E+03	**4.40E+03**	Yes	No reference	NVA	NVA	NVA	NVA	NVA	NVA	
Manganese	10/10	1.71E+03	8.96E+02	3.49E+02	**2.20E+02**	Yes	Plant tox	NVA	NVA	**220**	**500**	NVA	2/2	Plant tox
Mercury	10/10	3.10E-01	2.17E-01	3.50E-02	**5.80E-02**	Yes	No reference	10	6.6	NVA	**0.3**	**0.1**	2/4	
Nickel	10/10	1.36E+01	1.19E+01	9.10E+00	3.80E+01	No								
Potassium	7/7	1.44E+03	1.35E+03	8.56E+02	NVA	Yes		NVA	NVA	NVA	NVA	NVA	NVA	
Selenium	8/10	5.80E+00	5.80E+00	3.10E-01	**5.20E-01**	Yes	Plant tox	NVA	**1**	**0.52**	**1**	70	3/4	Plant tox
Sodium	5/9	5.23E+02	4.07E+02	3.13E+02	NVA	Yes		NVA	NVA	NVA	NVA	NVA	NVA	
Vanadium	10/10	4.24E+01	3.60E+01	2.04E+01	**7.80E+00**	Yes	Bird tox	NVA	130	NVA	**2**	NVA	1/2	EcoSSL says data insufficient to derive direct contact SSL
Zinc	10/10	1.05E+02	8.25E+01	4.87E+01	**4.60E+01**	Yes	Plant tox (OHMTADS)	720	200	120	**50**	200	1/5	Plant tox

All values presented in mg/kg.

BOLD Text = MDC exceeds screening concentration.

NVA = No Value Available

LMW = Low Molecular Weight PAH

HMW = High Molecular Weight PAH

Surface soil pH of 7.87 is geometric mean of five samples collected at Area P (pH not measured at SWMU 43).

(1) COPECs from Table 7-6.

(2) Screening toxicity values from BTAG (1995) or EcoSSL (USEPA, 2007). EcoSSLs given highest priority as they are more definitive.

(3) Dutch Intervention Values are from the Netherlands Ministry of Housing, Spacial Planning and Environment (February 2000).

(4) Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines, December 2003.

(5) Lowest EcoSSL value for direct contact toxicity for either plants or terrestrial invertebrates (USEPA, 2007).

(6) Screening benchmarks for plants from ORNL (1997, ES/ER/TM-85/R3).

(7) Screening benchmarks for earthworms from ORNL (1997, ES/ER/TM-126/R2).

(8) EcoSSL (USEPA, 2007) for LMW PAHs and HMW PAHs.

LMW and HMW PAHs based on the number of ring structures (less than 4 rings = LMW; 4 or more rings = HWM).

Table 7-14
Surface Water Direct Contact Assessment for Aquatic Life at SWMU 43

COPEC	MDC (ug/L)	EPC (ug/L)	USEPA Region 3 BTAG (ug/L)[A]	NAWQC (ug/L)[B]		Virginia Criteria (ug/L)[C]		Tier II Secondary Values (ug/L)[D]		Lowest Chronic Values (ug/L)[D]				USEPA Region 4 Benchmark Screening Values (ug/L)[E]	Weight of Evidence Exceedence	
				Acute	Chronic	Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non-Daphnids	Aquatic Plants		Using MDC	Using EPC
Carbon disulfide	3.30E+00	3.30E+00	**0.92**	---	---	---	---	17	**0.92**	9538	244	---	---	84	2 / 6	2 / 6
Aluminum	4.03E+02	4.03E+02	**87**	750	**87**	---	---	---	---	3288	1900	---	460	**87**	3 / 7	3 / 7
Arsenic	1.52E+01	1.52E+01	**5**	340	150	340	150	---	---	2962	914.1	---	2320	190	1 / 9	1 / 9
Barium	1.94E+02	1.94E+02	**4**	---	---	---	---	**110**	**4**	---	---	---	---	**3.9**	4 / 4	4 / 4
Calcium	9.20E+04	9.20E+04	116000	---	---	---	---	---	---	---	116000	---	---	116000	0 / 3	0 / 3
Iron	3.23E+04	3.23E+04	**300**	---	**1000**	---	---	---	---	**1300**	**158**	---	---	**1000**	5 / 5	5 / 5
Magnesium	4.11E+04	4.11E+04	82000	---	---	---	---	---	---	---	82000	---	---	82000	0 / 3	0 / 3
Manganese	1.30E+03	1.30E+03	**120**	---	---	---	---	2300	**120**	1780	<1,100	---	---	**80**	3 / 6	3 / 6
Potassium	1.51E+03	1.51E+03	53000	---	---	---	---	---	---	---	53000	---	---	53000	0 / 3	0 / 3
Sodium	2.08E+04	2.08E+04	680000	---	---	---	---	---	---	---	680000	---	---	680000	0 / 3	0 / 3
Vanadium	1.32E+01	1.32E+01	20	---	---	---	---	280	20	80	1900	---	---	19	0 / 6	0 / 6

BOLD/Shaded Text = MDC exceedance of the NAWQC and/or Virginia WQS.

BOLD Text = MDC exceeds screening concentration.

--- No Value Available

COPEC = Chemical of potential ecological concern

EPC = Exposure Point Concentration. The 95% UCL was selected as the EPC unless it exceeded the maximum detected concentration, in which case the MDC was chosen as the EPC

MDC = Maximum detected concentration

NAWQC = National Ambient Water Qualtiy Criteria

95% UCL = 95% upper confidence limit concentration

[A] Values from USEPA Region 3 BTAG Screening Levels (July 2006). Values are for freshwater.

[B] Unless otherwise noted, values from USEPA (2006) - 4304T. National Recommended Water Quality Criteria.

[C] Values from Virginia Water Quality Standards, 9 VAC 25-260, October 2008.

[D] Unless otherwise noted, values from Suter, G.W., and Tsao, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision, ES/ER/TM-96/R2.

[E] Values from USEPA Region 4 Ecological Benchmark Screening Values for Surface Water (2000).

7.2.4.1 Surface Soil

Based on the results of the first step, eight COPECs were selected based on an EcoSSL or BTAG exceedance while six additional chemicals were evaluated further because of the lack of available EcoSSL or BTAG screening values (**Table 7-13**). In the second step, the MDC of these 14 chemicals was compared with up to five individual soil screening values. The results of the second screening step are as follows:

There were no available benchmarks available for acetone, carbon disulfide, dicamba, calcium, potassium, or sodium.

- Aluminum was not considered for the direct contact evaluation since the soil pH was estimated to be above 5.5. Therefore, further action is not required for aluminum at SWMU 43.
- The manganese MDC exceeded the two available benchmarks. The EcoSSL and ORNL exceedances were for plant toxicity, and as discussed in *Section 7.2.3.1*, 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 43.
- The mercury MDC exceeded two of the four available benchmarks for direct contact for mercury. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 43.
- The selenium MDC exceeded three of the four available benchmarks for direct contact for selenium. However, two of the exceeded benchmarks were for plants; therefore, there is potential for direct contact toxicity for selenium at SWMU 43. This may or may not result in the reduction of terrestrial invertebrates as a food source at SWMU 43, as the EcoSSL invertebrate toxicity benchmark of 4.1 mg/kg was exceeded.
- The vanadium MDC exceeded one (for plant toxicity) of the two available benchmarks, however, the EcoSSL guidance (USEPA, 2008c) indicates 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 43.
- The zinc MDC exceeded one of the five available benchmarks for direct contact for zinc. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 43.
- None of the other COPECs selected in the first screening step had any benchmark exceedance.

These results suggest that direct contact toxicity for COPECs in soil may be a concern for selenium. 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.

7.2.4.2 Surface Water

Using the surface water benchmarks discussed in *Section 7.1.8*, direct contact exposure to aquatic biota was assessed. As shown in **Table 7-14**, up to 12 benchmarks were potentially available for comparison purposes for surface water COPECs. Using a weight-of-evidence approach, based on the MDC and the 95% EPC concentration for each COPEC, five of the surface water COPECs had concentrations that did not exceeded any of the available surface water benchmarks (note: only two surface water samples were collected, therefore the EPC equals the MDC). Aluminum, arsenic, barium, carbon disulfide, iron, and manganese each had at least one exceedance of their respective surface water benchmarks. The results of the screening are as follows:

- The aluminum MDC and EPC exceeded three of the seven available benchmarks for aluminum, including the NAWQC for chronic exposure. Since a promulgated standard was exceeded, there is potential for direct contact toxicity for aluminum at SWMU 43. Based on this finding, it is possible that organisms inhabiting the streams near SWMU 43 may be adversely impacted by levels of aluminum.
- The arsenic MDC and EPC only exceeded one of the nine available benchmarks for arsenic. It also did not exceed the NAWQC or the Virginia Water Quality Standard for arsenic. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 43.
- The barium MDC and EPC exceeded all four available benchmarks for barium. Therefore, there is potential for direct contact toxicity for barium at SWMU 43. Based on this finding, it is possible that organisms inhabiting the streams near SWMU 43 may be adversely impacted by levels of barium.
- The carbon disulfide MDC and EPC exceeded two of the six available benchmarks for carbon disulfide but no promulgated criteria. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 43.
- The iron MDC and EPC exceeded all five available benchmarks for iron, including the NAWQC for chronic exposure. Therefore, there is potential for direct contact toxicity for iron at SWMU 43. Based on this finding, it is possible that organisms inhabiting the streams near SWMU 43 may be adversely impacted by levels of iron.
- The manganese MDC and EPC exceeded three of the six available benchmarks for manganese but no promulgated criteria. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 43.

These results suggest that direct contact toxicity for COPECs in surface water at SWMU 43 may be a concern for aluminum, barium, and iron.

7.2.5 Background Metals Considerations

A background evaluation was conducted on the surface soil analytical results to determine if any inorganic COPEC drivers discussed in the previous sections were potentially related to naturally-occurring soil concentrations. From the Tier 2 LOAEL assessment, there were four inorganic COPEC drivers (arsenic, chromium, selenium, and zinc) with EEQs greater than 1 for the food chain assessment. The COPEC hazard driver for the direct contact assessment was selenium. Inorganic COPECs that were not statistically different based on appropriate statistical tests are considered background related (see *HHRA Section 6.4.2* for details). Based on information presented in **Table 7-15**, selenium and zinc are direct contact and/or COPECs in SWMU 43 surface soil considered to be potentially site related and not attributed to background.

Table 7-15
Background Comparison for Surface Soil at SWMU 43

Soil COPEC	Gehan Test [a, b] Site > Background?	Considered to be Background?
Arsenic [c]	No	**Yes**
Chromium [c]	No	**Yes**
Selenium	Yes	No
Zinc [c]	Yes	No

[a] Gehan test used unless otherwise noted. See Appendix for backup statistics.
[b] If both site and Background data sets had normal distribution with 100% detects, the t-test was used.
[c] Wilcoxin-Mann Whitney test used for 100% detected data sets.

7.2.6 Groundwater Evaluation

Groundwater samples were collected from six monitoring wells at SWMU 43 (four downgradient wells 43MW3, 43MW4, 43MW5 and 43MW6, and two upgradient wells 43MW1 and 43MW2). Samples collected at two spring locations, 43SP1 and 43SP2, are also considered to be indicative of groundwater quality in the SWMU 43 area. Therefore, results from these samples are summarized with the groundwater samples from SWMU 43. SWMU 43 is located in close proximity of the New River (approximately 100 to 125 ft), and the fact that groundwater flows directly toward the New River (Shaw, 2007), it is possible COPECs in groundwater are migrating to the New River and potentially having an adverse impact on aquatic life or wildlife that use the New River. This section evaluates these potential exposure pathways.

Chemicals detected in groundwater were compared with direct contact surface water screening values and were also evaluated to determine if they were important bioaccumulative compounds (**Table 7-16**). Filtered results for metals detected in groundwater samples are preferred for this assessment as filtered results are more indicative of concentrations available for possible transport to the New River. However, filtered groundwater samples from SWMU 43 were not available, and total groundwater results were used in the evaluation. Results from the upgradient wells, 43MW1 and 43MW2, are not directly used in the screening table, as these results are not site-related; however, they are presented to indicate which chemicals may be moving onto the site from an upgradient source.

Detected groundwater constituents were compared to the Region 3 BTAG surface water screening values. If the concentration of a chemical exceeded its BTAG concentration, it was selected for further consideration in the surface water evaluation. Additionally, chemicals that are considered to be bioaccumulative based on USEPA, 2000c are selected as COPECs. Eleven (11) groundwater COPECs (carbon disulfide, aluminum, arsenic, barium, beryllium, calcium, chromium, iron, manganese, nickel, and zinc) were selected as COPECs. Using the maximum and average groundwater concentrations of these COPECs that had concentrations that exceeded the BTAG surface water screening criteria, HQs were estimated using the direct contact surface water screening values (**Table 7-17**). Results of this initial assessment showed that if measured groundwater concentrations occur in the New River surface water without any dilution, HQs would range from 0.07 to 108 using MDCs, and from 0.05 to 39 using average concentrations (**Table 7-17**).

Table 7-16
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Exposure at SWMU 43

Scenario Timeframe: Current/Future
Medium: Water
Exposure Medium: Groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Upgradient Well Value (2)	Screening Toxicity Value (3)	Important Bioaccumulative Compound (4) ? (Y/N)	COPEC Flag (Y/N)	Rationale for Selection or Deletion (5)
Groundwater	75-15-0	Carbon disulfide	3.30E-03	3.30E-03	mg/l	43SP1 (RDWB*7)	1/6	5.00E-04 - 2.00E-03	3.30E-03	ND	9.20E-04	No	Yes	ASL
	86-30-6	n-Nitrosodiphenylamine	4.50E-03 J	4.50E-03 J	mg/l	43MW6	1/6	3.00E-03 - 5.00E-03	4.50E-03	ND	2.10E-01	No	No	BSL
	127-18-4	Tetrachloroethene	2.70E-04 J	2.60E-03	mg/l	43MW6	3/6	1.00E-03 - 1.60E-03	2.60E-03	4.50E-04	1.11E-01	No	No	BSL
	7429-90-5	Aluminum	4.03E-01	4.03E-01	mg/l	43SP1 (RDWB*7)	1/6	7.90E-02 - 1.41E-01	4.03E-01	7.14E-01	8.70E-02	No	Yes	ASL, BKG
	7440-38-2	Arsenic	3.94E-03	3.49E-02	mg/l	43MW3	4/6	3.70E-03 - 3.70E-03	3.49E-02	4.40E-03	5.00E-03	Yes	Yes	ASL, IBC
	7440-39-3	Barium	7.54E-02 J	2.26E-01	mg/l	43MW4	6/6	N/A	2.26E-01	6.32E-02	4.00E-03	No	Yes	ASL
	7440-41-7	Beryllium	1.10E-03 J	1.50E-03 J	mg/l	43MW4	2/6	1.00E-03 - 5.00E-03	1.50E-03	2.00E-03	6.60E-04	No	Yes	ASL, BKG
	7440-70-2	Calcium	7.23E+01	1.52E+02	mg/l	43MW3	6/6	N/A	1.52E+02	9.48E+01	1.16E+02	No	Yes	ASL
	7440-47-3	Chromium	1.40E-03 J	2.20E-03 J	mg/l	43MW4	4/6	6.02E-03 - 6.02E-03	2.20E-03 J	1.09E-02	1.10E-02	Yes	Yes	IBC, BKG
	7440-48-4	Cobalt	2.30E-03 J	6.20E-03 J	mg/l	43MW4	3/6	1.00E-03 - 2.50E-02	6.20E-03	1.60E-03	2.30E-02	No	No	BSL
	7439-89-6	Iron	1.73E+00	3.23E+01	mg/l	43SP1 (RDWB*7)	5/6	1.50E-02 - 1.50E-02	3.23E+01	1.18E+01	3.00E-01	No	Yes	ASL
	7439-95-4	Magnesium	2.83E+01	6.41E+01 J	mg/l	43MW3	6/6	N/A	6.41E+01	3.49E+01	8.20E+01	No	No	BSL
	7439-96-5	Manganese	3.10E-03 J	1.30E+00	mg/l	43SP1 (RDWB*7)	6/6	N/A	1.30E+00	1.73E-02	1.20E-01	No	Yes	ASL
	7440-02-0	Nickel	1.20E-03 J	4.10E-03 J	mg/l	43MW3	3/6	1.00E-03 - 3.43E-02	4.10E-03	3.30E-03	5.20E-02	Yes	Yes	IBC
	7440-09-7	Potassium	8.56E-01	3.60E+00 J	mg/l	43MW3	6/6	N/A	3.60E+00	2.94E+00	5.30E+01	No	No	BSL
	7440-23-5	Sodium	6.75E+00 J	2.08E+01	mg/l	43SP1 (RDWB*7)	6/6	N/A	2.08E+01	8.90E+00	6.80E+02	No	No	BSL
	7440-62-2	Vanadium	1.32E-02	1.32E-02	mg/l	43SP1 (RDWB*7)	1/6	1.10E-03 - 1.10E-02	1.32E-02	1.70E-03	2.00E-02	No	No	BSL
	7440-66-6	Zinc	8.00E-03 J	8.00E-03 J	mg/l	43MW4	1/6	5.00E-03 - 2.11E-02	8.00E-03	5.70E-03	1.20E-01	Yes	Yes	IBC
	14797-73-0	Perchlorate	ND	ND	mg/l	N/A	0/4	2.00E-04 - 2.00E-04	ND	2.03E-04	NVA	No	No	BKG

(1) Maximum, unfiltered sample concentrations used for screening, including data from monitoirng wells 43MW3, 43MW4, 43MW5, and 43MW6 and samples collected from spring locations 43SP1 and 43SP2.
(2) Maximum detect from up-gradient groundwater monitoring wells (Wells: 43MW1 and 43MW2).
(3) Screening toxicity values are Freshwater Screening Benchmarks from Region III BTAG (2009).
(4) Important Bioaccumulative Compound, per USEPA (2000)
(5) Rationale Codes

Selection Reason: Toxicity Information Available (TX)
Above Screening Level (ASL)
Important Bioaccumulative Compound (IBC)
Deletion Reason: Below Screening Level (BSL)
Physical/Chemical (PHYS)
Nutrient (NUT)
Below Upgradient (background) Concentration (BKG)

Definitions:
N/A = Not Applicable or Not Available
NVA = No Value Available
COPEC = Chemical of Potential Ecological Concern
J, K, L = Estimated Values
ND = Not Detected

Table 7-17

Impact Evaluation of Groundwater COPEC Concentrations in Surface Water Adjacent to SWMU 43

COPEC [a]	Ground-water MDC (mg/L) [b]	Groundwater Mean of Detected Data (mg/L) [b]	Screening Value (mg/L) [c]	HQ [d] Estimated Using MDC	HQ [d] Estimated Using Mean Concentration	Groundwater to Surface Water Dilution Factor [e]	HQ Estimated Using MDC and DF	HQ Estimated Using Mean Concentration and DF	Potential Surface Water Concern From SWMU 43 Groundwater COPECs?
Carbon disulfide	3.30E-03	3.30E-03	9.20E-04	3.6	3.6	100	0.04	0.04	No, HQs < 1 when DF used
Aluminum	4.03E-01	4.03E-01	8.70E-02	4.6	4.6	100	0.05	0.05	No, HQs < 1 when DF used
Arsenic	3.49E-02	1.56E-02	5.00E-03	7.0	3.1	100	0.07	0.03	No, HQs < 1 when DF used
Barium	2.26E-01	1.55E-01	4.00E-03	57	39	100	0.6	0.4	No, HQs < 1 when DF used
Beryllium	1.50E-03	1.30E-03	6.60E-04	2	2.0	100	0.02	0.02	No, HQs < 1 when DF used
Calcium	1.52E+02	1.03E+02	1.16E+02	1.3	0.9	100	0.01	0.01	No, HQs < 1 when DF used
Chromium	2.20E-03	1.88E-03	1.10E-02	0.2	0.2	100	0.002	0.002	No, all HQs < 1
Iron	3.23E+01	1.17E+01	3.00E-01	108	39	100	1	0.4	No, HQs < 1 when DF used
Manganese	1.30E+00	3.98E-01	1.20E-01	11	3	100	0.1	0.03	No, HQs < 1 when DF used
Nickel	4.10E-03	2.73E-03	5.20E-02	0.08	0.05	100	0.001	0.001	No, all HQs < 1
Zinc	8.00E-03	8.00E-03	1.20E-01	0.07	0.07	100	0.001	0.001	No, all HQs < 1

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from the screening assessment (excluding important bioaccumulative compunds that did not exceed the direct contact screening criterion).

[b] Only unfiltered metals results are available for SWMU 43.

[c] Direct contact screening value (Table 7-33).

[d] HQ = hazard quotient (groundwater concentration divided by screening value)

[e] Mixing zone dilution factor of 100 based on site-specific groundwater flow rate and New River low flow rate (see text for discussion).

Notes:

MDC = maximum detection concentration

DF = Dilution Factor

As discussed in *Section 7.1.10*, the dilution factor for SWMU 43 groundwater discharging to the New River is assumed to be 100. This dilution factor is used in **Table 7-17** to estimate the potential concentration of groundwater COPECs in the New River during low flow conditions (i.e., the August-September period). Revised HQs, taking into account this conservative dilution factor, are all 1.0 or lower. This finding supports the conclusion that groundwater COPECs in surface water are not expected to adversely impact sensitive aquatic biota residing in the New River.

An additional assessment was performed to evaluate COPECs potentially partitioning to sediment from pore water and overlying water influenced by groundwater migrating from the site, per a request from McCloskey (2006) following the approach used by TetraTech (2005). This assessment utilized soil/water portioning theory, where the Freundlich soil/water partition coefficient (K_d) is multiplied by the water (solution) concentration to estimate the sorbed sediment concentration (USEPA, 2002b). The K_d values for organics were estimated by multiplying the organic carbon partition coefficient (K_{oc}) by the sediment fraction of organic carbon (f_{oc}). The K_{oc} values used in this assessment are taken from EPI Suite (USEPA, 2007b). As no site-specific f_{oc} results are readily available for New River sediment adjacent to the site, a default value of 0.01 recommended in Appendix D of *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997e) was used to estimate the K_d values for organic COPECs. Inorganic COPEC K_d values were obtained from the following hierarchy: (1) Risk Assessment Information System (RAIS) (ORNL, 2006) on-line database, (2) Baes et al. (1984).

To estimate the impact of the discharge of contaminated groundwater on the sediments in the riverbed, three different methods of calculating the concentrations in the riverbed sediments were used, following the approach used by TetraTech (2005) recommended by McCloskey (2006). The most conservative method of calculating the predicted sediment concentrations was based on the assumption that the sediment equilibrates directly with the groundwater seepage (i.e., pore water). The second method assumes that the riverbed sediments equilibrate with the surface water (“diluted groundwater”). To estimate the impact of the long-term discharge of groundwater on New River sediments, the groundwater concentrations were divided by the estimated dilution factor of 100 to yield the predicted concentrations in the New River. A long-term dilution factor of 100 is actually conservative, as the calculated dilution factor for SWMU 43 was 4.88E+5. The third method is simply the arithmetic mean of the calculated values determined by the first two methods. The third method is considered to be the best representation of actual site conditions because sediment chemistry is affected by both the pore water and the overlying surface water column. These three methods were used to calculate the predicted sediment concentrations presented in **Tables 7-18, 7-19, and 7-20**.

The predicted COPEC sediment concentrations were compared with BTAG (USEPA, 2006b) sediment screening values and HQs were calculated (**Tables 7-18 through 7-20**). If no BTAG sediment screening value was available, the lowest sediment screening value from the sediment direct contact evaluation was used. As shown in the tables, no COPECs had HQs that exceeded 1.0 when the conservative pore water method was used (**Table 7-18**), no COPEC HQs exceeded 1.0 when the dilution method was used (**Table 7-19**), and no COPECs had HQs exceeding 1.0 when the recommended average of the pore water and dilution methods was used (**Table 7-20**). HQs could not be estimated for barium, beryllium, and calcium since no appropriate sediment screening value was available.

Table 7-18
Evaluation of Groundwater COPECs That May Partition to Sediment at SWMU 43 - Pore Water Method

COPEC [a]	Ground-water MDC (mg/L) [b]	Ground-water Mean (mg/L) [b]	K_{oc} (L/kg)	K_d (L/kg) [c]	Source of K_{oc} or K_d Data [d]	Predicted Sediment Concentration Using MDC (mg/kg) [e]	Predicted Sediment Concentration Using Mean (mg/kg) [e]	Sediment Screening Value (mg/kg) [f]	HQ [g] Estimated Using MDC	HQ [g] Estimated Using Mean Concentration
Carbon disulfide	3.30E-03	3.30E-03	1.00E+00	1.00E-02	1	3.30E-05	3.30E-05	8.51E-04	0.039	0.039
Aluminum	4.03E-01	4.03E-01	NA	1.50E+03	2	6.05E+02	6.05E+02	5.80E+04	0.010	0.010
Arsenic	3.49E-02	1.56E-02	NA	2.90E+01	2	1.01E+00	4.51E-01	9.80E+00	0.10	0.046
Barium	2.26E-01	1.55E-01	NA	4.10E+01	2	9.27E+00	6.36E+00	NVA	NVA	NVA
Beryllium	1.50E-03	1.30E-03	NA	7.90E+02	2	1.19E+00	1.03E+00	NVA	NVA	NVA
Calcium	1.52E+02	1.03E+02	NA	4.00E+00	3	6.08E+02	4.11E+02	NVA	NVA	NVA
Chromium	2.20E-03	1.88E-03	NA	8.50E+02	2	1.87E+00	1.59E+00	4.34E+01	0.043	0.037
Iron	3.23E+01	1.17E+01	NA	2.50E+01	2	8.08E+02	2.92E+02	2.00E+04	0.040	0.015
Manganese	1.30E+00	3.98E-01	NA	6.50E+01	2	8.45E+01	2.59E+01	4.60E+02	0.18	0.056
Nickel	4.10E-03	2.73E-03	NA	6.50E+01	2	2.67E-01	1.78E-01	2.27E+01	0.012	0.0078
Zinc	8.00E-03	8.00E-03	NA	6.20E+01	2	4.96E-01	4.96E-01	1.21E+02	0.0041	0.0041

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 7-33.

[b] Only unfiltered metals results are available for SWMU 43.

[c] Organic K_d estimated by multiplying K_{oc} by the fraction of organic carbon (foc), estimated to be 0.01, per Appendix D of *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997).

[d] (1) Organic K_{oc} values from EPI Suite (USPEA, 2007). (2) Inorganic K_d values from The Risk Assessment Information System (RAIS) ORNL, 2009 on-line database.
(3) K_d values are from Baes et al., (1984).

[e] Predicted sediment concentration = K_d x COPEC concentration in groundwater, per Equation 4-12 in USEPA (2002).

[f] Sediment screening concentration from USEPA Region III BTAG (USEPA, 2006). If no BTAG value available, the lowest value from the sediment direct contact table (Table 7-13) is used.

[g] HQ = hazard quotient (predicted sediment concentration divided by screening value)

Notes:

MDC = maximum detection concentration
NA = not available
NVA = No Value Available

Table 7-19
Evaluation of Groundwater COPECs That May Partition to Sediment at SWMU 43 - Dilution Method

COPEC [a]	Ground-water MDC (mg/L) [b]	Ground-water Mean (mg/L) [b]	Predicted Water Column Concentration Using MDC (mg/L) [c]	Predicted Water Column Concentration Using Mean (mg/L) [c]	K_{oc} (L/kg)	K_d (L/kg) [d]	Source of K_{oc} or K_d Data [e]	Predicted Sediment Concentration Using MDC (mg/kg) [f]	Predicted Sediment Concentration Using Mean (mg/kg) [f]	Sediment Screening Value (mg/kg) [g]	HQ [h] Estimated Using MDC	HQ [h] Estimated Using Mean Concentration
Carbon disulfide	3.30E-03	3.30E-03	3.30E-05	3.30E-05	1.00E+00	1.00E-02	1	3.30E-07	3.30E-07	8.51E-04	0.00039	0.00039
Aluminum	4.03E-01	4.03E-01	4.03E-03	4.03E-03	NA	1.50E+03	2	6.05E+00	6.05E+00	5.80E+04	0.00010	0.00010
Arsenic	3.49E-02	1.56E-02	3.49E-04	1.56E-04	NA	2.90E+01	2	1.01E-02	4.51E-03	9.80E+00	0.0010	0.00046
Barium	2.26E-01	1.55E-01	2.26E-03	1.55E-03	NA	4.10E+01	2	9.27E-02	6.36E-02	NVA	NVA	NVA
Beryllium	1.50E-03	1.30E-03	1.50E-05	1.30E-05	NA	7.90E+02	2	1.19E-02	1.03E-02	NVA	NVA	NVA
Calcium	1.52E+02	1.03E+02	1.52E+00	1.03E+00	NA	4.00E+00	3	6.08E+00	4.11E+00	NVA	NVA	NVA
Chromium	2.20E-03	1.88E-03	2.20E-05	1.88E-05	NA	8.50E+02	2	1.87E-02	1.59E-02	4.34E+01	0.00043	0.00037
Iron	3.23E+01	1.17E+01	3.23E-01	1.17E-01	NA	2.50E+01	2	8.08E+00	2.92E+00	2.00E+04	0.00040	0.00015
Manganese	1.30E+00	3.98E-01	1.30E-02	3.98E-03	NA	6.50E+01	2	8.45E-01	2.59E-01	4.60E+02	0.0018	0.00056
Nickel	4.10E-03	2.73E-03	4.10E-05	2.73E-05	NA	6.50E+01	2	2.67E-03	1.78E-03	2.27E+01	0.00012	0.000078
Zinc	8.00E-03	8.00E-03	8.00E-05	8.00E-05	NA	6.20E+01	2	4.96E-03	4.96E-03	1.21E+02	0.000041	0.000041

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 7-33.

[b] Only unfiltered metals results are available for SWMU 43.

[c] Dilution factor of 100 used, see text for discussion.

[d] Organic K_d estimated by multiplying K_{oc} by the fraction of organic carbon (foc), estimated to be 0.01, per Appendix D of *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997).

[e] (1) Organic K_{oc} values from EPI Suite (USPEA, 2007). (2) Inorganic K_d values from The Risk Assessment Information System (RAIS) ORNL, 2009 on-line database. (3) K_d values are from Baes et al., (1984).

[f] Predicted sediment concentration = K_d x COPEC concentration in groundwater, per Equation 4-12 in USEPA (2002).

[g] Sediment screening concentration from USEPA Region III BTAG (USEPA, 2006). If no BTAG value available, the lowest value from the sediment direct contact table (Table 7-13) is used.

[h] HQ = hazard quotient (predicted sediment concentration divided by screening value)

Notes:

MDC = maximum detection concentration

NA = not available

NVA = No Value Available

Table 7-20
Evaluation of Groundwater COPECs That May Partition to Sediment at SWMU 43
Average of Pore Water Method and Dilution Method

COPEC [a]	HQ [b] Estimated Using MDC and Pore Water Method	HQ [b] Estimated Using Mean Concentration and Pore Water Method	HQ [c] Estimated Using MDC and Dilution Method	HQ [c] Estimated Using Mean Concentration and Dilution Method	HQ Estimated Using MDC and Average of Pore Water Method and Dilution Method	HQ Estimated Using Mean Concentration and Average of Pore Water Method and Dilution Method
Carbon disulfide	0.039	0.039	0.00039	0.00039	0.0196	0.0196
Aluminum	0.010	0.010	0.00010	0.00010	0.0053	0.0053
Arsenic	0.10	0.046	0.0010	0.00046	0.052	0.023
Barium	NVA	NVA	NVA	NVA	NVA	NVA
Beryllium	NVA	NVA	NVA	NVA	NVA	NVA
Calcium	NVA	NVA	NVA	NVA	NVA	NVA
Chromium	0.043	0.037	0.00043	0.00037	0.022	0.019
Iron	0.040	0.015	0.00040	0.00015	0.020	0.007
Manganese	0.18	0.056	0.0018	0.00056	0.093	0.028
Nickel	0.012	0.0078	0.00012	0.000078	0.006	0.004
Zinc	0.0041	0.0041	0.000041	0.000041	0.002	0.002

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 7-33.

[b] HQs from Table 7-35.

[c] HQs from Table 7-36.

Notes:

MDC = maximum detection concentration in groundwater.

HQ = hazard quotient

NA = not available

NVA = no value available

In addition to potential hazards associated with direct contact with COPECs in sediments from groundwater, there is also the concern for bioaccumulation of COPECs from sediment to fish and potential adverse food chain impacts to higher order wildlife such as mink or great blue heron. As recommended by McCloskey (2006), this exposure pathway was also evaluated following the general approach used by TetraTech (2005). Based on the average sediment COPEC concentrations using the pore water method (**Table 7-18**) and using the dilution method (**Table 7-19**), sediment to fish bioaccumulation factors were used to estimate COPEC concentrations of important bioaccumulative compounds in fish tissue. Sediment to fish bioaccumulation factors were primarily from *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997e) and, if not available from this source, *Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation* (Bechtel Jacobs, 1998b) was used as a surrogate. The estimated fish tissue concentrations (**Table 7-21**) were compared with NOAEL-based benchmarks for fish as food for the mink and great blue heron, using benchmarks from Table 12 of *Toxicological Benchmarks for Wildlife* (Sample et al.,1996). HQs were calculated for each COPEC and for those COPECs that have available benchmark, they were below 1 (**Table 7-21**). These findings demonstrate that bioaccumulation of COPECs from sediments to fish, and subsequent higher order food chain impacts to wildlife receptors such as mink and great blue heron, are not a concern for the site.

7.2.7 Uncertainty Analysis

There were 143 and 147 chemical constituents not detected in surface soil and surface water analytical samples, respectively. **Appendix F-2, Tables F-26** (surface soil) and **F-27** (surface water) evaluate 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. Region III BTAG soil SLs are antiquated (last published in 1995) relative to Region III BTAG surface water (updated in 2006); therefore, non-detect soil values were compared to BTAG soil levels as well as additional soil screening values presented in **Appendix F-2, Table F-25**. Region III BTAG surface water screening values were used for the surface water comparison.

Thirty-one (31) of the non-detect surface soil and 51 of the non-detect surface water constituents had maximum detection limits that exceeded the screening criteria, respectively. These findings are not unexpected, given the conservative and numerically low screening values.

Four inorganics (arsenic, chromium, selenium, and zinc) and one organic (TCDD) had Tier 2 LOAEL-based EEQs that exceeded 1 when round to one significant figure. Given the uncertainties associated with the SLERA process, the key parameters associated with these slightly elevated EEQs were examined in more detail in the following sections.

<u>Arsenic</u>. For arsenic, the EEQ was slightly elevated for the short-tailed shrew (EEQ of 2.2). The short-tailed shrew EEQ was primarily from the earthworm and soil ingestion pathways (53 and 46 percent, respectively). The LOAEL of 1.26 mg/kg-day that was used was based on a laboratory mouse study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 8 (**Appendix F-2, Table F-4**). The use of this UF is quite conservative, and the use of an alternative UF of approximately 4 or 5 would result in the arsenic EEQ dropping to 1 when rounded to one significant figure.

Table 7-21

Evaluation of Groundwater COPECs That May Partition to Sediment at SWMU 43 and Bioaccumulate in Fish Tissue

COPEC [a]	Sediment Concentration Estimated Using MDC in Groundwater and Average of Pore Water and Dilution Methods (mg/kg) [b]	Sediment Concentration Estimated Using Mean Groundwater Concentration and Average of Pore Water and Dilution Methods (mg/kg) [c]	Sediment to Fish Biaccumlation Factors	Reference [d]	Estimated Fish Concentration Using MDC in Groundwater (mg/kg) [e]	Estimated Fish Concentration Using Mean Concentration in Groundwater (mg/kg) [e]	NOAEL-Based Benchmark for Fish as Food for Mink (mg/kg) [f]	NOAEL-Based Benchmark for Fish as Food for Great Blue Heron (mg/kg) [f]	HQ for Mink Estimated Using Highest Fish Tissue Concentration	HQ for Great Blue Heron Estimated Using Highest Fish Tissue Concentration
Arsenic	5.11E-01	2.28E-01	0.143	2	7.31E-02	3.26E-02	0.383	14	0.19	0.0052
Chromium	9.44E-01	8.05E-01	0.1	2	9.44E-02	8.05E-02	15366	5.69	0.0000061	0.017
Nickel	1.35E-01	8.97E-02	0.486	2	6.54E-02	4.36E-02	224.57	440.44	0.00029	0.00015
Zinc	2.50E-01	2.50E-01	1.936	2	4.85E-01	4.85E-01	898.30	82.5	0.00054	0.0059

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 7-33, that are important bioaccumulative compounds.

[b] Sediment concentrations are means from MDC columns in Tables 7-35 and 7-36.

[c] Sediment concentrations are means from Mean columns in Tables 7-35 and 7-36.

[d] (1)*The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997); and, if not available, then surrogate used from (2) *Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation* (Bechtel Jacobs, 1998).

[e] Sediment concentration times sediment to fish bioaccumulation factor

[f] *Toxicological Benchmarks for Wildlife* (Table 12) (Sample, B.E., D.M. Opresko, and G.W. Suter, 1996).

Notes:

MDC = maximum detected concentration.

NA = not avaiable.

HQ = hazard quotient

Chromium. For chromium, the slightly elevated American robin EEQ of 2.3 was primarily from the earthworm ingestion pathway (64 percent), with 22 percent being from soil ingestion. The LOAEL TRV of 2.78 mg/kg-day that was used was based on laboratory studies on the black duck, as cited in USEPA (2008c). This chromium LOAEL was the lowest available value from USEPA (2008c) for birds, for the critical endpoints of reproduction, growth, or survival. However, the black duck LOAEL cited in USEPA (2008c) was based on an unpublished study by Haseltine et al., and therefore, the validity of this LOAEL could not be verified. The next highest LOAEL in USEPA (2008c) was 9.91 mg/kg-day, based on chicken study by Montozono et al. (1998). Use of this alternative LOAEL of 9.91 mg/kg-day would decrease the American robin EEQ by approximately 3.5-fold, from 2.3 to less than 1. Also, a UF of 8 was used for extrapolation from a black duck chromium toxicity study to the selected wildlife receptor (the American robin) (**Appendix F-2, Table F-6**). The use of this UF is quite conservative, and the use of an alternative UF of approximately 4 would result in the chromium EEQ of 2.3 dropping to 1 when rounded to one significant figure. Based on this evaluation for chromium, the use of alternative factors (e.g., an alternative LOAEL TRV and/or alternative UF for TRV species extrapolation), would reduce the estimated American robin LOAEL-based EEQ to 1 (rounded to one significant figure) or less.

Selenium. For selenium, the EEQs were elevated for the short-tailed shrew (EEQ of 14.1), the meadow vole (EEQ of 9.6) and the American robin (EEQ of 6.1). The short-tailed shrew EEQ was primarily from the earthworm ingestion pathway (85 percent). The LOAEL of 0.33 mg/kg-day that was used was based on a laboratory rat study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 8 (**Appendix F-2, Table F-4**). The use of this UF is quite conservative; however, the use of an alternative UF of 1 would still result in the selenium EEQ slightly exceeding 1 (2) when rounded to one significant figure. The meadow vole EEQ of 9.6 was primarily from the plant ingestion pathway (96 percent, respectively). The LOAEL of 0.33 mg/kg-day that was used was based on a laboratory rat study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 4 (**Appendix F-2, Table F-2**). The use of this UF is quite conservative; however, the use of an alternative UF of 1 would still result in the selenium EEQ still slightly exceeding 1 (2) when rounded to one significant figure. The American robin EEQ of 6.1 was primarily from the plant and invertebrate ingestion pathways (59 and 35 percent, respectively). The LOAEL of 1.0 mg/kg-day that was used was based on a mallard duck study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 8 (**Appendix F-2, Table F-6**). The use of this UF is conservative, and the use of an alternative UF of approximately 1 would result in the selenium EEQ dropping to 1 when rounded to one significant figure.

Zinc. For zinc, the were slightly elevated American robin EEQ of 2.2 was primarily from the earthworm ingestion pathway (79 percent). The LOAEL of 131 mg/kg-day that was used was based on a laboratory chicken study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 8 (**Appendix F-2, Table F-6**). The use of this UF is conservative, and the use of an alternative UF of approximately 4 would result in the zinc EEQ to 1 when rounded to one significant figure.

TCDD. For TCDD, the slightly elevated short-tailed shrew EEQ of 3.1 was primarily from the earthworm ingestion pathway (97 percent). The LOAEL of 1E-5 mg/kg-day that was used was based on a laboratory rat study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 8 (**Appendix F-2, Table F-4**). The use of this UF is conservative, and the use of an alternative UF of approximately 3 would result in the zinc EEQ to 1 when rounded to one significant figure.

Based on this evaluation for Tier 2 LOAEL-based risk drivers (EEQs >1), arsenic, chromium, zinc, and TCDD, and the use of alternative factors (e.g., an alternative UF for TRV species extrapolation), would reduce the estimated LOAEL-based EEQs to 1 (when rounded to one significant figure) for all receptors. The LOAEL-based selenium EEQs were still slightly elevated above 1 for the shrew and the vole even with the use of alternative UFs.

7.2.8 SLERA Results and Conclusions

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting SWMU 43. 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 7-12**, and direct contact exposure results, which may serve as a food source for wildlife, are summarized in **Tables 7-13** (surface soil) and **7-14** (surface water) and discussed in *Section 7.2.4*.

The food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles for modeled contact with the hazard drivers (TCDD, arsenic, chromium, selenium, and zinc) in surface soil. However, arsenic and chromium in surface soil concentrations were determined to be background related (**Table 7-15**).

When alternative exposure and/or toxicity factors were used in the Tier 2 LOAEL-based EEQ calculations, estimated EEQs would be expected to drop to 1 or less for all constituents except selenium, which had alternative EEQs that slightly exceeded 1 (EEQ = 2). The direct contact assessment results suggest a potential reduction in wildlife food supply due to selenium in surface soil and aluminum, barium, and iron in surface water. However, due to the relatively small size of the site (3.0 acres), this potential reduction in food is not considered biologically significant. In addition, although three COPECs in surface water had concentrations that exceeded more than 50 percent of the available screening benchmarks and/or exceeded a promulgated criterion, the small size of the site (3.0 acres), the lack of true aquatic habitat and the associated small size of the sampled aquatic habitat (ground water seeps), and the migration of COPECs in groundwater to surface water and sediment of the New River was determined not to be a significant ecological concern, suggests further ecological assessment is not warranted.

Based on uncertainties of toxicity, arsenic and chromium in soil concentrations are background related, no Tier 2 LOAEL EEQs except selenium (EEQ = 2) exceeding 1 (when rounded to one significant figure, and using alternative UFs and/or alternative LOAEL TRVs), the fact that no wildlife rare, threatened, or endangered (RTE) species have been found at the SWMU study area, the relatively small size of the SWMU (3.0 acres), and groundwater migration to the New River was determined not to be a significant ecological concern, remedial measures solely to address ecological concerns are not warranted for soil, surface water, or groundwater. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

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 SUMMARY AND CONCLUSIONS

SWMU 43 is a closed unlined sanitary landfill consisting of two adjacent cells located immediately adjacent to the New River in the northeast section of the MMA. The study area consists of two adjacent approximately 1.5-acre cells divided by a central drainage ditch. Based on geophysics and aerial photos, the landfill extends east-west approximately 700 ft on either side of the drainage ditch. The western section of the landfill is currently used to store office and equipment trailers. Elongated depressions, which corresponded to the disposal trenches, were filled in and the site was regraded in August 1995.

Data from a previous investigation at SWMU 43 was combined with data from the current (2007) investigation to evaluate the nature and extent of contamination (*Section 4.0*) and to assess potential impacts to human health (*Section 6.0*) and/or ecological receptors (*Section 7.0*).

8.1 Contamination Assessment

The contamination assessment indicated that VOCs, non PAH SVOCs, pesticides, and herbicides are not a concern in soil at SWMU 43 since they were not greater than SLs in any soil samples. For surface water at SWMU 43, VOCs and SVOCs are not a concern since they were not detected above SLs. In groundwater, SVOCs, PAHs, pesticides, PCBs, herbicides, explosives, and perchlorate are not a concern at SWMU 43.

The soil at SWMU 43 was characterized during the 2007 sampling event. The data indicates that one PAH [benzo(a)pyrene] was detected above its r-SL in 4 out of 30 soil samples collected. PCB-1016 and PCB-1254 were detected above their r-SLs in 1 and 7 out of 30 samples, respectively. One explosive (2,4,6-TNT) was detected above its r-SL in 1 out of 30 soil samples. Two metals were detected above SLs in soil samples. Arsenic was detected above its r-SL, i-SL, and background level in 1 out of 30 samples. Mercury was detected above its r-SL and background level in 2 out of 30 samples. Four total dioxins/furans were detected above their r-SL in site samples. Total PECDD was detected above its r-SL in two out of six samples. Total HXCDD, total HPCDD, and total HXCDF were detected above their r-SLs in one out of six samples. Some of the compounds (arsenic and dioxins/furans) that were found to be greater than soil r-SLs or i-SLs were also identified by the HHRA or SLERA as posing a significant risk to human health or the environment. The only soil analyte that was detected above its SLs and was also detected in 2007 groundwater samples was arsenic. The results indicate that there are no major concerns in soil because of the relatively low concentrations and sparsely located constituents of concern.

Surface water was investigated only during the 1992 investigation. Two surface water samples were collected from groundwater seeps located along the New River shoreline at SWMU 43. Surface water results indicated that only four metals (aluminum, arsenic, iron, and manganese) were detected above their screening limits. Aluminum was detected above its MCL in one sample. Arsenic and manganese were found above their tw-SLs and MCLs in the two samples. Iron was detected above its MCL in both samples, and also above its tw-SL in one of the samples. The surface water analytes detected above SLs in 1992 that were also detected in 2007 groundwater samples were four metals: aluminum, arsenic, iron, and manganese.

Groundwater was investigated during both the 1992 and 2007 investigations. The 2007 data is considered to be the representative of the current state of groundwater and indicated that one VOC (PCE) and five metals (aluminum, arsenic, cobalt, iron, and manganese) were detected above their screening limits. PCE was detected above its tw-SL, but below its MCL, in four out of six samples. Arsenic, iron, and manganese were found above their MCLs and tw-SLs. Aluminum was only detected above its MCL in two upgradient samples. Cobalt was only detected above its tw-SL in four samples, but did not have an MCL. PCE, aluminum, arsenic, cobalt, and iron were all found above their SLs in at least one of the upgradient wells and therefore may not be originating from SWMU 43. Some of the compounds (PCE, arsenic, cobalt, iron, and manganese) that were found to be greater than groundwater SLs were also identified by the HHRA or SLERA as posing a significant risk to human health or the environment.

8.2 Human Health Risk Assessment

An HHRA (*Section 6.0*) was performed to evaluate the potential human health effects associated with previous activities at SWMU 43. 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.

8.2.1 HHRA Summary

The total cancer risk for current maintenance worker exposures to surface soil was within the acceptable risk range (elevated above the lower end of the range due to arsenic). HI was less than 1. The total cancer risk associated with groundwater was below the acceptable risk range. The HI was below 1.

For the future maintenance worker, the total cancer risk for exposures to surface soil was within the acceptable risk range (elevated above the lower end of the range due to arsenic). The total cancer risk for exposures to total soil and groundwater were below the acceptable risk range. All HIs were less than 1.

For the future industrial worker exposures to surface and total soil, the total cancer risks were within the acceptable risk ranges (elevated above the lower end of the range due to arsenic). Both HIs were below 1. The total cancer risk associated with groundwater was above the acceptable risk range due to PCE and arsenic. The total HI for groundwater was above 1, due to arsenic.

For the future excavation worker, the total cancer risk for exposures to total soil and groundwater were below the acceptable risk ranges. Both HIs were below 1.

For the future lifetime resident, the total cancer risk for exposures to total soil was within the acceptable risk range [elevated above the lower end of the range due to dioxins/furans, benzo(a)pyrene, and arsenic]. The total HI was less than 1. The total cancer risk associated with groundwater was above the acceptable risk range, primarily due to PCE and arsenic. The total HI was above 1, primarily due to arsenic.

For the child resident, the total cancer risk for exposures to total soil was within the acceptable risk range (elevated above the lower end of the range due to dioxins/furans and arsenic). The total HI for total soil was above 1; however, no individual COPC had an HI above 1. Aluminum, arsenic, cobalt, and iron are within background concentrations for total soil. If HQs for background-related metals were excluded, the total HI for total soil would be 1. The total cancer risk associated with groundwater was above the acceptable risk range, due to PCE and arsenic. The total HI was above 1, due to arsenic, cobalt, iron, and manganese.

Off-site recreational users were evaluated address potential future migration of COPCs in groundwater and springs/seeps at SWMU 43 to surface water at the New River. For the future adult recreational user, the total cancer risk for exposures to off-site surface water (3E-06) was within the acceptable risk range (elevated above the lower end of the range due to PCE and arsenic). It is noted, however, that concentrations of COPCs in SWMU 43 spring/seeps and groundwater were conservatively used in the risk and hazard calculations without adjustment for dilution. Considering the dilution factor of 100 assumed in the SLERA (*Section 7.1.10*), the risk associated with discharge from SWMU 43 is expected to be below the acceptable risk range of 1E-06 to 1E-04. The total HI was below 1.

Overall, it appears that arsenic, dioxins/furans (TCDD TE), and benzo(a)pyrene are the main risk-drivers in soil, arsenic and PCE are the main risk-drivers in surface water and groundwater.

8.3 Screening Level Ecological Risk Assessment

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 43. Common methods and procedures are presented in *Section 7.1* and individual results for SWMU 43 are presented in *Section 7.2*.

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting SWMU 43. Conclusions are derived from the risk assessment and are based on the responses to the assessment hypotheses and assessment endpoints.

8.3.1 SLERA Summary

The food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles for modeled contact with the hazard drivers (TCDD, arsenic, chromium, selenium, and zinc) in surface soil. However, arsenic and chromium in surface soil concentrations were determined to be background related (**Table 7-15**).

When alternative exposure and/or toxicity factors were used in the Tier 2 LOAEL-based EEQ calculations, estimated EEQs would be expected to drop to 1 or less for all constituents except selenium, which had alternative EEQs that slightly exceeded 1 (EEQ = 2). The direct contact assessment results suggest a potential reduction in wildlife food supply due to selenium in surface soil and aluminum, barium, and iron in surface water. However, due to the relatively small size of the site (3.0 acres), this potential reduction in food is not considered biologically significant. In addition, although three COPECs in surface water had concentrations that exceeded more than 50 percent of the available screening benchmarks and/or exceeded a promulgated criterion, the small size of the site (3.0 acres), the lack of true aquatic habitat and the associated small size of the sampled aquatic habitat (ground water seeps), and the migration of COPECs in groundwater to surface water and sediment of the New River was determined not to be a significant ecological concern, suggests further ecological assessment is not warranted.

Based on uncertainties of toxicity, arsenic and chromium in soil concentrations are background related, no Tier 2 LOAEL EEQs except selenium (EEQ = 2) exceeding 1 (when rounded to one significant figure, and using alternative UFs and/or alternative LOAEL TRVs), the fact that no wildlife RTE species have been confirmed at the SWMU study area and should stay that way since RFAAP will continue to groom the area, the relatively small size of the SWMU (3.0 acres), and groundwater migration to the New River was determined not to be a significant ecological concern, remedial measures solely to address ecological concerns are not warranted for soil, surface water, or groundwater. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

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.

8.4 Controls

Institutional controls (ICs) are being implemented at the site within the boundaries depicted on **Figure 8-1**. The objective of the ICs is to maintain the site in its current industrial/commercial state as a closed SWMU and to prevent any future residential use. Specifically, this site has been incorporated into a plant management manual to ensure long-term protection of human health and the environment. Any operating contractor must abide by the rules and restrictions within the plant management manual. The management manual provides for advance notice, assessment and approval of intrusive work that may occur within the plant with a general digging prohibition as well as groundwater-use and extraction restrictions at sites such as this. In the event the property is transferred or leased, equivalent ICs will be put into terms and conditions of the deed or lease, which are no less restrictive than the IC objectives described above. Furthermore, the transferee or lessee will be responsible for ensuring IC compliance by any future users. However, the Army acknowledges the responsibility for all original liability under CERCLA and its right and responsibility to enforce ICs unless otherwise transferred to the new property recipient.

8.5 Conclusion

Total risks associated with exposures to COPCs in soil were within the acceptable risk range for the current and potential future maintenance worker, potential future industrial worker, potential future lifetime resident, and potential future child resident. For the industrial scenario, these risks were attributable to arsenic. For the residential scenario, these risks were attributable to dioxins/furans, benzo(a)pyrene, and arsenic. Concentrations of arsenic in soil were within background levels at the site.

The total HIs for soil were below 1 for all receptors except the child resident. For the child resident, however, individual HQs for metals in soil were less than 1. Furthermore, when the background-related HQs were excluded, the total HI for soil was less than 1.

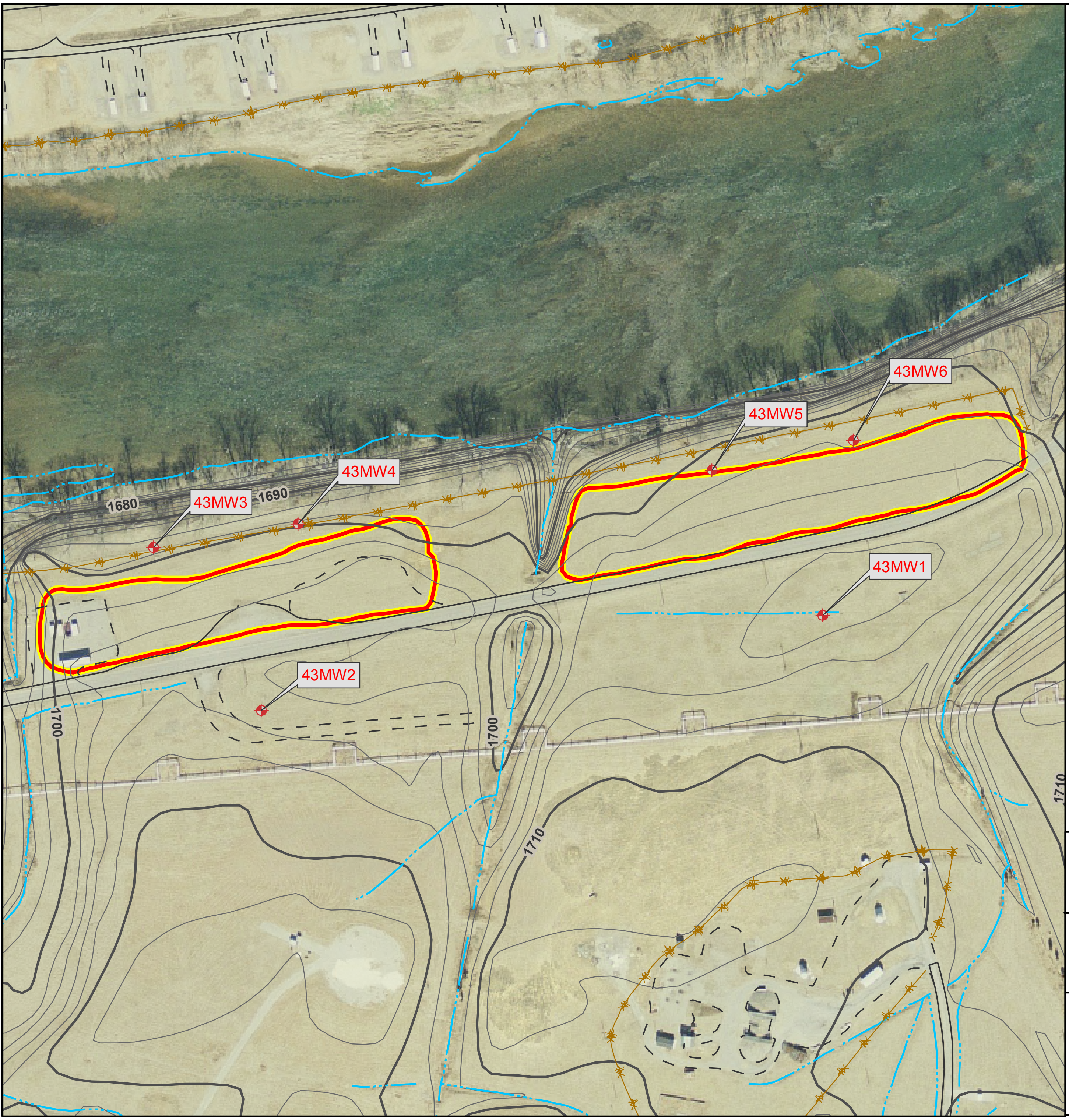
Total risks associated with exposures to COPCs in groundwater were above the acceptable risk range for the potential future industrial worker, potential future lifetime resident, and potential future child resident. These risks were attributable primarily to PCE, arsenic, and manganese.

The total HIs for exposures to COPCs in groundwater were above 1 for the potential future industrial worker, potential future lifetime resident, and potential future child resident. For the industrial scenario, the elevated HI was attributable to arsenic. For the residential scenario, the elevated HIs were attributable to several metals.

Potential future migration of COPCs in groundwater and springs/seeps at SWMU 43 to surface water at the New River was evaluated in this HHRA. Total risk associated with exposures to off-site surface water by off-site recreational users was within the acceptable risk range, primarily attributable to PCE and arsenic. Concentrations of COPCs in SWMU 43 spring/seeps and groundwater were conservatively used in the risk and hazard calculations without adjustment for dilution. Therefore, considering the dilution factor of 100 assumed in the SLERA, the risk associated with discharge from SWMU 43 is expected to be below the acceptable risk range of 1E-06 to 1E-04. The total HI was below 1.

Overall, these potential risks and hazards can be associated with arsenic, dioxins/furans (TCDD TE), and benzo(a)pyrene in soil, and arsenic, manganese, and PCE in surface water and groundwater at the site. However, the arsenic soil concentrations were within background levels at the site. The dioxin/furan, TCDD TE, was not detected above its SLs in any soil samples. Benzo(a)pyrene was only detected above its r-SL in four shallow samples out of the 30 soil samples collected in 2007. Arsenic was undetected in all four 2007 groundwater samples. Manganese was detected above both its MCL and tw-SL in two 2007 groundwater samples (43MW4 and 43MW6). PCE was detected above its tw-SL only in four out of six 2007 groundwater samples, but all were well below its MCL. However, PCE was also found in an upgradient well. The SLERA concluded that there may be potential adverse impacts to terrestrial wildlife from site media. However, because no RTE wildlife species have been confirmed at the site, because of the relatively small size of the site, and because groundwater migration to the New River was determined not to be a significant ecological concern, remedial measures to address ecological concerns are not warranted.

Based on the results of the Nature and Extent of Contamination Assessment, as well as the results of Human Health and Ecological Risk Assessments, both of which show limited risk to theoretical receptors, Institutional Controls are recommended for this site. This recommendation of Response Complete with Institutional Controls is in support of the current Industrial/ Commercial use of the property, and would prevent any residential development from occurring at the site.



LEGEND

- Monitoring Well
- Water Feature
- 2 ft Contour Line
- 10 ft Contour Line
- Dirt Road
- Paved Road
- Railroad
- Fence
- 🟥 SWMU 43 Boundary
- 🟨 Institutional Control Boundary

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

N

Scale:
0 100 200 400
Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 8-1
Institutional Controls at SWMU 43

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\SWMU_43\RFAAP_Fig8-1_SWMU43_InstControls_RFI.mxd (11/9/2009)

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