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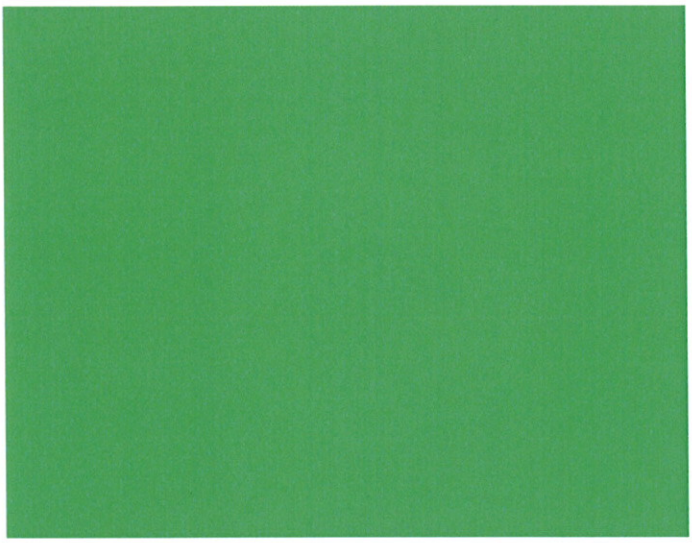

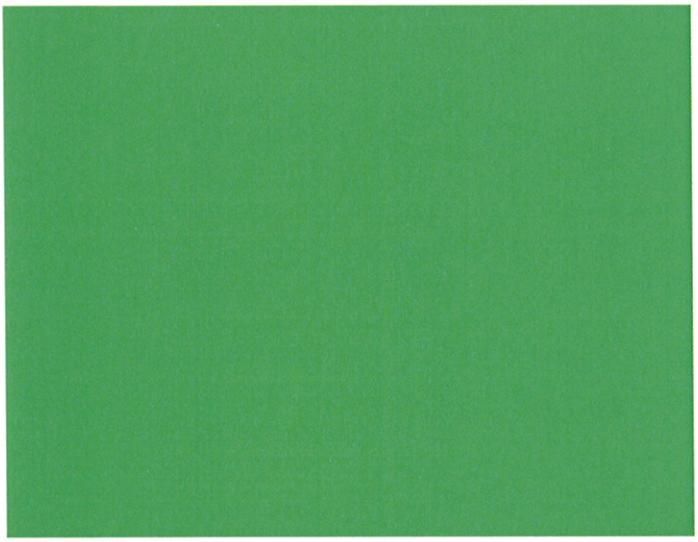

US Army Corps
of Engineers
Baltimore District

Engineering Evaluation/Cost Analysis
Northern Burning Ground, New River Unit (RAAP-044)

Radford Army Ammunition Plant
Radford, Virginia

Prepared for:
Radford Army Ammunition Plant

July 2009

Action Memorandum for the Soil Removal Action at the Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

1. Purpose

This action memorandum documents selection of the non-time-critical removal action recommended in the *Engineering Evaluation/Cost Analysis (EE/CA)*, dated July 2009 (*Attachment 1*), for the Northern Burning Ground (NBG) located at the Radford Army Ammunition Plant – New River Unit (NRU). This action is being conducted to remediate lead and chromium related impacts in soil at the site. This action will be the final remedial action required for the site.

2. Site Conditions and Background

The NRU was established in 1940, and was originally known as the New River Ordinance Works (NROW). The NROW was incorporated into the main Radford Army Ammunition Plant (RAAP) in 1945 and was renamed the NRU. The NRU facility operated as a bag manufacturing and loading plant for artillery, cannon, and mortar projectiles during World War II. Although active manufacturing activities at the RAAP-NRU were reported to have ceased in the 1940's (after World War II), portions of the RAAP-NRU are still utilized as storage facilities in support of operations at the Main Manufacturing Area (MMA).

The area of the NRU identified as the NBG was temporarily utilized as a burning ground for the facility in the past. Anecdotal evidence suggests that the burning operations may have been conducted to remove energetics from metal components used in the former manufacturing activities at the NRU. No buildings have existed at the NBG site; burning operations were conducted directly on the ground surface. The burning ground operations are believed to have been the source of contaminants detected in soil at the site.

The NBG is located in the northwest portion of the NRU, east of Gate 20 (Figure 1-2). A surface water drainage ditch and paved road define the northern boundary of the site. A dirt access road also loops around the NBG and defines the eastern, southern, and western boundaries of the site. The majority of the area identified as the NBG is heavily wooded, with the exception of a small (approximately 350 ft^2) area in the central portion of the site where burning operations are believed to have been performed. This central portion of the site has a grass and shrub groundcover and a few small trees. Little to no visible evidence of past burning activities is apparent. A site map depicting the layout of the NBG is presented in Figure 1-3.

Although there is significant topographic relief across the RAAP-NRU, the majority of the NBG site is relatively level at an elevation of approximately 2,100 feet above mean sea level (ft msl). Surface water runoff from the NBG flows toward the drainage ditch that runs parallel to the paved surface road on the northern boundary of the site.

Comprehensive environmental investigations were completed at the NBG site between 1997 and 2008. These investigations included soil, sediment, and groundwater sampling activities; a geophysical investigation; and on-site screening of soils using X-Ray Fluorescence (XRF). The findings from these

investigations indicate that soils in the former burn area of the site contain levels of several metals (e.g. arsenic, chromium, and lead) at levels that exceed human health and ecological risk screening values. Polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and dioxins/furans were also detected in soil samples at levels greater than human health and/or ecological screening values; although the presence of these constituent detections is limited to a few isolated samples. The findings of the site investigation activities are discussed in detail within the July 2009 EE/CA for the NBG (Attachment 1). Tables and site maps presenting historical analytical data collected from the NBG during the course of environmental investigation are also provided within the EE/CA.

3. Threats to Public Health and the Environment

The EE/CA for the NBG presents the findings of a site-specific human-health and ecological risk assessment that was conducted to evaluate potential risks and hazards associated with constituents detected at the site. The risk assessment concluded that exposure to lead in surface and near surface soil presented a potential risk or hazard to human receptors under hypothetical industrial site worker, construction worker, and residential land use scenarios. Chromium in surface and near surface soil was also found to present a potential risk; although only under a residential land use scenario. No other constituents or media including the PCB's PAH's and dioxin/furans noted in section 2 above were identified as risk drivers within the human-health risk assessment. The ecological risk assessment concluded that no significant adverse effects are expected for environmental receptors at the site due to the limited areal extent of contaminant detections.

4. Endangerment Determination

Based on the results of the risk assessments, actual or threatened releases of hazardous substances from this site, if not addressed by implementing the Non-Time Critical Removal Action selected in this Action Memorandum, may present an imminent and substantial endangerment to human health at the Northern Burning Ground within RAAP-NRU.

5. Proposed Activities

The July 2009 EE/CA for the NBG examined three possible remedial alternatives for the site, including: 1) No Action; 2) Excavation, Off-Site Stabilization and Disposal of Impacted Soils to Achieve Industrial Level Closure; and 3) Excavation, Off-Site Stabilization and Disposal of Impacted Soils to Achieve Residential Level Closure. The requisite No Action Alternative was included in this evaluation to establish a baseline while the other alternatives were selected based on their ability to protect human health and the environment and to comply with Applicable or Relevant and Appropriate Requirements (ARARs). The three alternatives were screened using the criteria of effectiveness, implementability, and cost in accordance with the USEPA's *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA* (USEPA, 1993). Based on the findings of the screening process, the most aggressive removal alternative, Excavation, Off-Site Stabilization and Off-Site Disposal of Impacted Soils to Achieve Residential Level Closure was recommended for the site and has been proposed for implementation. Following is a summary of the activities that are included in this alternative:

- Soil containing lead at concentrations above the Remedial Action Level (RAL) of 3,000 mg/kg and chromium at concentrations above the Remedial Action Level (RAL) of 1,620 mg/kg will be excavated and removed from the site for further treatment (stabilization) and disposal. Based on the extensive delineation work completed at the site, the footprint of the excavation area will be approximately 110 ft by 50 ft. The depth of the excavation will be 1 ft below ground surface (bgs) across the majority of the area, with the exception of a 35 ft by 10 ft area where the depth of excavation will extend to 4 ft bgs. In total approximately 250 cubic yards of soil will be removed.

- Prior to beginning the excavation activities, any trees or other large vegetation within the excavation footprint will be cleared from the site.

- Excavated soils will be loaded directly onto dump trucks and transported to a permitted off-site disposal facility. Once at the disposal facility, the soil will be mixed with a stabilizing agent to reduce the potential for leachable constituent and then properly disposed of in the facility's approved landfill.

- During the removal activity verification soil samples from the northeast and northwest perimeter of the excavation and the base of the excavation will be field screened using XRF to ensure that soils containing lead and chromium at concentrations above the applicable RALs are removed. A subset of these samples will also be submitted for laboratory analysis. If necessary, the excavation footprint may be expanded to make sure the remedial goals are achieved. It is not anticipated that perimeter samples will need to be collected from the southern half of the excavation. A sufficient number of soil samples have already been collected in these areas to verify and confirm that the foot print of the excavation does not need to be expanded.

- Upon completion of the removal action, the excavated areas will be backfilled with clean soil from a clean off-site source. The area will be prepared and seeded with grass to minimize the potential for erosion.

The removal of soils containing lead and chromium at concentrations above their respective RALs will reduce the average lead concentration at the NBG below the USEPA's residential screening level of 400 mg/kg and the 95th upper concentration limit (UCL) for chromium to below the residential soil screening level of 230 mg/kg. The residual risks and hazards at the site will be within the USEPA's acceptable risk range for residential land use scenarios; therefore, the requirements of a residential level closure will be achieved. There will be no need for continued monitoring or restrictions on the long term development of the site. The approximate life cycle cost for this action is $238,000.

6. Statutory and Regulatory Authority

The proposed removal action at the NBG is being undertaken by the United States Army as part of the Installation Restoration Program (IRP) at Radford Army Ammunition Plant. The remediation activities at the NRU are being managed under CERCLA, with the Virginia Department of Environmental Quality (VDEQ) as the lead review agency. The investigation, reporting, and remedial actions conducted at the

NRU are being conducted in accordance with the requirements outlined in National Oil and Hazardous Substances Pollution Contingency Plan (aka National Contingency Plan [NCP]), 40 Code of Federal Regulations (CFR) Part 300.

The NBG site presents a relatively time-sensitive, non-complex problem that can and should be addressed relatively cost effectively. Based on the considerations outlined in 40 CFR 300.415(b)(2)(iv), the removal action proposed for the NBG within the EE/CA is appropriate due to the presence of elevated levels of hazardous substances (i.e., chromium and lead) in soils that are largely at or near the surface which could potentially migrate to adjacent soils, drainage ditch sediments, and groundwater. The proposed removal action at the NBG will comply with all ARARs outlined in the EE/CA.

7. Public Participation

Following VDEQ review, the EE/CA for the Northern Burning Ground site was made available for public review and comment beginning September 20, 2009 at the Christiansburg Branch of the Montgomery-Floyd Regional Library System. The Notice of Availability for the EE/CA was published on September 20, 2009 in the Sunday Edition of the Roanoke Times. A public meeting was also held on October 14, 2009 at the New River Competitiveness Center located at 6580 Valley Center Drive in Radford, Virginia, that provided an opportunity for public comment on the EE/CA. No member of the public attended this meeting. The public comment period remained open until October 20, 2009. No written or verbal comments were received from any members of the public during the open comment period.

8. Recommendation

The Virginia Department of Environmental Quality (VDEQ) has endorsed the EE/CA for the Northern Burning Ground site at the RAAP-NRU. Based on the analysis of the available alternative presented within the EE/CA, the recommended soil removal action is appropriate and will be implemented in accordance with CERCLA and the applicable ARARs. This action will be the final required remedial action for the site.

Antonio Munera,
LTC, CM
Commanding

20 Nov 2009
Date

Attachments:

1) ARCADIS 2009. Final Engineering Evaluation/Cost Analysis for the Northern Burning Ground, New River Unit (RAAP-044), Radford Army Ammunition Plant, Radford, Virginia. July.

Legals

PUBLIC NOTICE OF AVAILABILITY

CERCLA Engineering Evaluation / Cost Analysis for the Northern Burning Ground at the Radford Army Ammunition Plant

PURPOSE OF NOTICE: The US Army Radford Army Ammunition Plant (RFAAP) announces the availability of a document relating to the installation restoration activities at the Northern Burning Ground (NBG) located within the New River Unit.

FACTILITY NAME AND LOCATION: The Northern Burning Ground is located within the New River Unit of the RFAAP which is about six miles west of the main facility, near the town of Dublin, Virginia. The NBG is located in the northwest portion of the New River Unit. Burning operations were conducted directly on the ground surface at the NBG in the past.

PROJECT DESCRIPTION: The Engineering Evaluation/Cost Analysis (EE/CA) is a document that evaluates three cleanup alternatives for soils at the NBG. The alternatives include: 1) a no action alternative as required to establish a baseline to compare the other alternatives; 2) excavation and off-site disposal of soil containing lead and chromium to achieve industrial closure; and 3) excavation and off-site disposal of soil containing lead and chromium to achieve residential closure. The recommended alternative is excavation and off-site disposal of soil containing lead and chromium to achieve residential closure. This alternative is preferred because it is most protective of human health and the environment and eliminates the need for maintaining long-term land-use controls.

TO REVIEW THE EE/CA: The public may view the document at the Christiansburg Branch of the Montgomery-Floyd Regional Library System during normal library hours.

Legals

PUBLIC COMMENT PERIOD: Public comments will be received for 30 days beginning September 20, 2009 ending October 20, 2009.

HOW TO COMMENT: Radford Army Ammunition Plant will accept comments by e-mail, fax, or postal mail. All comments must include the name, address, and telephone number of the person commenting and be received by the Army within the designated comment period. All comments must be directed to Joy Case, Public Affairs Officer, Radford Army Ammunition Plant, Route 114, Peppers Ferry Road, Building 220, Radford, VA 24141-0099; phone (540) 731 5762; fax (540) 639-7789; e-mail joy.case@us.army.mil.

PUBLIC MEETING: A public meeting will be held on October 14, 2009 from 7:00 pm to 8:00pm at the New River Competitiveness Center located at 6580 Valley Center Dr., Radford VA, 24141.

HOW THE DECISION IS MADE: Following the public comment period, all comments will be reviewed and considered. The selected alternative will be documented in an Action Memorandum, which will be made available to the public later this year. The final remediation decision will be made jointly by the Army and the Virginia Department of Environmental Quality.

(11670014)

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L. Preston Bryant, Jr.
Secretary of Natural Resources

David K. Paylor
Director

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

August 20, 2009

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

Re: EE/CA, NBG-New River Unit (RAAP-044), Radford Army Ammunition Plant

Dear Mr. McKenna:

The Virginia Department of Environmental Quality (VDEQ) has reviewed the Engineering Evaluation/Cost Analysis for the Northern Burning Ground in the New River Unit dated July 2009 and approves the report as finalized.

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

James L. Cutler, Jr., CPG
Federal Facilities Project Manager

cc: Paige Holt, ATK
Durwood Willis, VDEQ
Beth Lohman, VDEQ-BRRO

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

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August 14, 2009

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

Subject: Transmittal Acknowledgement, Engineering Evaluation/Cost Analysis Northern Burning Ground, New River Unit (RAAP-044), July 2009
EPA ID# VA1 210020730

Dear Mr. Cutler:

This letter is to acknowledge transmittal of the subject document that was sent to you on July 30, 2009. Enclosed is a copy of the 30 July 2009 transmittal email as well as our response to your comments. We anticipate approval of this report.

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

Sincerely,

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

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

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IMAE-CDN
Rock Island, Illinois 61299

09-815-134
JMcKenna

Tom Meyer
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10 South Howard Street
Baltimore, MD 21201

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bc: Administrative File
J. McKenna, ACO Staff
Rob Davie-ACO Staff
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Comments and Responses on the
Draft Northern Burning Ground EE/CA
New River Unit RFAAP 044
Radford Army Ammunition Plant
January 2009

Item No.	Report Reference	COMMENT	RESPONSE
Commenter: Ahmet Bulbulkaya (VDEQ) – April 10, 2009 Memorandum to Jim Cutler			
1	Page 8, Section 2.3.1	Early in the text of the EE/CA the authors explain that two human health risk assessments were conducted; one on current conditions and one based on conditions following potential future removal actions. The ecological risk assessment follows this same approach. The problem with this approach is that often removal plans change. If the removal plans change then the conclusions of the risk assessment, which was based on the original removal plans, are called into question. Strictly speaking each time the removal plans are altered a new risk assessment should be performed that corresponds to the new potential future conditions. This could lead to a very long iterative cycle of risk assessments being produced, submitted and reviewed. To avoid this situation, only the ecological and human health risk assessment based on current conditions will be considered for this site. This will also be the case for other New River Unit sites that reach the risk assessment phase.	*Agreed. The EE/CA will be revised to remove the discussion of the risk assessment results based on the hypothetical "post removal action" scenario.*

Comments and Responses on the
Draft Northern Burning Ground EE/CA
New River Unit RFAAP 044
Radford Army Ammunition Plant
January 2009

Item No.	Report Reference	COMMENT	RESPONSE
2	General	The removal is being planned without any consideration of groundwater conditions. There is a well in the middle of the site (NBG-MW-01) and to ignore the well because "groundwater at the RFAAP-NRU is being investigated on a facility-wide basis" is not adequate rationale for not presenting and/or discussing historical well monitoring results. It would seem that the extent of possible groundwater impacts by site-related constituents should have some bearing on the degree and extent of the planned soil removal.	*There are two monitoring wells located at the Northern Burning Ground (NBG-MW01 and NBG-MW02). Groundwater samples have been collected from these wells as part of the facility-wide groundwater investigation at the RFAAP-NRU. The analytical results from the groundwater samples indicate that there have been no adverse effects observed in groundwater as a result of historic operations, including within the two wells located at the NBG. ARCADIS will include a brief discussion of the monitoring results from the NBG wells within the EE/CA. However, it should be noted that groundwater at the RFAAP-NRU has been investigated as a facility-wide resource at this site, and is not specific to the NBG. Therefore, groundwater should have no bearing on the remedial action being proposed for soil at the NBG within this EE/CA.*
3	Section 3.4.	For lead the "area-average" approach for attaining cleanup goals for the site seems appropriate as well as the Iterative Truncation Method used to develop Remedial Action Levels (RALs). However RALs should be developed for chromium as well as lead. They should be based on a site-wide 95% UCL and not the "area-average".	*The Iterative Truncation Method will also be used to develop the RAL for chromium, in the same manner that it was used for lead, except that the selected RAL will ensure that the 95th UCL of the remaining sample concentrations will not exceed the PRG.*

Comments and Responses on the
Draft Northern Burning Ground EE/CA
New River Unit RFAAP 044
Radford Army Ammunition Plant
January 2009

Item No.	Report Reference	COMMENT	RESPONSE
4	Figure 4-2	The estimated footprint of the excavation that was selected and presented in this figure will have to be re-evaluated. There appears to be a relative paucity of data in the more contaminated areas of the site. This, along with having so much more data collected in the un-impacted peripheral areas of the site, is most likely skewing the calculation of the lead RAL downward thereby resulting in a smaller excavation footprint than is warranted. It was also noted that there were two XRF sample points exceeding the RAL of 3,000 ppm for lead outside of the proposed footprint. These were 1S1W (5,430 ppm) and 9S0W (11,000 ppm). Also, NBGDW4 is designated as a Historical Sample with concentrations below 400 ppm of lead in Figure 4-2 while in Figure 2-1 it is indicated that it is a Historic TCLP sample that should not be included in the derivation of the footprint or the RAL and final area average. These discrepancies should be resolved and considered in the re-evaluation of the planned area of excavation.	*Please see response to Item No. 9. The excavation area for Alternative 3 has been expanded to include areas that lacked sufficient data and historical sample locations that had lead concentrations above 3,000 mg/kg (e.g. XRF sample location 1SW1).* *Please note that the expanded excavation area does not encompass historical sample location 9SOW. While the XRF data from this point indicated a lead concentration of 11,000 ppm, other data points collected immediately adjacent to this point had concentrations far below the RAL of 3,000 mg/kg. During the February 19, 2009 partnering meeting in Baltimore, Mr. Cutler agreed that this sample appeared to be an anomaly and would not need to be included in the excavation area.*
5	Appendix B: Human Health Risk Assessment	As stated in the above comments, it does not seem to be appropriate to conduct a risk assessment on future post-removal conditions. Only a base-line HHRA should be conducted.	*Agreed. The discussion of the hypothetical post removal conditions will be removed from the HHRA.*

Comments and Responses on the
Draft Northern Burning Ground EE/CA
New River Unit RFAAP 044
Radford Army Ammunition Plant
January 2009

Item No.	Report Reference	COMMENT	RESPONSE
6	Appendix B: Human Health Risk Assessment Page 14, last paragraph	In this paragraph it states that once the removal is completed the maximum concentration of lead will be 348 mg/kg. This contradicts Section 3.4 of the EE/CA which provides the RAL of 3,000 ppm (which allows for concentrations up to 3,000 ppm to remain on site). This appears to demonstrate that what the EE/CA considers post-removal conditions is not the same as what the HHRA considers post-removal conditions and also demonstrates the potential problems of conducting a risk assessment on potential future conditions.	*This paragraph was in error and was intended to say that once the removal is completed, the remaining arithmetic mean concentration for lead will be 343 mg/kg. This text will be corrected.*
7	Appendix B: Human Health Risk Assessment Tables	Please submit an intermediate table(s) that includes the risk algorithms between the selection of the COPCs and the tabulation of the carcinogenic and non-carcinogenic risk levels. Also, please include a table with the non-carcinogenic and carcinogenic toxicity values that were used in the risk assessment. There is a discrepancy with the non-carcinogenic risk presented for chromium in Table B-6. 12.6 is reported as the HQ but 25.6 was calculated by VRP risk spreadsheets. Without the additional information the source of the discrepancy cannot be determined.	*As shown in Table B-5 of the HHRA, the risk assessment was conducted using a ratio approach rather than forward risk calculations. To derive the cancer risk estimate, the Regional Screening Level for the cancer endpoint (cRSL), which was based on a $1x10^{-6}$ risk level, was compared with the calculated, site-specific exposure point concentration (EPC) to estimate potential risk using the following ratio:* *Cancer risk = $(EPC*1x10^{-06})/(cRSL)$.* *Similarly, the potential noncancer hazard was calculated by comparing the Regional Screening Level for the noncancer endpoint (ncRSL), which was based on a Hazard Index of 1, with the EPC using the following equation:* *Noncancer hazard = (EPC*1)/(ncRSL).* *Thus, by default, the toxicity values upon which they are based are the same as those used to derive the RSLs. This point will be clarified in the text and the above equations will be presented and explained.*

Comments and Responses on the
Draft Northern Burning Ground EE/CA
New River Unit RFAAP 044
Radford Army Ammunition Plant
January 2009

Item No.	Report Reference	COMMENT	RESPONSE
8	Appendix C: Ecological Risk Assessment	The predominant issue with the ERA is that it contains an ERA based on future conditions and attempts to quantitatively demonstrate that ecological risk is acceptable based on this predictive risk assessment. Otherwise the methodology and methods employed seemed appropriate.	*The ERA will be modified to exclude the discussion of potential ecological risks under post-removal conditions and to provide a discussion of the screening level ecological risks under current conditions and the constituents of potential concern in relation to the planned removal action.*
Commenter: Jim Cutler (VDEQ)			
9	Proposed Excavation Areas	Mr. Cutler provided a markup of a site map to depict the area he believed should be included in the proposed remedial action in order to achieve residential closure of the site (Alternative 3). Mr. Cutler's map is attached to this RTC as Attachment 1.	*Based on discussions with Mr. Cutler during the February 19, 2009 partnering meeting in Baltimore, MD and the June 23, 2009 partnering meeting in Philadelphia, PA. ARCADIS agreed to expand the excavation area for Alternative 3 in order to achieve the stated remedial action level of 3,000 mg/kg for lead.* *Within the EE/CA ARCADIS has proposed to collect confirmation samples during the excavation process to make sure the target RAL of 3,000 mg/kg is achieved. The excavation area will be expanded if the confirmation sampling indicates that it is warranted.*

Greene, Anne

From: McKenna, Jim
Sent: Thursday, July 30, 2009 3:46 PM
To: ealohman@deq.virginia.gov; Druck, Dennis E Mr CIV USA MEDCOM CHPPM; diane.wisbeck@arcadis-us.com; durwood willis2; Geiger.William@epamail.epa.gov; Redder, Jerome; jim spencer; jlcutler@deq.virginia.gov; kjsismour@deq.virginia.gov; Llewellyn, Tim; Mendoza, Richard R Mr CIV USA IMCOM; Meyer, Tom NAB02; Parks, Jeffrey N; Timothy.Leahy@shawgrp.com; Tina_Devine@URSCorp.com
Subject: Tracking Numbers for the NRU NBG EE/CA (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.

Certification letter will follow from Radford AAP under separate cover.

Immediately below are the POCs with tracking numbers:

James McKenna - 7978 0620 1997: 2 Paper copies/2 CDs

Richard Mendoza - 7968 1896 7703:1 Paper copy/1 CD

Susan Ryan - 7978 0622 6155: 1 CD

Tom Meyer - 7978 0623 9486: 1 Paper copy/1 CD

Dennis Druck - 7968 1900 1892: 1 Paper copy

James Cutler - 7968 1902 0052: 1 Paper copy/1 CD

Elizabeth Lohman - 7978 0631 8403: 1 CD

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

Jim McKenna

Classification: UNCLASSIFIED
Caveats: FOUO

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

14 AUG 2009

MCHB-TS-REH

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

SUBJECT: Draft Engineering Evaluation/Cost Analysis Report for Northern Burning Ground, New River Unit (RAAP-044), Radford Army Ammunition Plant, Virginia, July 2009

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

2. Our previous comments have been addressed and we concur with the recommended removal action as being protective of human health and the environment.

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

FOR THE COMMANDER:

JEFFREY S. KIRKPATRICK
Director, Health Risk Management

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

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

15 APR 2009

MCHB-TS-REH

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

SUBJECT: Document Titled: "Draft Engineering Evaluation/Cost Analysis Report for Northern Burning Ground, New River Unit (RAAP-044), Radford Army Ammunition Plant, Virginia, March 2009"

1. The US Army Center for Health Promotion and Preventive Medicine reviewed the subject document on behalf of the Office of The Surgeon General pursuant to Army Regulation 200-1 (Environmental Protection and Enhancement). We appreciate the opportunity to review this report and concur with the revisions made to address our previous comments.

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

FOR THE COMMANDER:

JEFFREY S. KIRKPATRICK
Director, Health Risk Management

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

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

WASTE DIVISION
OFFICE OF REMEDIATION PROGRAMS

MEMORANDUM

TO: Jim Cutler

CC: Pat McMurray, Karen Sismour

FROM: Ahmet Bulbulkaya

DATE: April 10, 2009

SUBJECT: Engineering Evaluation/Cost Analysis, Northern Burning Ground, New River Unit, Radford Army Ammunition Plant

I have reviewed the subject Engineering Evaluation/Cost Analysis (EE/CA) as well as the attached Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) and have the following comments:

EE/CA:

1. Early in the text of the EE/CA (Page 8, Section 2.3.1) the authors explain that two human health risk assessments were conducted; one on current conditions and one based on conditions following potential future removal actions. The ecological risk assessment follows this same approach. The problem with this approach is that often removal plans change. If the removal plans change then the conclusions of the risk assessment, which was based on the original removal plans, are called into question. Strictly speaking each time the removal plans are altered a new risk assessment should be performed that corresponds to the new potential future conditions. This could lead to a very long iterative cycle of risk assessments being produced, submitted and reviewed. To avoid this situation, only the ecological and human health risk assessment based on current conditions will be considered for this site. This will also be the case for other New River Unit sites that reach the risk assessment phase.

2. The removal is being planned without any consideration of groundwater conditions. There is a well in the middle of the site (NBG-MW-01) and to ignore the well because "groundwater at the RFAAP-NRU is being investigated on a facility-wide basis" is not adequate rationale for not presenting and/or discussing historical well monitoring results. It would seem that the extent of possible groundwater impacts by site-related constituents should have some bearing on the degree and extent of the planned soil removal.

3. Section 3.4: For lead the "area-average" approach for attaining cleanup goals for the site seems appropriate as well as the Iterative Truncation Method used to develop Remedial Action Levels (RALs). However RALs should be developed for chromium as well as lead. They should be based on a site-wide 95% UCL and not the "area-average".

4. Figure 4-2: The estimated footprint of the excavation that was selected and presented in this figure will have to be re-evaluated. There appears to be a relative paucity of data in the more contaminated areas of the site. This, along with having so much more data collected in the unimpacted peripheral areas of the site, is most likely skewing the calculation of the lead RAL downward thereby resulting in a smaller excavation footprint than is warranted. It was also noted that there were two XRF sample points exceeding the RAL of 3,000 ppm for lead outside of the proposed footprint. These were 1S1W (5,430 ppm) and 9S0W (11,000 ppm). Also, NBGDW4 is designated as a Historical Sample with concentrations below 400 ppm of lead in Figure 4-2 while in Figure 2-1 it is indicated that it is a Historic TCLP sample that should not be included in the derivation of the footprint or the RAL and final area average. These discrepancies should be resolved and considered in the re-evaluation of the planned area of excavation.

Appendix B: Human Health Risk Assessment

5. As stated in the above comments, it does not seem to be appropriate to conduct a risk assessment on future post-removal conditions. Only a base-line HHRA should be conducted.

6. Page 14, last paragraph: In this paragraph it states that once the removal is completed the maximum concentration of lead will be 348 mg/kg. This contradicts Section 3.4 of the EE/CA which provides the RAL of 3,000 ppm (which allows for concentrations up to 3,000 ppm to remain on site). This appears to demonstrate that what the EE/CA considers post-removal conditions is not the same as what the HHRA considers post-removal conditions and also demonstrates the potential problems of conducting a risk assessment on potential future conditions.

7. Table section: Please submit an intermediate table(s) that includes the risk algorithms between the selection of the COPCs and the tabulation of the carcinogenic and non-carcinogenic risk levels. Also, please include a table with the non-carcinogenic and carcinogenic toxicity values that were used in the risk assessment. There is a discrepancy with the non-carcinogenic risk presented for chromium in Table B-6. 12.6 is reported as the HQ but 25.6 was calculated by VRP risk spreadsheets. Without the additional information the source of the discrepancy cannot be determined.

Appendix C: Ecological Risk Assessment:

8. The predominant issue with the ERA is that it contains an ERA based on future conditions and attempts to quantitatively demonstrate that ecological risk is acceptable based on this predictive risk assessment. Otherwise the methodology and methods employed seemed appropriate.

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

13 FEB 2009

MCHB-TS-REH

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

SUBJECT: Document Titled: "Draft Engineering Evaluation/Cost Analysis for the Northern Burning Ground, New River Unit (RAAP-044), Radford Army Ammunition Plant, Virginia, January 2009"

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

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

FOR THE COMMANDER:

Jeffrey S. Kirkpatrick

Encl

JEFFREY S. KIRKPATRICK
Director, Health Risk Management

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

COMMENTS AND RECOMMENDATIONS
Draft Engineering Evaluation/Cost Analysis for the Northern Burning Ground, New River Unit (RAAP-044), Radford Army Ammunition Plant, Virginia, January 2009

1. Page ES-2, Executive Summary
   Site History and Characterization
   Comment: The last sentence of the last paragraph of this section does not make the distinction that chromium was only found to pose a non-cancer hazard for the hypothetical residential land use scenario.
   Recommendation: Please consider rewriting the sentence to make clear that chromium only presented a health hazard for residential land use as was done in the last sentence of section 2.4 on page 10.

2. Page ES-5, Executive Summary and Page 29, Section 6
   Recommended Removal Action Alternative
   Comment: Nothing is said here concerning how the recommended removal action will reduce the potential for adverse impacts from exposure of ecological receptors to the current surface soil.
   Recommendation: Suggest addressing the impact that the planned removal action will have on the potential for adverse ecological impacts as indicated by elevated HQs for exposure to current soil conditions.

3. Appendix B, Page 9, Section 4.2.2
   Hypothetical Future Resident
   Comment: The statement is made that the RSLs for noncarcinogens are derived based on exposure by young children. This is only correct for the soil pathway as the other residential pathways use the 30-year combined adult and child resident to determine the noncancer RSLs.
   Recommendation: Although only the soil pathway is evaluated in this risk assessment, for clarity, please insert the word "soil" before "RSLs" in this section.

4. Appendix B, Page 15, Section 6
   Summary and Conclusions
   Comment: In the second and third paragraph of this section reference is made to potential "risks and hazards" being within the USEPA target risk range.
   Recommendation: It would be more accurate to just state that "risks" were within the target risk range.

5. Appendix C, Page 2-6, Section 2.1.1.6; Tables C-4 and C-5
   Description of Potentially Exposed Receptors
   Comment: The receptors are identified as terrestrial plants and wildlife including mammals, birds, reptiles, and invertebrates. Although there are USEPA Eco-SSLs for plants, soil invertebrates, avian, and mammalian, Tables C-4 and C-5 only show one Eco-SSL for each chemical of concern. It appears from the tables that only the Eco-SSLs for plants were used. How does this provide a representative screen for the terrestrial wildlife when for instance

Enc 2

cadmium and copper have avian (0.77, 28 mg/kg) and mammalian (0.36, 49 mg/kg) Eco-SSLs that are lower than the plant Eco-SSLs (32, 70 mg/kg)? It is also not clear why the USEPA Eco-SSLs for plants were chosen when most of the Region 5 ESLs for soil that were used are based on exposure to a masked shrew. It should also be pointed out in the text that although this risk assessment lists reptiles as potentially exposed receptors, there are no or very few screening values available.

Recommendation: Suggest that the ecological screening risk assessment include, when available, the Eco-SSLs for terrestrial plants and the three categories of terrestrial wildlife. Or if only one Eco-SSL is to be used to represent both plant and wildlife, then at least use the most conservative value. In any event, the text needs to describe and justify in more detail how the USEPA Eco-SSLs were selected.

6. Appendix C, Page 3-2, Section 3
   Conclusions and Summary

   Comment: The last paragraph states that impacts to terrestrial receptors are unlikely or are not ecologically significant without stating that this is only true after the soil removal action to protect human health has been taken.

   Recommendation: Suggest qualifying this statement by referring to the removal action.

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

www.atk.com

January 30, 2009

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

Subject: Draft Engineering Evaluation / Cost Analysis, Northern Burning Ground, New River Unit (RAAP-044), Radford Army Ammunition Plant, January 2009
EPA ID# VA1 210020730

Dear Mr. Cutler:

This is to acknowledge that the subject document was sent to you on January 16, 2009. Enclosed is a copy of the 16 January 2009 transmittal email message.

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
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Rob Davie-ACO Staff
M.A. Miano
P.W. Holt
J. J. Redder
Env. File

Coordination: J. McKenna

09-815-10
JMcKenna

Greene, Anne

From: McKenna, Jim
Sent: Friday, January 16, 2009 3:12 PM
To: Greene, Anne; ealohman@deq.virginia.gov; Druck, Dennis E Mr CIV USA MEDCOM CHPPM; diane.wisbeck@arcadis-us.com; durwood willis2; Geiger.William@epamail.epa.gov; Redder, Jerome; jim spencer; jlcutler@deq.virginia.gov; kjsismour@deq.virginia.gov; Llewellyn, Tim; Mendoza, Richard R Mr CIV USA IMCOM; Meyer, Tom NAB02; Parks, Jeffrey N; Timothy.Leahy@shawgrp.com; Tina_Devine@URSCorp.com
Subject: Draft Northern Burning Ground Environmental Engineering / Cost Analysis (EE/CA), Radford Army Ammunition Plant, January 2009. (UNCLASSIFIED)

Importance: High

Classification: UNCLASSIFIED
Caveats: NONE

All:

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

Follow up letter will be sent from Radford AAP under separate cover.

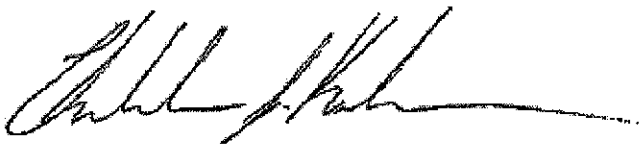
Thank you in advance for support of the Radford AAP Installation Restoration Program.

Jim McKenna

Below are the POCs with tracking numbers:

James McKenna	7972 5822 6329
Richard Mendoza	7962 6181 0988
Tom Meyer	7972 5825 1812
Dennis Druck	7962 6184 7334
James Cutler	7962 6187 7359
Karen Sismour	7979 5832 5862
Elizabeth Lohman	7962 6196 2120

Classification: UNCLASSIFIED
Caveats: NONE



Christopher Kalinowski
Site Manager

Diane D. Wisbeck
Deputy Project Manager

Tim Llewellyn
Project Manager

Northern Burning Ground Engineering Evaluation/Cost Analysis (EE/CA)

Radford Army Ammunition Plant

Prepared for:
U.S. Army

Prepared by:
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Our Ref.:
GP08RAAP.0044

Date:
July 2009

Table of Contents

Tables

Figures

Appendices

Acronyms and Abbreviations

AEC	U.S. Army Environmental Command
ARAR	Applicable or Relevant and Appropriate Requirements
BDDT	Building Debris Disposal Trench
BERA	Baseline Ecological Risk Assessment
bgs	Below Ground Surface
BLA	Bag Loading Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Constituent of Concern
CY	Cubic yard
EE/CA	Engineering Evaluation/Cost Analysis
ELCR	Excess Lifetime Cancer Risk
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ESL	Ecotoxicity Screening Level
FS	Feasibility Study
ft	Feet
ft msl	Feet Above Mean Sea Level
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IAA	Igniter Assembly Area
LUCs	Land Use Controls
MMA	Main Manufacturing Area
NBG	Northern Burning Ground
NCP	National Contingency Plan
NROW	New River Ordinance Works
NRU	New River Unit
PAH(s)	polycyclic aromatic hydrocarbon
PBC	Performance Based Contract
PCB	polychlorinated biphenyl
QAPA	Draft Quality Assurance Plan Addendum
RAL	Remedial Action Level
RAO	Removal Action Objective
RFAAP	Radford Army Ammunition Plant
RI	Remedial Investigation
RSL	Regional Screening Levels
SACM	Superfund Accelerated Cleanup Model
SARA	Superfund Amendments and Reauthorization Act
SLERA	Screening-Level Ecological Risk Assessment
SMDP	Scientific Management Decision Point
SVOC	semi-volatile organic compound
UTL	Upper Tolerance Limit

USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
WBG	Western Burning Ground

EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis (EE/CA) was prepared to evaluate the Non-Time Critical Removal Action (removal action) alternatives planned to address impacted soils at the Northern Burning Ground (NBG). The NBG is one of six Study Areas that have been identified at the Radford Army Ammunition Plant (RFAAP), New River Unit (NRU). The NBG has been selected for the removal action based on the fact that the contamination at this site has been adequately characterized and delineated, and soil contamination is present at levels that exceed human health and ecological risk thresholds. Performing this removal action would be consistent with the Superfund Accelerated Cleanup Model (SACM). This EE/CA identifies the objectives of the removal action for the NBG, presents the various alternatives to satisfy the removal action objectives, and recommends the most appropriate alternative.

Introduction and Background

Radford Army Ammunition Plant is planning a removal action to address impacted soils that have been identified at the NBG at the RFAAP-NRU facility. The RFAAP facility is located in the mountains of southwestern Virginia and consists of two noncontiguous units: the NRU and the Main Manufacturing Area (MMA). The MMA is located approximately 5 miles northeast of the City of Radford, Virginia. The NRU is located about six miles west of the MMA, near the town of Dublin, Virginia. The NBG removal action is being conducted under the guidance of the U.S. Environmental Protection Agency (USEPA) and the Virginia Department of Environmental Quality (VDEQ) pursuant to the authorities and procedures provided for under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Contingency Plan (NCP). The removal action proposed in this EE/CA will be the final remedy for the NBG and a component of the final remedy for the RFAAP-NRU.

Groundwater at the RFAAP-NRU has been investigated on a facility-wide basis. Groundwater data collected from two monitoring wells at the NBG will be incorporated into the facility-wide data set and evaluated during the RI/FS process for the overall RFAAP-NRU facility.

Site History and Characterization

The RFAAP-NRU was established in 1940, and was originally known as the New River Ordinance Works (NROW). The NROW was incorporated into the RFAAP in 1945. The RFAAP-NRU facility operated as a bag manufacturing and loading plant for

artillery, cannon, and mortar projectiles during World War II. Although active manufacturing activities at the RFAAP-NRU were reported to have ceased in the 1940's (after World War II), portions of the RFAAP-NRU are still utilized as storage facilities for operations at the MMA.

The NBG is located in the northwest portion of the RFAAP-NRU, east of Gate 20, along Guard Road. Anecdotal evidence suggests that burning operations may have been conducted at the NBG in the past to remove energetics from metal components used in the former manufacturing activities at the site. No buildings have existed at the NBG site; burning operations were conducted directly on the ground surface. The majority of the area identified as the NBG is now heavily wooded, with the exception of a small area in the central portion of the site where burning operations are believed to have been performed. This central portion of the site has a grass and shrub groundcover and a few small trees. Little to no visible evidence of past burning activities is apparent.

Several rounds of environmental investigations were conducted at the NBG between 1997 and 2008 to characterize the nature and extent of the impacts associated with the former operations at the NBG site. The findings from these investigations indicate that soils in the former burn area of the site contain levels of several metals (e.g. arsenic, chromium, and lead) at levels that exceed human health and ecological risk screening values. PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene], PCBs (Aroclor-1254), and dioxins/furans (2,3,4,7,8-PeCDF; 2,3,7,8 TCDF; OCDD) have also been detected in a limited number of samples at levels that exceed human health and ecological screening values; although the extent of these constituent detections is limited in comparison to the metals. Further evaluation of the available data within the site specific human-health risk assessment concluded that lead in surface soils presented a risk under current and hypothetical future industrial and residential land use scenarios. Chromium was also found to present a non-cancer hazard under a hypothetical future residential land use scenario. As such, lead and chromium were determined to be the only drivers for remedial action at the NBG.

Identification of Removal Action Objectives

The following removal action objectives (RAOs) were determined for the NBG removal action:

- Minimize the potential for exposure to impacted soils contaminated at levels exceeding remedial action levels appropriate for the current and/or reasonably anticipated future land uses of the site.

- Minimize the potential for contaminants present in surface soil to migrate to other areas.

Relevant federal, state, and facility requirements were reviewed to determine applicable or relevant and appropriate requirements (ARARs) that could apply to the removal action and would need to be achieved by the removal action alternatives.

Identification and Analysis of Removal Action Alternatives

Three alternatives were developed for addressing the impacted soils present at the NBG. In accordance with CERCLA requirements, the No Action Alternatives was considered among the presented alternatives. The other alternatives were selected based on their ability to protect human health and the environment and to comply with the ARARs. A summary of the major components for each of the alternatives is as follows:

- **Alternative 1 – No Additional Action**. No additional action would be performed at the NBG under this alternative. All impacted soils would be left in place and there would be no change in the risks associated with the site.

- **Alternative 2 – Excavation, Off-Site Stabilization, and Disposal of Impacted Soils to Achieve Industrial Level Closure.** This alternative proposes to excavate impacted soils and dispose of the material off-site at an approved disposal facility. The excavation would be performed to remove the impacted surface soils from the former burning ground to a level sufficient to achieve an industrial risk level closure for the site. This option would necessarily include the use of Land Use Controls (LUCs) to control the future use of the area to industrial only without further actions.

- **Alternative 3 – Excavation, Off-Site Stabilization, and Disposal of Impacted Soils to Achieve Residential Level Closure.** This alternative is very similar to Alternative 2 in that it involves the excavation and off-site disposal of the impacted soils. However, the footprint of the excavation operation would be expanded to achieve a residential risk level closure for the site. There would be no need for future LUCs under this option.

Other possible removal action alternatives involving on-site treatment were not developed based on treatability and economic considerations associated with relatively small volume of impacted material at the site.

The three proposed alternatives were screened using the following criteria in accordance with the USEPA's Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA (USEPA, 1993):

- **Effectiveness** - The ability of the alternative to meet the removal action objectives, be protective of human health and the environment, and comply with the proposed ARARs. Considerations include the reduction of toxicity, mobility, and/or volume of contaminant through treatment, as well as a reduction in the risk to remediation workers.

- **Implementability** - The measure of technical feasibility; administrative feasibility to construct, operate and maintain the alternative method; and the local availability of services and materials.

- **Cost** - The net present worth of the alternative to include capital expenditures (labor, materials, and other construction costs), annual operation and maintenance costs, and periodic costs (e.g., equipment replacement, 5-year reviews).

Comparative Analysis of Alternatives

For the comparative analysis of the alternatives, each alternative was compared against the others using the criteria of effectiveness, implementability, and cost in meeting the remedial action objectives for the current and reasonably anticipated future use. Alternative 1 is not considered effective because the alternative does not perform any removal action and is not protective of the public health and environment. Because no action is being implemented, the ARARs and removal objectives are not met. No costs are associated with this alternative.

Alternatives 2 and 3 provide methods to achieve ARARs and provide a reduction in risk. Both alternatives can be readily implemented and will not expose the community, Installation workers, or the environment to unacceptable additional risk. In comparing the alternatives, there is a higher capital cost associated with Alternative 3; however, land use restrictions will not need to be applied to the site as with Alternative 2. Alternative 2 also has long term inspection and/or maintenance requirements associated with them that would have the potential to drive up future costs.

Alternatives 2 and 3 provide a permanent reduction in the risk levels associated with the site.

Recommended Removal Action Alternative

The removal action recommended for the NBG Removal Action is Alternative 3 – Excavation and Disposal of Impacted Soils to Achieve Residential Closure. Although the current and reasonably anticipated future use of the area is industrial, and CERCLA only requires remediation to the reasonably anticipated future use, a cost benefit analysis indicates that in this specific case it is to the Army's advantage to remediate to residential levels and eliminate the need for long term monitoring of LUCs. The recommended removal action will also effectively minimize the spatial distribution of the COPECs remaining on-site such that the potential for adverse ecological effects would be unlikely. This alternative was selected in accordance with the guidelines and procedures outlined in USEPA guidance (USEPA, 1993) and the requirements of the NCP (40 CFR 300). The excavation and disposal of the impacted soil would be the most protective of public health and the environment, achieve the removal action objectives, and comply with ARARs. The life-cycle costs associated with Alternative 3 were also less than those for Alternative 2.

1. Introduction

ARCADIS U.S., Inc. (ARCADIS) has been retained by the United States Army Environmental Command (AEC) to perform Installation Restoration Program (IRP) activities at the Radford Army Ammunition Plant (RFAAP). The RFAAP facility is located in the mountains of southwestern Virginia and consists of two noncontiguous units: the New River Unit (NRU) and the Main Manufacturing Area (MMA). The MMA is located approximately 5 miles northeast of the City of Radford, Virginia. The NRU is located about six miles west of the MMA, near the town of Dublin, Virginia (Figure 1-1). The IRP activities for both the RFAAP-MMA and the NRU are being conducted as part of a Performance Based Contract (PBC) awarded to ARCADIS under contract W91ZLK-05-D-0015: Task Order 0002. The RFAAP-NRU is managed under the Comprehensive Environmental Response and Compensation Liability Act (CERCLA).

ARCADIS has prepared this Engineering Evaluation/Cost Analysis (EE/CA) to evaluate alternatives for addressing impacted soils at the Northern Burning Ground (NBG). The NBG is one of six study areas that have been identified at the RFAAP-NRU. The other study areas include the Building Debris Disposal Trench (BDDT), the Bag Loading Area (BLA), the Igniter Assembly Area (IAA), the Rail Yard (RY), and the Western Burning Ground (WBG). Figure 1-2 depicts the layout of the six study areas within the RFAAP-NRU. Groundwater at the RFAAP-NRU is being investigated on a facility-wide basis; as such, the groundwater data collected at the NBG and other study areas will be addressed during the RI/FS process for the overall facility, rather than specific to an individual study area.

1.1 Purpose and Objectives

The purpose of this EE/CA is to: (1) satisfy the environmental review requirements for removal actions; (2) satisfy the administrative record requirements for documenting the selection of removal actions; and (3) provide a framework for evaluating and selecting remedial alternatives for addressing the impacted soils at the NBG. In doing so, the EE/CA identifies the objectives of the NBG removal action and analyzes the effectiveness, implementability, and cost of various alternatives that may satisfy these objectives.

Metals, polycyclic aromatic hydrocarbons (PAHs), and the polychlorinated biphenyl (PCB) Aroclor-1254 have been detected in soil at the NBG at concentrations exceeding background concentrations and the health based screening levels for residential and industrial soil developed by the United States Environmental Protection

Agency (USEPA). The nature and extent of impacted media at the NBG has been adequately characterized and delineated over the course of several environmental investigations at the NBG. In order to expedite the clean-up process, a Non-Time Critical Removal Action (removal action) will be performed during the Remedial Investigation/Feasibility Study (RI/FS) process to address the impacted area. The NBG Removal Action selected in this EE/CA will be the final remedy for the NBG and a component of the overall final remedy for the RFAAP-NRU.

This EE/CA for the NBG Removal Action has been prepared with the guidance set forth in the National Oil and Hazardous Substances Contingency Plan (NCP) [40 Code of Federal Regulations (CFR) 300] and the USEPA guidance document on removal actions, *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (USEPA, 1993). These documents provide information on the procedures and activities to be followed while conducting non-time-critical removal actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the NCP.

1.2 Site History

The RFAAP-NRU was established in 1940, and was originally known as the New River Ordinance Works (NROW). The NROW was incorporated into the RFAAP in 1945. The RFAAP-NRU facility operated as a bag manufacturing and loading plant for artillery, cannon, and mortar projectiles during World War II. Although active manufacturing activities at the RFAAP-NRU were reported to have ceased in the 1940's (after World War II), portions of the RFAAP-NRU are still utilized as storage facilities for operations at the MMA.

The area of the RFAAP-NRU identified as the NBG was temporarily utilized as a burning ground for the facility. Anecdotal evidence suggests that the burning operations may have been conducted to remove energetics from metal components used in the former manufacturing activities at the site. No buildings have existed at the NBG site; burning operations were conducted directly on the ground surface.

1.3 Site Description

The NBG is located in the northwest portion of the RFAAP-NRU, east of Gate 20, along Guard Road (Figure 1-2). A dirt road follows the outer perimeter of the NBG and defines the outermost boundary of the site. A drainage ditch parallels Guard Road on the north side of the site. The majority of the area identified as the NBG is heavily

wooded, with the exception of a small area in the central portion of the site where burning operations are believed to have been performed. This central portion of the site has a grass and shrub groundcover and a few small trees. Little to no visible evidence of past burning activities is apparent. A site map depicting the layout of the NBG is presented in Figure 1-3.

Although there is significant topographic relief across the RFAAP-NRU, the majority of the NBG is relatively level at an elevation of approximately 2,100 feet above mean sea level (ft msl). Land surface elevation in the western half of the RFAAP-NRU ranges from 2,020 ft msl to 2,115 ft msl. Surface water runoff from the NBG flows toward the drainage ditch that runs parallel to the paved surface road on the northern boundary of the site.

2. Site Characterization

Characterization of the contaminant distribution at the NBG and other study areas at the RFAAP-NRU has been ongoing since 1997. The summary of the historical investigations presented within the following sections provides an overview of the data and information collected from the NBG to date. Section 2.1 presents a brief summary of the environmental setting at the NBG. Section 2.2 presents a summary of the nature and extent of contamination at the NBG. Section 2.3 presents the findings of a streamlined human health and ecological risk assessment performed to address the existing conditions at the NBG.

2.1 Environmental Setting

The NBG is located in the northwest portion of the RFAAP-NRU near the boundary of the facility (Figure 1-2). There is little to no visual evidence of the past burning operations conducted at the site; although, the area where the burning operations are believed to have been conducted is not as heavily vegetated as the surrounding area. In generally the site is wooded with pines and a sparse undergrowth of mimosa trees, shrubs, and grass. There are no buildings or any active operations at, or in the immediate vicinity of the NBG. Soil at the NBG is considered to be part of the Groseclose and Pomplimento Silt Loam Complex (Shaw 2004). The approximate area of investigation at the NBG is 500 ft long by 300 ft wide (Figure 1-3).

2.2 Nature and Extent of Contamination

Investigations at the NBG have included a geophysical survey in 1998; soil sampling events in 1997, 1998, 1999, 2002, and 2004; and drainage ditch sediment sampling events in 2002 and 2004. The 2004 soil investigation included on-site screening of soils with X-Ray Fluorescence (XRF) in addition to laboratory analysis for metals. With the exception of the 2004 soil and sediment sampling activities, these investigations are summarized in the February 2004 Draft New River Unit Investigation Report: BDDT, BLA, IAA, NBG, RY & WBG (Shaw, 204). The 2004 sampling events are summarized in the October 2007 NRU Additional Characterization Sampling & Groundwater Investigation Data Report (Shaw, 2007). The historical analytical data from the NBG investigations are summarized within the tables presented in Appendix A. Site maps depicting historical sampling locations at the NBG are presented in Figures 2-1 and 2-2. The discussion in the following sections will focus on the

constituents detected at concentrations above the specified screening levels [i.e., USEPA Regional Screening Levels (RSLs) (USEPA 2008) and the facility-wide background metals concentrations (IT Corporation 2001)].

In addition to the soil investigations completed at the NBG, two groundwater monitoring wells have been sampled at the NBG as part of a facility-wide groundwater investigation for the RFAAP-NRU. The groundwater monitoring wells were installed at the NBG in 2007 and sampling events were performed in 2007 and 2008. The well installation and sampling activities are summarized in the October 2007 NRU Additional Characterization Sampling & Groundwater Investigation Data Report (Shaw, 2007) and the June 2009 Draft New River Unit Remedial Investigation Report (ARCADIS 2009). While groundwater has been investigated and assessed as a facility-wide resource at the RFAAP-NRU, the results of the sampling activities at the two NBG wells will be presented in the following sections.

2.2.1 Geophysical Survey

The approximate area of investigation at the NBG is 350 ft long by 250 ft wide. However, the actual burning operations are believed to have been confined to a relatively small area in the central portion of the site. In order to help refine the investigation activities at the site, a geophysical survey was conducted in 1998 in attempt to locate the former burn area. During this investigation the remains of several metal fence posts were found that appeared to mark the boundaries of the site. Some anomalies were also found in the central portion of the site where evidence of burning was found, including cinders and small pieces of metal. Based on this information, the former burning operations appear to correspond with an area of the site that has been cleared of larger vegetation. The vegetation in this area currently consists of grasses, shrubs and small trees, while the surrounding area is heavily forested with large pine trees.

2.2.2 Soil

Between 1997 and 2004, approximately 96 soil samples were collected at the NBG and submitted for laboratory analysis to delineate the extent of impacts associated with the former burning ground operations. The majority of these samples (47 surface soil samples and 45 subsurface soil samples) were collected within, or on the boundary of the area defined as the NBG. Four surface soil/sediment samples were also collected from the dry drainage ditch located to the north of the NBG along Guard Road. The analyte lists varied somewhat between the various sampling events and locations, but

have included dioxins/furans, explosives, herbicides, metals, organochlorine pesticides, PAHs, PCBs, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and toxicity characteristic leaching procedure (TCLP) metals. Table A-1 in Appendix A presents a summary of the historical analytical data from the soil samples collected at the site.

Review of the analytical data indicates dioxins, furans, PAHs, metals, and the PCB Aroclor-1254 were detected at the NBG at concentrations exceeding applicable USEPA RSLs for residential and industrial soil. The following sections provide a brief discussion of the nature and extent of detected constituents.

- Arsenic was detected in excess of the industrial RSL (1.6 mg/kg) in 84 of the 85 NBG soil samples analyzed for inorganics. However, the detected concentrations of arsenic only exceeded the established facility wide background concentration for arsenic (15.8 mg/kg) in 9 samples. Five of the background exceedances occurred in subsurface soil sample locations.

- Iron was detected in excess of the residential RSL (55,000 mg/kg) in seven soil samples from the NBG (1 surface soil and 6 subsurface soil sample locations). The detected exceedances, which ranged from 55,200 mg/kg to 63,100 mg/kg also exceeded the facility wide background concentration for iron of 50,962 mg/kg, but did not exceed the industrial RSL of 720,000 mg/kg.

- Antimony and zinc were detected in excess of their respective residential RSLs in one surface soil sample (NBGSB11).

- Lead was detected in excess of the residential RSL of 400 mg/kg in 17 soil samples from the NBG. Of the 17 detected residential exceedances, 16 also exceeded the industrial RSL of 750 mg/kg. The maximum detected concentration of lead was 111,000 mg/kg. Other observations from the lead data include:

    - The detected lead exceedances were generally confined to the central portion of the site believed to be used for the former burning operations; although some surface impact appears to have spread towards the drainage ditch on the north side of the site (see sample locations NBGSD03 and NBGSD04).

    - The lead impacted soils are primarily confined to surface soils (i.e. surface to 1 ft bgs); However there are two areas of elevated

concentrations in the central portion of the site where lead has been detected in excess of industrial RSLs to a depth of 4 ft bgs. These impacted areas are in the vicinity of the NBGSB11 sample location and the NBGSB14/NBGSB21 sample locations.

- Chromium was detected in excess of the residential RSL (230 mg/kg) in a total of 11 soil samples from the NBG. The detected concentrations in 5 of these samples also exceeded the industrial RSL of 1,460 mg/kg.
    - Chromium was detected at a maximum concentration of 25,700 mg/kg in surface soil and 352 mg/kg in subsurface soil.
    - The chromium exceedances generally coincide with the samples where lead was detected at the highest levels.
    - As with lead, the detected chromium exceedances were generally confined to surface soils in the area believed to have been used for the former burning operations.
- The PCB, Aroclor 1254 was detected in 8 surface soil samples at concentrations exceeding the residential RSL of 0.16 mg/kg. Of these detections, 6 also exceeded the industrial RSL of 0.74 mg/kg. There were no exceedances of Aroclor 1254 in subsurface soil. The detections in surface soil were generally found in the area believed to have been used for the former burning operations, extending towards the drainage ditch on the north side of the site.
- The furan 2,3,7,8-TCDF was detected in one surface soil sample (NBGSB11) at a concentration exceeding the industrial RBC 0.00011 mg/kg. This constituent was the only dioxin/furan detected at a concentration exceeding industrial RSLs. 2,3,7,8-TCDF was detected in one other surface soil sample (NBGSB13) at a concentration exceeding the residential RSL The only other dioxin/furan residential exceedances included: the furan 2,3,4,7,8 PeCDF at surface soil sample location NBGSB11; and the dioxin OCDD at surface soil sample locations NBGSB14 and NBGSB19. No exceedances of the RSLs for dioxins/furans were detected in subsurface soil samples.
- The PAHs, benzo(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; dibenzo(a,h)anthracene; and indeno(1,2,3-cd)pyrene were detected at concentrations exceeding their respective residential RSL in the surface soil

sample (NBGSD01) collected from the drainage ditch on the north side of Guard Road. The detected concentration of benzo(a)pyrene (0.21 mg/kg) also exceeded the industrial RSL for this constituent of 0.21 mg/kg.

Although, some subsurface impacts have been detected in the former burn area, the samples submitted for laboratory analysis indicate that the impacts at the NBG are primarily confined to surface soils. In an effort to further delineate the areal extent of impacts a field screening program was performed in 2004. The field program included the collection of 288 surface soil samples and field screening them for lead using XRF. Lead was selected as the indicator metal for impacts because it was the most widespread constituent detected at concentrations exceeding both the RSLs and background metals concentrations. The XRF screening results confirm that the metals impacts are generally limited to the former burn area; and to a lesser extent the area between the burn area and the drainage ditch to the north. Figure 2-2 depicts the XRF field screening results. Table A-2 in Appendix A also presents a summary of the field screening results.

Thirteen soil samples from the former burn area were submitted for TCLP analysis during field investigation activities in 1999. The analytical results indicated that 3 of the TCLP samples (NBGDW1, NBGDW11, and NBGDW13) had lead concentrations exceeding the lead standard of 5 mg/L. These 3 samples were collected from surface soils in the central portion of the site, where the highest metals concentrations were detected. No other metals were detected at concentrations exceeding applicable TCLP standards.

2.2.3 Groundwater

Two monitoring wells were installed at the NBG in 2007 as part of a facility-wide groundwater investigation conducted for the RFAAP-NRU. Monitoring Well NBGMW01 was installed in the central portion of former burning ground and Monitoring Well NBGMW02 was installed to the north of the NBG (see Figure 1-3). The construction details for these two monitoring wells are presented in Table A-3 within Appendix A, along with depth-to-water measurements collected during 2007 and 2008 sampling events.

Facility-wide groundwater sampling events were performed at the RFAAP-NRU in 2007 and 2008 which included the two monitoring wells at the NBG. The analyte list for the samples collected during the 2007 sampling event included dioxins/furans, explosives, herbicides, pesticides, PAHs, PCBs, VOCs, SVOCs, inorganics, total

organic carbon, and total organic halides. The 2008 sampling event only included total and dissolved metals. Table A-4 in Appendix A presents a summary of the analytical results from both the 2007 and 2008 monitoring events.

Review of the groundwater analytical results from the NBG monitoring wells indicated the following:

- Several dioxin/furan compounds were detected in the groundwater samples from monitoring wells NBGMW01 and NBGMW02 during the 2007 sampling event (see Table A-4 in Appendix A). The reported concentrations of 2,3,4,7,8-PeCDF and 2,3,7,8-TCDD, 2,3,7,8-TCDF were above the tap water RSLs. However, these constituents, along with the majority of the detected dioxin/furan constituents, were present at concentrations that were quantified as estimated by the laboratory (i.e., J-flagged) or were also detected in a laboratory blank sample associated with the analyses. Samples collected from monitoring wells located in other areas of the RFAAP-NRU during the 2007 sampling event were also found to contain dioxin/furan constituents at similar concentrations and in blank samples, indicating that the reported concentrations are likely due to laboratory contamination.

- Several inorganic constituents were detected in the groundwater samples from monitoring wells NBGMW01 and NBGMW02 during both the 2007 and 2008 sampling events (see Table A-4 in Appendix A). However, during the 2007 sampling event arsenic at NBGMW01 was the only constituent detected at a concentration above the tap water RSLs. During the 2008 sampling event total aluminum, arsenic, iron, and lead were detected in Monitoring Well NBGMW02 at concentrations above the tap water RSL. The results from the filtered samples collected during the 2008 sampling event indicated that the dissolved concentrations were far lower than the total concentrations and that no constituents were present at concentrations above applicable RSLs (see Table A-4 in Appendix A). The detected inorganic constituents all occur naturally in soils at the RFAAP-NRU, and the detections in the unfiltered samples have been attributed to suspended solids in the samples.

- No VOCs, SVOCs, PAHs, PCBs, pesticides, or herbicides were detected in either monitoring well at the NBG.

Groundwater at the RFAAP-NRU is being assessed on a facility-wide basis at the RFAAP-NRU. The groundwater monitoring results from the NBG will be incorporated into the evaluation of groundwater quality at the facility and therefore will not be

incorporated into the risk assessment activities for the individual NBG site. The results of the facility-wide groundwater evaluation are presented in the June 2009 Draft New River Unit Remedial Investigation Report (ARCADIS 2009).

2.3 Risk Assessment

2.3.1 Streamlined Human Health Risk Assessment

A streamlined human health risk assessment was performed for the NBG to evaluate exposure to soil under current/future industrial and future hypothetical residential land-uses under existing conditions and assuming that constituent concentrations in soil would remain constant in the future. The evaluation assumed that individuals could be exposed to both surface and subsurface soils. A detailed summary of the human health risk assessment for the NBG is presented in further detail within Appendix B.

Based on the existing soil data from the site, the risk assessment determined that the potential risks and hazards for the industrial worker and resident were all within the USEPA target risk range ($1x10^{-4}$ to $1x10^{-6}$). The noncancer hazards were approximately equal to the benchmark Hazard Index (HI) of 1 for the industrial site worker but were greater than 1 for the hypothetical future resident . The driver for the elevated HI for the residential conditions was the elevated concentrations of chromium.

Due to the lack of available toxicity values, an excess lifetime cancer risk (ELCR) and hazard quotient (HQ) could not be calculated for lead; therefore, lead was not evaluated using the same method as the other constituents at the site. Instead, a qualitative method was utilized to evaluate lead, based on the relatively small area of impact (i.e. less than 1 acre). The exposure point concentration (EPC) for lead was determined based on the average concentration of lead detected in the samples from the NBG. This EPC, was compared to the residential and industrial soil RSLs of 400 mg/kg and 750 mg/kg, respectively. As a result of the high concentrations of lead detected in the central portion of the site, the lead EPC for the existing conditions was well above the RSLs for both residential and industrial soils.

2.3.2 Ecological Risk Assessment

An ecological risk assessment (ERA) was performed for the NBG based on the analytical data collected throughout the course of environmental investigation at the site. The assessment was broken into two main sections, including a screening-level ecological risk assessment (SLERA) and a baseline risk assessment (BERA). These

assessments focused on the evaluation of constituents identified in surface soil, which has been identified as the interval from 0 to 1 foot below ground surface. The conclusions of the SLERA and BERA are based on hazard quotients (HQs), taking into consideration the conservatism of ecotoxicity screening levels (ESLs), and the existing biological survey of community types and potentially occurring threatened and endangered species conducted at RFAAP (VDGIF, 1999). The ERA process culminates in a scientific management decision point (SMDP). The SMDP represents the critical step in the process where results are presented and risk management decision-making occurs. As discussed in further detail within Appendix C, the SLERA and BERA for the NBG site provide adequate information to conclude that adverse impacts to terrestrial wildlife and plants exposed to constituents in surface soil are likely to occur based on existing conditions.

Potential risks were largely associated with chromium, lead, and zinc, as well as to PCBs and dioxins. However, it should be noted the that SLERA and BERA were conservatively based on upper bound estimates of site-specific exposures as well as very conservative toxicity benchmarks. There is considerable uncertainty regarding the significance of the potential risks because of the range of available screening benchmarks. In addition, evaluation of the distribution of the chemicals of concern at the site indicates that in general the highest concentrations are associated with the area believed to have been used for the former burning operations. A targeted soil removal action implemented to address human health based target levels in this area would also address potential ecological concerns by removing the most elevated concentrations of the primary risk drivers and significantly reducing the remaining exposure area. Consequently, significant adverse impacts to ecological receptors are unlikely on the population level, and risks would be considered *de minimis*. Therefore, the human health risks associated with the existing chromium and lead impacts discussed in Section 2.3.1 would remain the driver for remediation at the site.

2.4 Constituents of Concern

Potential risks associated with exposure to soil under industrial and future residential land use conditions were within the USEPA target risk range; thus, no Constituents of Concern (COCs) were identified based on a cancer endpoint. However, elevated chromium concentrations at the site could pose a potential non-cancer hazard to individuals under residential land use conditions. The potential non-cancer hazard associated with the existing chromium concentrations were within acceptable limits under industrial land use conditions. In addition, the EPC for lead, which was based on the average concentration detected in surface soil samples at the site, was greater

than both the residential (400 mg/kg) and industrial (750 mg/kg) screening levels for the site. Therefore, under both current industrial and future residential land-use conditions, lead was identified as a COC. As such, lead would be the driver for performing an industrial level cleanup at the site, while both lead and chromium would be drivers for a residential level cleanup at the site.

3. Identification of Removal Action Objectives

The objectives of the NBG Removal Action are discussed in the following sections. The evaluation of various federal and state regulations to determine the applicable or relevant and appropriate requirements (ARARs) that will need to be achieved in order to meet the removal action objectives are also included.

3.1 Removal Action Objectives

The NBG site presents a relatively time-sensitive, non-complex problem that can and should be addressed relatively cost effectively. The Burning Ground has elevated levels of hazardous substances (i.e., chromium and lead) in soils that are largely at or near the surface which could migrate and act as a source area that could contaminate adjacent soils, drainage ditch sediments, and ground water. Based on section 40 CFR 300.415.(b)(2)(iv) of the NCP, a removal action is therefore appropriate for this site. A prompt removal action as proposed in this EE/CA will provide a substantial risk reduction for the site without requiring the preparation of a full scale remedial investigation and feasibility study.

The Removal Action Objectives (RAOs) for the NBG were developed in accordance with the NCP (40 CFR 300) and EPA guidance (EPA, 1993). The RAOs for this EE/CA are as follows:

- Minimize the potential for exposure to impacted soils contaminated at levels exceeding remedial action levels appropriate for the current and/or reasonably anticipated future land uses of the site.

- Minimize the potential for elevated constituent concentrations in soils to migrate.

This removal action will be the final remedy for the NBG; therefore, the intended future uses of the site were considered in determining whether the removal action should be performed to industrial or residential clean-up levels. The current and anticipated future use of the NBG, and the other study areas at the RFAAP-NRU, is industrial. However, the Army requires that a cost-benefit analysis be performed on a site-by-site basis to determine the economic advantages of performing a clean (i.e. residential level) closure relative to performing an industrial closure. The Army performs these

evaluations because of the long term costs that can be associated with the land use controls required for industrial level closures. Therefore, both industrial and residential level removal actions will be considered in this EE/CA.

3.2 Applicable or Relevant and Appropriate Requirements

Actions that "clean up" hazardous substances at CERCLA sites must comply with state and federal standards and criteria that are legally applicable to the substance, pollutant, or contaminant; or that are relevant and appropriate under the circumstances [42 U.S.C. 9621(d)(2)(A)].

3.2.1 Definition of Applicable or Relevant and Appropriate Requirements

According to the NCP [40 CFR 300.400(g)], a requirement may be either "applicable" or "relevant and appropriate" to a removal action, but not both. The definitions of these types of requirements are as follows:

- Applicable Requirements - "cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance found at a CERCLA site" (40 CFR 300.5).

- Relevant and Appropriate requirements - "cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 CFR 300.5).

Once a federal or state law has been identified as an ARAR, the specific requirements must be distinguished as either substantive or administrative. "Substantive" requirements are "those requirements that pertain directly to actions or conditions in the environment". "Administrative" requirements are "those mechanisms that facilitate the implementation of the substantive requirements of a statue or regulation". Compliance with administrative requirements is not mandated for on-site actions (USEPA, 1988). Furthermore, only those promulgated State requirements that are more stringent than Federal requirements are ARARs [40 CFR 300.5]. "More

stringent" would also include those state laws or programs that have no federal counterpart as they add to the Federal law requirements that are specific to the environmental conditions in the State. State requirements, however, must be promulgated and applied through the state [42 U.S.C. 9621(d)(2)(C)(iii)(I)].

In addition, the NCP identifies a third category of guidance, termed "information to-be-considered" (TBC). The TBC category "consists of advisories, criteria, or guidance that were developed by USEPA, other federal agencies, or states that may be useful in developing CERCLA remedies" [40 CFR 300.400(g)(3)]. TBCs do not have the status of ARARs because they are not promulgated requirements but may be used when they are necessary to ensure protection of public health and the environment.

3.2.2 Types of Applicable or Relevant and Appropriate Requirements

Response actions may trigger several different types of requirements or ARARs. The USEPA provides guidance on three categories of ARARs specific to the pollutant, location, or action as discussed below:

- Chemical-specific requirements set health- or risk-based concentration limits or ranges for specific substances in various environmental media.

- Location-specific requirements set restrictions on activities according to characteristics of the site or its immediate environs (e.g., regulations pertaining to development in a 100-year floodplain). These requirements may apply if the CERCLA site is located in such a restricted area.

- Action-specific requirements set controls or restrictions on specific activities related to the management of hazardous substances (e.g., RCRA standards for design and operation of hazardous waste management facilities). These requirements are not chemical-specific, but are specific to specific actions.

3.2.3 Chemical-Specific ARARS

The USEPA RSLs for residential and industrial soils utilized for the RFAAP-NRU are considered TBC guidances. Groundwater quality criteria established by the USEPA and the State of Virginia are not considered potential ARARs for this removal action as the remediation of groundwater is not within the scope of the NBG Removal Action and

this EE/CA. However, the groundwater quality criteria will be considered during the RI/FS process for the RFAAP-NRU as a whole.

3.2.4 Location-Specific ARARS

Removal action alternatives may be restricted or limited by federal or state regulations based on its location or immediate environment. Location-specific ARARs can address the immediate environment of the site as well as the location where a component of the removal action is conducted. Table 3-2 identifies the federal and state regulation laws that contain requirements, criteria, or limitations that will be considered as potential ARARs for this EE/CA.

3.2.5 Action Specific ARARS

Table 3-3 identifies the proposed action-specific ARARs for this EE/CA. The removal action alternatives developed in Section 4.0 will be controlled or restricted by these action-specific ARARs.

For removal action alternatives involving excavation, the Army will employ "best management practices" to control storm water, erosion and sediment transport necessary to achieve compliance with applicable ARARs. In addition, excavation and material processing activities have high potential to emit fugitive dust. NCP 40 CFR 50.12 outlines fugitive dust restrictions and requirements.

The substantive requirements in 40 CFR 262 regarding the management of wastes that are classified as hazardous are applicable once the waste materials that are considered RCRA listed or characteristic wastes are removed and thereby generated, as shown in Table 3-3. Generated hazardous waste requires shipment off-site for disposal within the accumulation time period. If this is not possible, then the generated hazardous waste would need to be managed in accordance with the substantive requirements of 40 CFR 264.

3.3 Remedial Goals

Industrial and residential remedial goals were established to facilitate the evaluation of remedial alternatives for the NBG. The streamlined HHRA conducted as part of this EE/CA identified the two COCs that will drive the cleanup requirements for this site: chromium and lead. Potential hazards associated with exposure to chromium in soil were greater than the USEPA benchmark HI of 1.0 under a future residential land-use

scenario only. The average lead concentration in surface soil was also greater than both the residential and industrial screening levels. For the purpose of this EE/CA, the USEPA RSLs (USEPA 2008) are proposed as Cleanup Levels. The residential RSL for chromium is 230 mg/kg. Lead is not listed within the RSL tables; therefore, the USEPA (1994) residential screening soil level of 400 mg/kg and the USEPA (1999) industrial soil screening level of 750 mg/kg are proposed as the Cleanup Levels for lead. These screening levels (USEPA, 1994; 1999; 2008) have been utilized in this evaluation and adopted as the Cleanup Levels for the NBG Interim Removal Action based on their availability and conservatism relative to remediation goals.

3.4 Attainment of Cleanup Levels

The attainment of the final Cleanup Level for lead (either industrial or residential) will be evaluated based on an "area-average" using an approach provided by USEPA (1989 and 2005). Consistent with the screening level risk assessment provided in Appendix B and the USEPA risk-based approach for the evaluation of potential risks associated with lead in soil (USEPA 1999), the average concentration of lead will be used as the EPC for comparison to the lead Cleanup Level to determine whether or not cleanup has been achieved.

The attainment of the final Cleanup Level for residential exposure to chromium will be evaluated based on the 95th upper confidence limit on the arithmetic mean (95th UCL). The 95th UCL of chromium concentrations in residual soil will be used as the EPC for comparison to the chromium cleanup level to determine whether nor not cleanup has been achieved.

To facilitate the evaluation of the attainment of the Cleanup Level industrial (lead only) and residential (lead and chromium) Remediation Action Levels (RALs) were developed following USEPA's *Guidance on Surface Soil Cleanup at Hazardous Waste Sites* (USEPA 2005). As defined by USEPA (2005), the RAL is the maximum concentration that may be left in place within an exposure unit such that the predicted average concentration is at or below the Cleanup Level. The area average approach involves remediating soils within the exposure unit with the highest COC concentrations until the post-remediation EPC is at or below the Cleanup Level. The RAL is the maximum concentration, or not-to-exceed level, for the purposes of site remediation. Remediation of soil with COC concentrations greater than the RAL will ensure that the estimated post-remediation EPC achieves the Cleanup Level.

The Iterative Truncation Method (USEPA, 2005) was used to calculate the RAL for lead at the NBG. The steps involved are as follows:

1. Order the sampling data from highest to lowest;

2. Starting with the highest concentration, remove a sample and replace it with the post-remediation concentration (for the purpose of this EE/CA background levels of 26.8 mg/kg and 65.3 mg/kg were used for lead and chromium, respectively);

3. Recalculate the post-remediation EPC for the new data set and compare the resulting EPC to the cleanup level. For lead, the post-remediation EPC was based on the arithmetic mean, as recommended by USEPA (1999); for chromium, the post-remediation EPC was based on the 95^{th} UCL

4. If the EPC is higher than the Cleanup Level, repeat the process iteratively until the EPC is less than or equal to the Cleanup Level.

Two data sets were compiled for the evaluation of lead in soil: the laboratory analytical data and the screening level XRF data. Evaluations of each data set independently as well as combined were performed to provide additional level of confidence in this analysis. In addition, when duplicate samples were available, the higher concentration was conservatively used in this analysis. The following determinations were made based on this evaluation:

- The pre-remediation average lead concentration in soil is greater than 750 mg/kg.

- To achieve a residential-based Cleanup Level of 400 mg/kg, the RAL was determined to be 3,000 mg/kg. That is, once soil samples containing lead at a concentration greater than 3,000 mg/kg were removed from the data sets, the predicted average lead concentration is reduced to less than 400 mg/kg.

- To achieve an industrial-based Cleanup Level of 750 mg/kg, the RAL was determined to be 5,000 mg/kg. Soil samples containing lead at a concentration greater than 5,000 mg/kg were removed from the data sets which resulted in a predicted average lead concentration of less than 750 mg/kg.

The laboratory analytical data for chromium were used to determine the RAL for chromium under the residential scenario. As for lead, when duplicate samples were

available, the higher concentration was conservatively used in this analysis. The following determinations were made based on this evaluation:

- The pre-remediation 95th UCL of 2,827 mg/kg for chromium is greater than the residential RSL of 230 mg/kg;

To achieve a residential-based Cleanup Level of 230 mg/kg, the RAL was determined to be 1,620 mg/kg. That is, once soil samples containing lead at a concentration greater than 1,620 mg/kg were removed from the data set, the predicted 95th UCL would be less than 230 mg/kg.

3.5 Schedule for Removal Action

The overall schedule for the NBG Removal Action is presented in Appendix D. This removal action will be completed by October 2009. A period of over 6 months has been included in the schedule for the submission of this EE/CA and Action Memorandum to allow for regulatory response and approval in accordance with the FFA (USEPA, 1989), as well as community involvement and the removal action completion report.

4. Identification and Analysis of Removal Action Alternatives

Several removal action alternatives have been developed for the NBG Removal Action based on the RAOs and the ARARs identified in Section 3. The intent of the NBG Removal Action is to conduct a removal action that will be the final corrective action for this area and will meet completion requirements under CERCLA. In the following sections the alternatives are analyzed for their effectiveness, implementability, and cost in achieving these objectives.

4.1 Description of Removal Alternatives

Removal action alternatives were developed to address the impacted soils at the NBG. The No Further Action Alternative is considered in this EE/CA in accordance with CERCLA requirements. In addition to No Further Action, two removal action alternatives were developed based on their ability to protect human health and the environment and to comply with ARARs. These alternatives are consistent with the removal actions considered appropriate in the NCP [40 CFR 300.415(e)].

The preamble to the NCP identifies a preference for alternatives that involve on-site treatment; however, the waste materials at the NBG would likely require that future land use restrictions be enforced even if an on-site treatment could be effectively implemented. Furthermore, on-site treatment options would be much more expensive than the off-site alternatives due to the relatively small volume of impacted material. Therefore, the active alternatives presented in this EE/CA focused on options that include off-site disposal of the impacted material.

4.1.1 Description of Alternative 1 – No Additional Action

Alternative 1 consists of undertaking no additional action at the NBG.

4.1.2 Description of Alternative 2 – Excavation, Off-Site Stabilization, and Disposal of Impacted Soil to Achieve Industrial Closure

Alternative 2 consists of excavation, off-site stabilization, and off-site disposal of impacted soils to achieve an industrial level closure for the NBG. The excavation footprint for this alternative would focus on the central portion of the site where the highest concentrations of lead and chromium were detected. More specifically, the

excavation footprint encompasses the area where the lead concentrations exceed the RAL of 5,000 mg/kg. This removal area, which is depicted in Figure 4-1, also includes the sample locations where lead was detected in excess of the TCLP standards; therefore, the material will likely need to be disposed of as hazardous waste. In addition to reducing the risk associated with the primary COCs for the NBG (i.e., chromium and lead), review of the analytical data from the site also indicates that this removal action will include the highest concentrations of Aroclor-1254, dioxins/furans, and other metals detected during the course of investigation. Additional details on this removal action alternative are included in the following list:

- The soil data collected during the course of investigation at the NBG indicates that the highest concentrations of metals, Aroclor-1254, and dioxins/furans are generally confined to a 60 ft by 60 ft area in the central portion of the site. The impacts within this footprint are primarily confined to the interval from ground surface to 1 ft bgs. However, subsurface impacts have been detected to a depth of approximately 4 ft bgs within a smaller (approximately 35 ft by 10 ft) portion of this area. To ensure that the removal action meets the requirements for an industrial level closure, soils containing lead at concentrations exceeding the RAL of 5,000 mg/kg will need to be removed from the site. Based on the historical analytical data and the XRF field screening results from 2004, the RALs can be achieved by excavating the two small areas depicted in Figure 4-1. The first area is approximately 55 ft by 40 ft and the second area is approximately 15 ft by 25 ft. Both areas would be excavated to a depth of approximately 1 ft bgs, with the exception of a 35 ft by 10 ft portion of the larger area that would be excavated to a depth of 2 ft bgs. The increased depth of the excavation in this area would ensure that subsurface soils with lead concentrations above the RAL of 5,000 mg/kg would be removed. In total, approximately 120 cubic yards of material would be removed during this action.

- During the removal activity samples will be collected approximately every 20 feet around the northeast and northwest sides of the excavation. Samples will also be collected on 15 ft centers from the base of the excavation. The samples will be field screened for lead using an XRF sampling device to ensure that lead concentrations exceeding the RAL of 5,000 mg/kg are not left in place. If necessary, the excavation footprint will be expanded based on the results of the field screening program.

- Upon completion of the excavation activities, confirmation samples will be collected from the northeast and northwest perimeter of the excavation and the base of the

excavated area. These samples will be field screened using XRF. Half of the samples would also be submitted for laboratory analysis of metals by USEPA Method 6010 to confirm the XRF field screening results and the success of the removal action. The samples will be collected approximately every 30 feet on the northeast and northwest perimeter of the excavation with a focus on areas that lack historical samples. Samples will also be collected on 25 ft centers from the base of the excavation. All samples will be collected in accordance with the sampling procedures outlined in the Master Work Plan for the RFAAP (URS 2003). QA/QC samples will be collected in accordance with the Draft Quality Assurance Plan Addendum (QAPA) (ARCADIS, 2008b).

- The excavated material would be placed directly into roll-off containers or dump trucks and transported to an approved hazardous waste disposal facility. Once at the disposal facility, the soil will be mixed with a stabilization media to reduce the potential for leachable constituents. The facility will likely perform a TCLP analysis on the material to ensure that it has been sufficiently stabilized. The stabilized material would then be properly disposed of at the disposal facility. All material leaving the NBG site will be properly manifested

- Any existing vegetation within the excavation footprints would need to be cleared from the site during the excavation process. The bulk of the vegetation within the area consists of grasses, shrubs, and small trees. The cleared vegetation would be transported and disposed of with the soils at the approved disposal facility.

- Upon completion of the removal action, the excavated areas will be backfilled with clean soil imported from off site, unless an approved on-site source is identified. Samples of the backfill material will be submitted for laboratory analysis to ensure that contaminants are not imported to the site. Upon completion of the backfill activities, the area will be seeded with grass to minimize the potential for erosion.

- As discussed in Section 3.3, the removal of the lead impacted soils exceeding the RAL of 5,000 mg/kg will reduce the average lead concentration at the NBG below the industrial screening level of 750 mg/kg. The removal action would also encompass the area where chromium was detected in excess of the industrial RSL. Therefore, the requirements of an industrial level closure would be achieved. However, the lead EPC would still exceed the residential screening level of 400 mg/kg. As such, land use controls (LUCs) would need to be put into effect to control future land uses at the site.

- Annual inspections and reporting would be performed for a period of 30 years to confirm that no erosion is occurring within the backfilled area and to ensure that the LUCs are enforced.

- The PAH detections observed in the drainage ditch to the north of the site would not be included in this removal action, as they are not believed to be related to the NBG. The risk assessment also indicated that the detected PAHs were not a risk-driver for this site due to the limited area of impact.

Storm water controls will be established and maintained at the NBG throughout the duration of the removal action in accordance with the ARARs specified in Section 3.2.5.

4.1.3 Description of Alternative 3 – Excavation, Off-Site Stabilization, and Disposal of Impacted Soil to Achieve Residential Closure

Alternative 3 is similar in scope to Alternative 2 in that it consists of excavation, stabilization, and off-site disposal of impacted soils. However, the removal action would be expanded to remove additional materials to achieve a residential level closure for the NBG. As with Alternative 2, the excavation footprint for Alternative 3 would focus on the central portion of the site where the highest concentrations of lead and chromium were detected. However, the excavation footprint would be expanded to encompass the area where the lead concentrations exceed the RAL of 3,000 mg/kg. This removal area, which is depicted in Figure 4-2, also includes the sample locations where lead was detected in excess of the TCLP standards; therefore, the material will likely need to be disposed of as hazardous waste. In addition to reducing the risk associated with the primary COCs for the NBG (i.e., chromium and lead), review of the analytical data from the site also indicates that this removal action will include the highest concentrations of Aroclor-1254, dioxins/furans, and other metals detected during the course of investigation. Additional details on this removal action alternative are included in the following list:

- The soil data collected during the course of investigation at the NBG indicates that the highest concentrations of metals, Aroclor-1254, and dioxins/furans are generally confined to a 60 ft by 60 ft area in the central portion of the site. The impacts within this footprint are primarily confined to the interval from ground surface to 1 ft bgs. However, subsurface impacts have been detected to a depth of approximately 4 ft bgs within a smaller (approximately 35 ft by 10 ft) portion of this area. To ensure that the removal action meets the requirements for a

residential level closure, soils containing lead at concentrations greater than the RAL of 3,000 mg/kg and soils containing chromium at concentrations greater than 1,620 mg/kg will need to be removed from the site. Based on the historical analytical data and the XRF field screening results from 2004, the RALs can be achieved by excavating the area depicted in Figure 4-2. The area is approximately 110 ft by 50 ft and would be excavated to a depth of approximately 1 ft bgs. A smaller subset of this area (approximately 35 ft by 10 ft) would be excavated to a depth of 4 ft bgs to remove the deeper soils that had contained lead and chromium at concentrations above the applicable screening levels during historic sampling events. In total, approximately 250 cubic yards of material would be removed during this action.

- During the removal activity samples will be collected approximately every 20 feet on the northeast and northwest perimeter of the excavation. Samples will also be collected on 15 ft centers from the base of the excavation. The samples will be field screened for lead using an XRF sampling device to ensure that lead concentrations exceeding the lead RAL of 3,000 mg/kg and chromium RAL of 1,620 mg/kg are not left in place. Samples will not be collected from the southern perimeter of the excavation because historical sampling has confirmed the extent of lead and chromium impacts in this area. If necessary, the excavation footprint will be expanded on the northern boundary based on the results of the field screening program.

- Upon completion of the excavation activities, confirmation samples will be collected from the northeast and northwest perimeter and base of the excavated area. These samples will be field screened using XRF. Half of these samples will also be submitted for laboratory analysis of lead and chromium by USEPA Method 6010 to confirm the XRF field screening results and the success of the removal action. The samples will be collected approximately every 30 feet along the northeast and northwest perimter of the excavation with a focus on areas that lack historical samples. Samples will also be collected on 25 ft centers from the base of the excavation. All samples will be collected in accordance with the sampling procedures outlined in the Master Work Plan for the RFAAP (URS 2003). QA/QC samples will be collected in accordance with the Draft Quality Assurance Plan Addendum (QAPA) (ARCADIS, 2008b).

- The excavated material would be placed directly into roll-off containers or dump trucks and transported to an approved hazardous waste disposal facility. Once at the disposal facility, the soil will be mixed with a stabilization media to reduce the

potential for leachable constituents. The facility will likely perform a TCLP analysis on the material to ensure that it has been sufficiently stabilized. The stabilized material would then be properly disposed of at the disposal facility. All material leaving the NBG site will be properly manifested.

- Any existing vegetation within the excavation footprints would need to be cleared from the site during the excavation process. The bulk of the vegetation within the area consists of grasses, shrubs, and small trees. The cleared vegetation would be transported and disposed of with the soils at the approved disposal facility.

- Upon completion of the removal action, the excavated areas will be backfilled with clean soil imported from off site, unless an approved on-site source is identified. Samples of the backfill material will be submitted for laboratory analysis to ensure that contaminants are not imported to the site. Upon completion of the backfill activities, the area will be seeded with grass to minimize the potential for erosion.

- As discussed in Section 3.3, the removal of the soils containing lead and chromium at concentrations greater than their RALs will reduce the average lead concentration at the NBG below the residential screening level of 400 mg/kg and the 95th UCL for chromium to below the residential soil RSL of 230 mg/kg. Therefore, the requirements of a residential level closure would be achieved. As such, there would be no need for LUCs or long term monitoring at the site upon completion of the removal action.

- The PAH detections observed in the drainage ditch to the north of the site would not be included in this removal action, as they are not believed to be related to the NBG. The risk assessment also indicated that the detected PAHs were not a risk-driver for this site due to the limited area of impact.

Storm water controls will be established and maintained at the NBG throughout the duration of the removal action in accordance with the ARARs specified in Section 3.2.5.

4.2 Evaluation and Screening of Remedy Alternatives

The NCP [40 CFR 300.430 (e)(7)] and USEPA Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA (USEPA, 1993) cite the general evaluation criteria of effectiveness, implementability, and cost. Each of these criteria is

considered in the evaluation of alternatives. The types of specific considerations within each of these general criteria are listed below:

- **Effectiveness** - assesses the alternatives' ability to meet RAOs and to provide protection of human health and the environment now and in the future. Measures of effectiveness include: (1) reduction of contaminant toxicity, mobility, and/or volume through treatment; (2) long-term protection of human health and the environment; and (3) short-term protection of human health and the environment during the removal action. These evaluation criteria are defined in the NCP [40 CFR 300.430 (e)(7)(i)].

- **Implementability** - measure of (1) technical feasibility; (2) administrative feasibility to construct, operate, and maintain a removal action alternative; and (3) availability of services and materials. Technical feasibility is evaluated based on constructability, reliability (e.g., demonstrated performance and operation), maintenance, and timeliness/schedule of implementation. The implementability evaluation criteria are defined in the NCP [40 CFR 300 (e)(7)(ii)].

- **Cost** - involves developing the level of engineering detail and preparing a sufficiently accurate cost estimate for each alternative so that a relative and appropriate cost comparison can be made between competing alternatives. For purposes of this EE/CA, the cost estimates for construction were based on fiscal year 2008 costs. Other considerations in the evaluation of remedy selection include capital and annual Operations and Maintenance (O&M) costs as presented in the NCP [(40 CFR 300 (e)(7)(iii)]. CERCLA guidance indicates that the cost estimates should be prepared as feasibility study level costs having a range of accuracy of plus 50 percent to minus 30 percent (USEPA, 2000).

4.2.1 Analysis of Alternative 1 – No Additional Action

The No Additional Action alternative is not considered effective and does not require any implementation. There is no cost associated with the No Additional Action Alternative. The following sections present the analysis of this alternative in greater detail.

4.2.1.1 Effectiveness Evaluation

The No Action alternative is not effective in reducing the risk presented by the contaminants found in the surface soil due to the fact that contaminants are left in

place at concentrations above human health risk thresholds. The human health and ecological risks associated with the existing conditions are discussed in Appendices B and C, respectively. Impacted surface soils would also be left in place that would have the potential to migrate. The ARARs associated with the management of impacted soil are not achieved at the NBG through this alternative.

4.2.1.2 Implementability Evaluation

No activities would be undertaken as part of the No Action Alternative; therefore, this option is easily implementable.

4.2.1.3 Cost Evaluation

The No Additional Action Alternative has no remedial action and no follow on activities. As a result, the cost to implement the No Additional Action alternative is $0.

4.2.2 Analysis of Alternative 2 – Excavation, Off-Site Stabilization, and Disposal of Impacted Soil to Achieve Industrial Closure

The excavation and removal of the metals, PCB, and furan/dioxin impacted soil from the source area footprint proposed in Alternative 2 is considered effective and will achieve the RAOs. Alternative 2 will also require the implementation of LUCs which would need to be in place to limit future land use to industrial activity only. The following sections present a detailed analysis of this alternative.

4.2.2.1 Effectiveness Evaluation

The excavation and removal of the impacted soils within the footprint proposed in Alternative 2 will achieve the remedial action objectives of: 1.) minimizing risks to potential human and ecological receptors; and 2.) minimizing the potential for contaminated surface soils to migrate to off-site areas. The human health and ecological risk assessments presented in Appendices B and C, respectively, indicate that this removal action would result in sufficient risk reduction that would allow for continued and future industrial use of the area. The removal of the impacted surface soils from the source area would also reduce the potential for future migration of impacted materials. The removal and disposal of the impacted soil provides a permanent reduction in risk; however, this option does require the implementation and maintenance of LUCs to manage residual risk. During the excavation, appropriate

engineering and institutional controls will be used to ensure that this process is protective of human health and the community.

4.2.2.2 Implementability Evaluation

Alternative 2 can be implemented within a reasonable time frame. There are no significant construction considerations that would limit the implementability of the alternative. Minimal clearing activities would be necessary and off-site disposal facilities are available for the impacted soil that will be generated during the excavation activities. The excavated soil will be stabilized with an engineered media at the approved off-site disposal facility to promote immobilization of contaminants prior to final disposal. Confirmation samples would be collected and the site excavations would then be backfilled with clean soil imported from off-site or an approved on-site area.

4.2.2.3 Cost Evaluation

A cost estimate for implementing Alternative 2 is presented in Table 4-1. This estimate includes contractor costs for performing the required site work; transportation, stabilization, and disposal services; professional reporting and oversight fees; and follow on monitoring activities required for the LUCs (i.e. annual inspections and reporting). For the purposes of the cost estimate, it was assumed that the LUCs would be monitored for a period of 30-years after completion of the removal action. Due to the extended duration of the post excavation monitoring, the addition of the LUCs is a significant portion of the total cost of this alternative. Based on the current projected costs, the total cost for implementing this alternative is approximately $340,000.

4.2.3 Analysis of Alternative 3 – Excavation, Off-Site Stabilization, and Disposal of Impacted Soil to Achieve Residential Closure

The excavation and removal of the metals, PCB, and furan/dioxin impacted soil from the footprint proposed in Alternative 3 is considered extremely effective and will achieve the RAOs. Unlike Alternative 2, Alternative 3 will not require the implementation of LUCs upon completion. The following sections present a detailed analysis of this alternative.

4.2.3.1 Effectiveness Evaluation

The excavation and removal of the impacted soils within the footprint proposed in Alternative 3 will achieve the remedial action objectives of: 1.) minimizing risks to potential human and ecological receptors; and 2.) minimizing the potential for contaminated surface soils to migrate from the source area. The human health and ecological risk assessments presented in Appendices B and C, respectively, indicate that this removal action would result in sufficient risk reduction that would allow for future residential use of the area. The removal of impacted surface soils would also eliminate the potential for future migration of impacted materials from the source area due to erosion. The removal and disposal of the impacted soil provides a permanent reduction in risk and does not require the implementation and maintenance of engineered controls to manage residual risk. During the excavation, appropriate engineering and institutional controls will be used to ensure that this process is protective of human health and the community.

4.2.3.2 Implementability Evaluation

Alternative 3 can be implemented within a reasonable time frame. There are no significant construction considerations that would limit the implementability of the alternative. The foot print of the treatment area under this option is slightly larger than that proposed under Alternative 2; therefore, this option will require some additional site clearing and preparation activities. Off-site disposal services are available for the impacted soil that will be generated during the excavation activities. The excavated soil will be stabilized at an approved off-site disposal facility with an engineered stabilization media prior to final disposal. Confirmation samples would be collected to verify the success of the removal action, and the excavated areas would be backfilled with clean soil imported from off-site or an approved on-site source.

4.2.3.3 Cost Evaluation

A cost estimate for implementing Alternative 3 is presented in Table 4-2. This estimate includes contractor costs for performing the required site work and disposal activities, professional reporting and oversight fees, and site closure reporting. As this alternative would allow for a residential level closure for the NBG, there would be no need for follow on activities or LUCs, which provides a significant life-cycle cost savings measure. Based on the current projected costs, the total cost for implementing this alternative is approximately $238,000.

5. Comparative Analysis of Alternatives

The purpose of the comparative analysis of alternatives is to compare each alternative against the others and rank them based on their ability to meet the criteria of effectiveness, implementability, and cost.

The No-Action Alternative (Alternative 1) has been deemed inappropriate for the site and eliminated from further consideration. While there is no cost associated with Alternative 1, and it is easily implementable due to the fact that no action is taken, this alternative does not achieve the RAOs.

Alternative 2 (excavation and disposal of impacted soil to achieve industrial closure) and Alternative 3 (excavation and disposal of impacted soil to achieve residential closure) would both be very effective remedies for the site. Both would minimize the potential human health and ecological risks associated with the site. They would also achieve the RAO of minimizing the potential for migration of impacts within surface soil. Alternative 3 would be slightly more protective because the COCs exceeding the residential risk screening thresholds would be removed. However, Alternative 2 would likely be used in conjunction with land use restrictions to limit future use to industrial which would also minimize risk to individuals. The RFAAP-NRU is actively used as a storage facility for the RFAAP-MMA; therefore, restricting land use to industrial would be consistent with the current use of the property.

Both Alternative 2 and Alternative 3 are readily implementable. There are several contracting companies in the region that specialize in the excavation and disposal of contaminated soils. While the remedies are very similar in scope, Alternative 2 would rank slightly easier for implementation because of the smaller total footprint of the excavation. The site preparation work (i.e. clearing and establishing stormwater controls) and the volume of soil requiring treatment and disposal would also be less for Alternative 2 than Alternative 3.

The projected cost of implementing Alternative 3 ($238,000) is significantly lower than the costs for Alternative 2 ($340,000). The cost of having to implement, inspect, and maintain the LUCs required for the industrial level closure provided under Alternative 2 are far more expensive than the additional material that would be removed to achieve the residential (i.e. clean) closure provided by Alternative 3.

6. Recommended Removal Action Alternatives

The removal action recommended for the NBG Removal Action is Alternative 3 – Excavation, Off-Site Stabilization, and Disposal of Impacted Soils to Achieve Residential Closure. Although the current and reasonably anticipated future use of the area is industrial, a cost benefit analysis indicates that in this specific case it is to the Army's advantage to remediate to residential levels and eliminate the need for long term monitoring of LUCs. The long term monitoring costs associated with maintaining the LUCs under Alternative 2 are more expensive than the cost of removing the additional soil under Alternative 3. The recommended removal action will also effectively minimize the spatial distribution of the COPECs remaining on-site such that the potential for adverse ecological effects would be unlikely. This alternative was selected in accordance with the guidelines and procedures outlined in USEPA guidance (USEPA, 1993) and the requirements of the NCP (40 CFR 300). The excavation and disposal of the impacted soil would be the most protective of public health and the environment, achieve the removal action objectives, and comply with ARARs.

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Tables

Table 3-1 Proposed Chemical-Specific ARARs – Northern Burning Ground Removal Action EE/CA, Radford Army Ammunition Plant – New River Unit.

Media	Source	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Soil	USEPA Regional Screening Levels Table 2008	Risk Based Concentrations	Provides preliminary remediation goals for constituents in soils.	TBC – RSLs will be used to evaluate the potential risks to human health associated with the site COCs.
Ground-water	USEPA Regional Screening Levels Table 2008	Risk Based Concentrations	Provides preliminary remediation goals for constituents in tap water.	TBC – Groundwater is not included in this removal action, but will be considered for the overall RFAAP-NRU.
Ground-water	USEPA MCLs	Maximum Contaminant Levels	Provides maximum contaminant levels allowed in tap water.	TBC – Groundwater is not included in this removal action, but will be considered for the overall RFAAP-NRU..
Surface-water	Virginia Aquatic Life Freshwater Chronic Standards	Risk Based Concentrations	Provides preliminary remediation goals for constituents in surface water.	TBC – risk based guidance levels for constituents.
Surface-water	VIrginia Human Health Standards(All other surface waters)	Risk Based Concentrations	Provides preliminary remediation goals for constituents in surface water.	TBC– risk based guidance levels for constituents.

Notes:
ARAR Applicable or relevant and appropriate
EE/CA Engineering Evaluation/Cost Analysis
RBC Risk Based Concentration
TBC To be considered.
USEPA U.S. Environmental Protection Agency
MCL USEPA Maximum Contaminant Levels

Table 3-2 Proposed Location-Specific ARARs – Northern Burning Ground Removal Action EE/CA, Radford Army Ammunition Plant – New River Unit.

Location	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Archaeological Artifacts	National Archaeological and Historical Preservation Action 16 USC 469 National Historic Landmark Program 36 CFR 65	• Action to recover and preserve significant artifacts • Prevent irreparable harm, loss, or destruction of significant artifacts.	Not Applicable – No archaeological significant artifacts have been identified at the NBG.
Floodplain	Executive Order 11988, Floodplain Management 40 CFR 6, Appendix A Fish and Wildlife Coordination Act 40 CFR 6.302 16 USC et seq	• Actions to avoid adverse effects • Minimize potential harm • Enhance wetlands, to the extent possible.	Not Applicable – The NBG is not located within a floodplain
Wetlands	Executive Order 11990, Protection of wetlands 40 CFR Part 6, Appendix A	• Actions to avoid adverse effects • Minimize potential harm • Enhance wetlands, to the extent possible.	Not Applicable -
Wilderness Area	Fish and Wildlife Coordination Act 16 USC 661 et. seq.	• Presence of fish and wildlife resources; action by federal agencies resulting in the control or structural modification of a natural stream or body of water. • Off-site response actions.	Not Applicable -

ARAR Applicable or relevant and appropriate
CFR Code of Federal Regulations
EE/CA Engineering Evaluation/Cost Analysis
TBC To be considered.
USC U.S. Code

Table 3-3. Proposed Action-Specific ARARs - Northern Burning Ground Removal Action EE/CA, Radford Army Ammunition Plant – New River Unit.

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Stormwater Discharges to Surface Water	Stormwater Discharges Virginia VAC 25-151 (VAR 05)	Provides for the use of best management practices to control stormwater, erosion control and sediment transport.	ARAR Applicable to the use of best management practices to control stormwater, erosion and sediment transport during earthwork activities
Surface Water Quality Standards	Surface Water Discharges Virginia 9 VAC 25-260	Establishes water quality criteria based on toxicity to aquatic organisms and human health, and water use classifications and antidegradation policy.	ARAR Applicable to stormwater discharges during excavation activities.
Indirect Discharges to POTW	POTW Pretreatment Standards Virginia 9 VAC 25-31	Establishes list of toxic pollutants and promulgates pretreatment standards for discharge to POTWs.	TBC Not Applicable for the Removal Action.
	Pretreatment Standards 40 CFR Part 403.1-18	Established pretreatment standards for the control of pollutants discharge to POTWs.	TBC Not Applicable for the Removal Action.
	Disposal by Release into Sanitary Sewer 10 CFR 20.2003	Provides the conditions in which a licensee may discharge licensed material into a sanitary sewerage.	TBC Not Applicable for the Removal Action.
Sampling and Analysis	RCRA Hazardous Waste 40 CFR 261 Virginia 9 VAC 20-60	Specific requirements for identifying hazardous wastes. Establishes analytical requirements for testing and evaluating solid, hazardous, and water wastes.	ARAR Applicable for identifying hazardous waste.
On-Site Storage And Treatment	RCRA General Facility Standards 40 CFR 264, Subparts A and B	Sets general facility requirements including waste analysis, security measures, inspections, and training.	ARAR Applicable if hazardous waste is generated and stored on site beyond the accumulation times (i.e. 90 days) specified in 40 CFR 262.34.
	RCRA Preparedness and Prevention 40 CFR 264, Subpart C	Establishes requirement for safety equipment and spill control measures for hazardous waste TSD facilities.	ARAR Applicable if hazardous waste is generated and stored on site beyond the accumulation times (i.e. 90 days) specified in 40 CFR 262.34.
	RCRA Contingency Plan and Emergency Procedures 40 CFR 264, Subpart D	Outlines the requirements for emergency procedures to be used in the event of explosions, fires, etc.	ARAR Applicable if hazardous waste is generated and stored on site beyond the accumulation times (i.e. 90 days) specified in 40 CFR 262.34.

Table 3-3. Proposed Action-Specific ARARs - Northern Burning Ground Removal Action EE/CA (Continued)

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC Status
	RCRA Closure and Post-Closure 40 CFR 264, Subpart G Virginia 9 VAC 20-60-	Establishes post and post-closure requirements for facilities that treat, store or dispose hazardous waste.	ARAR Relevant and appropriate for the in-place closure for waste that would be RCRA listed or characteristic if generated.
	RCRA Storage in Containers 40 CFR 264, Subpart I	Requirements permit on-site storage of hazardous wastes in containers under certain design, operation and maintenance standards.	ARAR Applicable to storage of hazardous materials stored in containers.
	RCRA Tank Systems 40 CFR 264, Subpart J Virginia 9 VAC 25-	Establishes requirements for tank systems that store or treat hazardous waste. It provides design, containment, operating, closure and post-closure requirements.	ARAR Applicable if hazardous waste is generated during decontamination and stored on site beyond the accumulation times (i.e. 90 days) specified in 40 CFR 262.34.
	RCRA Impoundments 40 CFR 264, Subpart K Virginia 9 VAC 25-	Establishes requirements for impoundments that store or treat hazardous waste. It provides design, containment, operating, closure and post-closure requirements.	ARAR Relevant and appropriate for the design of an in-place closure for waste that would be RCRA listed or characteristic if generated.
	Solid Waste Disposal Virginia 9 VAC 20-70 and 20-80-	Provides the permitting and closure requirements for a solid waste disposal area.	ARAR Relevant and appropriate for the design of caps for solid wastes.
Off-Site Disposal of Hazardous Waste	RCRA Land Disposal Restrictions: 40 CFR 268, Subparts A through E	Identifies hazardous wastes that are restricted from land disposal and defines circumstances under which an otherwise restricted waste may continue to be land disposed.	ARAR Applicable for the off-site disposal of RCRA listed or characteristic hazardous waste in a permitted landfill.
Packaging, Labeling, and Storage	RCRA Treatment, Storage, and Disposal of Hazardous Waste 40 CFR 264 Subparts N	Universal treatment standards and specified technologies for wastes subject to the land disposal restrictions.	ARAR Applicable for the off-site disposal of RCRA listed or characteristic hazardous waste in a permitted facility.
	RCRA Hazardous Waste Generation 40 CFR 262 Subparts A through D	Specifies requirements for hazardous waste packaging, labeling, manifesting, record keeping, and accumulation time.	ARAR Applicable for the off-site disposal of RCRA listed or characteristic hazardous waste in a permitted facility.
	USDOT Hazardous Materials Transportation Regulations 49 CFR 171-173 and 177-180.	Establishes classification, packaging, and labeling requirements for shipments of hazardous materials.	ARAR Applicable for the off-site transportation of ACM and RCRA listed or characteristic hazardous.
Transportation	RCRA Hazardous Waste Transportation 40 CFR Parts 107, 171-177	Regulates transportation of hazardous materials.	ARAR Applicable for the off-site transportation of ACM and RCRA listed or characteristic waste.

Table 3-3. Proposed Action-Specific ARARs - Northern Burning Ground Removal Action EE/CA (Continued)

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Transportation (cont)	RCRA Hazardous Waste Transportation 40 CFR 263, Subparts A, B, and C	Specifies requirements for hazardous waste manifest compliance, record keeping, and hazardous waste discharges during hazardous waste transport.	ARAR Applicable for the off-site transportation of RCRA listed or characteristic waste.
	RCRA Hazardous Waste Generators 40 CFR 262.20(f)	This section excludes, from the requirements of Subpart B (The Manifest) transport of hazardous wastes on a public or private right-of-way within or along the border of contiguous property under control of the same person.	ARAR Applicable for the off-site transportation of RCRA listed or characteristic waste.
Air Emissions	Virginia Air Quality Standards 9 VAC 5-30	Provides long-range goals for ambient air quality throughout the state of Virginia in order to protect the public health and welfare.	ARAR Applicable to ensure standards are not exceeded during earthwork activities.
	Virginia Air Quality Standards 9 VAC 5-50	Establishes emission standards and performance criteria for new or modified sources emitting hazardous air pollutants (HAP) by adopting certain portions of 40 CFR Part 61 as of July 1994.	ARAR Applicable to ensure that HAPs emission standards are not exceeded during earthwork activities.
	New Source Performance Standards (NSPS) 40 CFR 60.1-19	Establishes technology based standards for emissions to air from regulated stationary sources.	ARAR Applicable to establish criteria pollutants and hazardous air pollutants might be emitted as a result of excavation activities.
	National Emission Standards for Hazardous Air Pollutants (NESHAP)	Includes emission standards for hazardous air pollutants such as beryllium, mercury, vinyl chloride, benzene, inorganic arsenic, and fugitive emissions from specific sources.	ARAR Applicable to hazardous air pollutants emitted as a result of earthwork activities being performed.
	Fugitive Particulate Emissions Virginia 9 VAC 5-40-70	Restricts persons from causing or allowing fugitive particulate matter to go beyond the premise where such matter originates.	ARAR Applicable to fugitive dust emission during earthwork activities.
	Fugitive Dust Emissions 40 CFR 50.12	Establishes national primary and secondary ambient air quality standards for lead and its compounds.	ARAR Applicable to fugitive dust emissions during earthwork activities.
	National Ambient Air Quality Standards (NAAQS) 40 CFR 52.1-30, 40 CFR 52.870-884	Establishes national standards for criteria pollutants in ambient air.	ARAR Applicable to particulate matter emitted as a result of earthwork activities.

ACM Asbestos containing material
ARAR Applicable or relevant and appropriate
CFR Code of Federal Regulations
CSR Code of State Regulations

Table 3-3. Proposed Action-Specific ARARs - Northern Burning Ground Removal Action EE/CA (Continued)

EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
HAPs	Hazardous air pollutants
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NSPS	New Source Performance Standards
POTW	Publicly Owned Treatment Works
RCRA	Resource Conservation and Recovery Act
TBC	To be considered
TSD	Treatment, storage, and disposal
USDOT	U.S. Department of Transportation

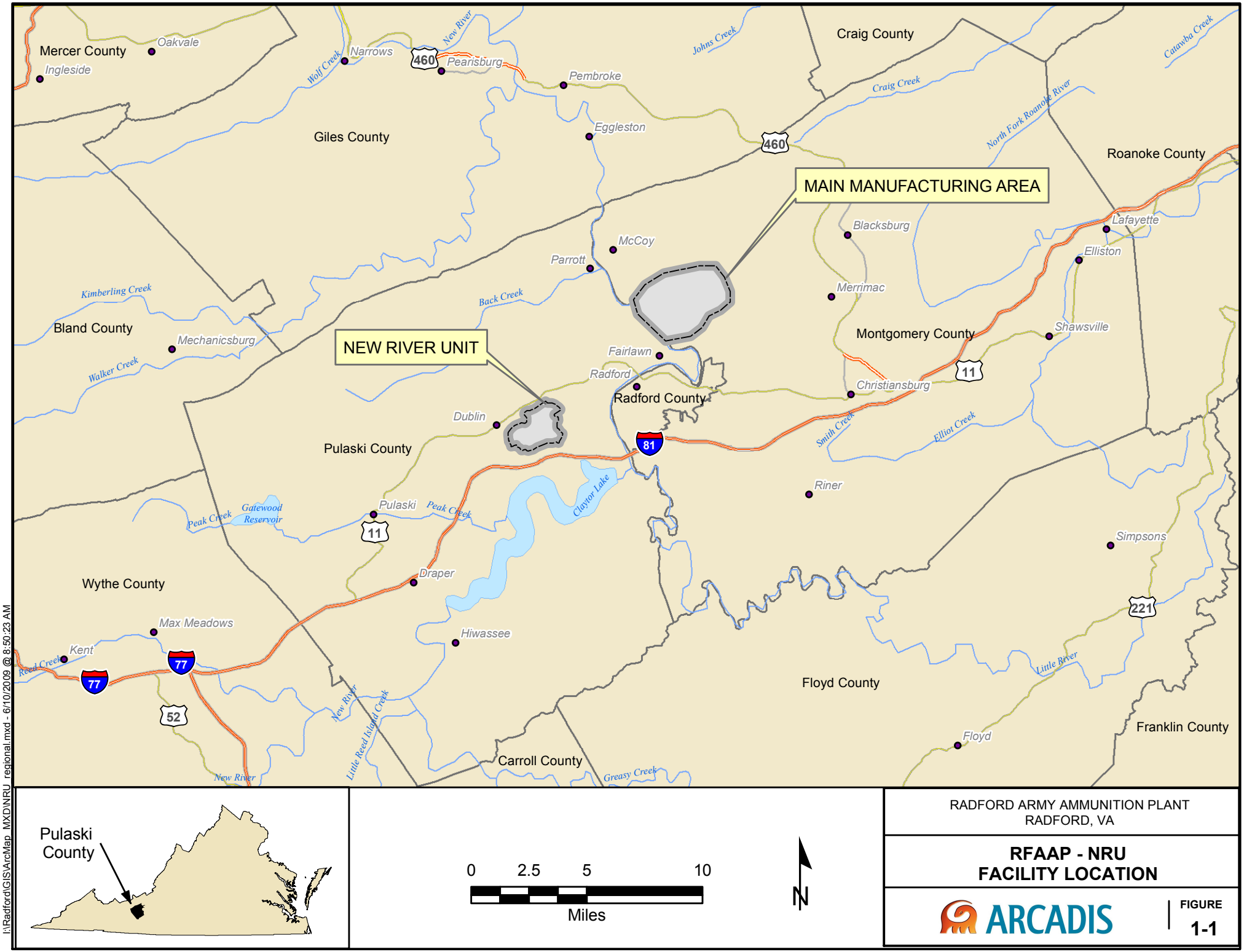
Table 4-1 Estimated Costs for Removal Action 2 - Excavation and Disposal of Soil Exceeding Industrial RBCs

Item	Description	Quantity	Unit of Measure	Unit Cost	Total
	Removal Action				
1	Contractor Mobilization/Demobilization	1	LS	$ 20,000.00	$ 20,000.00
2	Site Preparation/Clearing	1	LS	$ 5,000.00	$ 5,000.00
3	Excavation of Impacted Soils	120	CY	$ 30.00	$ 3,600.00
4	Transportation, Off-Site Stabilization, and Off-Site Disposal of Excavated Material	120	CY	$ 265.00	$ 31,800.00
5	XRF Rental	2	week	$ 3,500.00	$ 7,000.00
6	Analytical - Confirmation Soil Samples Includes metals only	25	sample	$ 125.00	$ 3,125.00
7	Analytical - TCLP/Waste Profiling Soil Samples Includes metals and PAHs	5	sample	$ 300.00	$ 1,500.00
8	Survey Excavation Footprint Area surveyed before and after excavation activities	2	day	$ 1,750.00	$ 3,500.00
9	Backfill	120	CY	$ 20.00	$ 2,400.00
10	Storm Water Controls	1	LS	$ 3,000.00	$ 3,000.00
11	Seeding	1	LS	$ 500.00	$ 500.00
	Subtotal				**$ 81,425.00**
	Professional Services For Removal Action				
12	Preparation of Work Plan and Remedial Design	1	LS	$ 15,000.00	$ 15,000.00
13	Excavation Oversight and Consulting Services	1	LS	$ 25,000.00	$ 25,000.00
14	Permitting	1	LS	$ 10,000.00	$ 10,000.00
15	Removal Action Completion Report	1	LS	$ 15,000.00	$ 15,000.00
16	Finalize Site Closure Report	1	LS	$ 20,000.00	$ 20,000.00
	Subtotal				**$ 85,000.00**
	Follow-On Professional Services				
17	Preparation of Land-Use Controls Area will need to need to be restricted from future residential use	1	LS	$ 15,000.00	$ 15,000.00
18	Legal Fees	1	LS	$ 5,000.00	$ 5,000.00
19	Annual Inspections and Reporting	30	YR	$ 2,500.00	$ 75,000.00
20	Inspections and Reporting for CERCLA 5 Year Reviews	6	Each	$ 3,000.00	$ 18,000.00
21	Misc. Project Communications and Project Management	30	YR	$ 1,000.00	$ 30,000.00
	Subtotal				**$ 143,000.00**
	Subtotal Cost for Alternative 2				**$ 309,425.00**
	Contingency (10% of Cost)				$ 30,942.50
	Total Cost for Alternative 2				**$ 340,367.50**

Table 4-2 Estimated Costs for Removal Action 3 - Excavation and Disposal of Soil Exceeding Residential RBCs

Item	Description	Quantity	Unit of Measure	Unit Cost	Total
	Removal Action				
1	Contractor Mobilization/Demobilization	1	LS	$ 20,000.00	$ 20,000.00
2	Site Preparation/Clearing	1	LS	$ 10,000.00	$ 10,000.00
3	Excavation of Impacted Soils	250	CY	$ 30.00	$ 7,500.00
4	Transportation, Off-Site Stabilization, and Off-Site Disposal of Excavated Material	250	CY	$ 265.00	$ 66,250.00
5	XRF Rental	2	week	$ 3,500.00	$ 7,000.00
6	Analytical - Confirmation Soil Samples Includes metals only	35	sample	$ 125.00	$ 4,375.00
7	Analytical - TCLP/Waste Profiling Samples Soil Samples Includes metals and PAHs	5	sample	$ 300.00	$ 1,500.00
8	Survey Excavation Footprint Area surveyed before and after excavation activities	2	day	$ 1,750.00	$ 3,500.00
9	Backfill	250	CY	$ 20.00	$ 5,000.00
10	Storm Water Controls	1	LS	$ 3,000.00	$ 3,000.00
11	Seeding	1	LS	$ 750.00	$ 750.00
	Subtotal				**$ 128,875.00**
	Professional Services For Removal Action				
12	Preparation of Work Plan and Remedial Design	1	LS	$ 15,000.00	$ 15,000.00
13	Excavation Oversight and Consulting Services	1	LS	$ 25,000.00	$ 25,000.00
14	Permitting	1	LS	$ 10,000.00	$ 10,000.00
15	Removal Action Completion Report	1	LS	$ 15,000.00	$ 15,000.00
16	Finalize Site Closure Report	1	LS	$ 20,000.00	$ 20,000.00
	Subtotal				**$ 85,000.00**
	Follow-On Professional Services				
16	Preparation of Land-Use Restrictions No land use restrictions will be required	0	LS	$ -	$ -
17	Misc Project Communications and Project Management	1	YR	$ 2,500.00	$ 2,500.00
	Subtotal				**$ 2,500.00**
	Subtotal Cost for Alternative 3				**$ 216,375.00**
	Contingency (10% of Cost)				$ 21,637.50
	Total Cost for Alternative 3				**$ 238,012.50**

Figures


MAIN MANUFACTURING AREA
NEW RIVER UNIT
Mercer County
Oakvale
Ingleside
Narrows
Wolf Creek
New River
460
Pearisburg
Pembroke
Johns Creek
Craig County
Catawba Creek
Craig Creek
North Fork Roanoke River
Giles County
Eggleston
460
Roanoke County
Blacksburg
Lafayette
Elliston
McCoy
Parrott
Merrimac
Kimberling Creek
Back Creek
Bland County
Mechanicsburg
Walker Creek
Montgomery County
Shawsville
Fairlawn
Radford
Christiansburg
11
Radford County
Dublin
Pulaski County
81
Smith Creek
Elliot Creek
Riner
Claytor Lake
Pulaski
Peak Creek
Gatewood Reservoir
11
Simpsons
Draper
Wythe County
Max Meadows
Hiwassee
221
Kent
Reed Creek
77
77
Little River
Floyd County
52
New River
Little Reed Island Creek
Franklin County
Floyd
Carroll County
Greasy Creek
New River
Pulaski County
0
2.5
5
10
Miles
N
RADFORD ARMY AMMUNITION PLANT
RADFORD, VA
RFAAP - NRU
FACILITY LOCATION
ARCADIS
FIGURE
1-1
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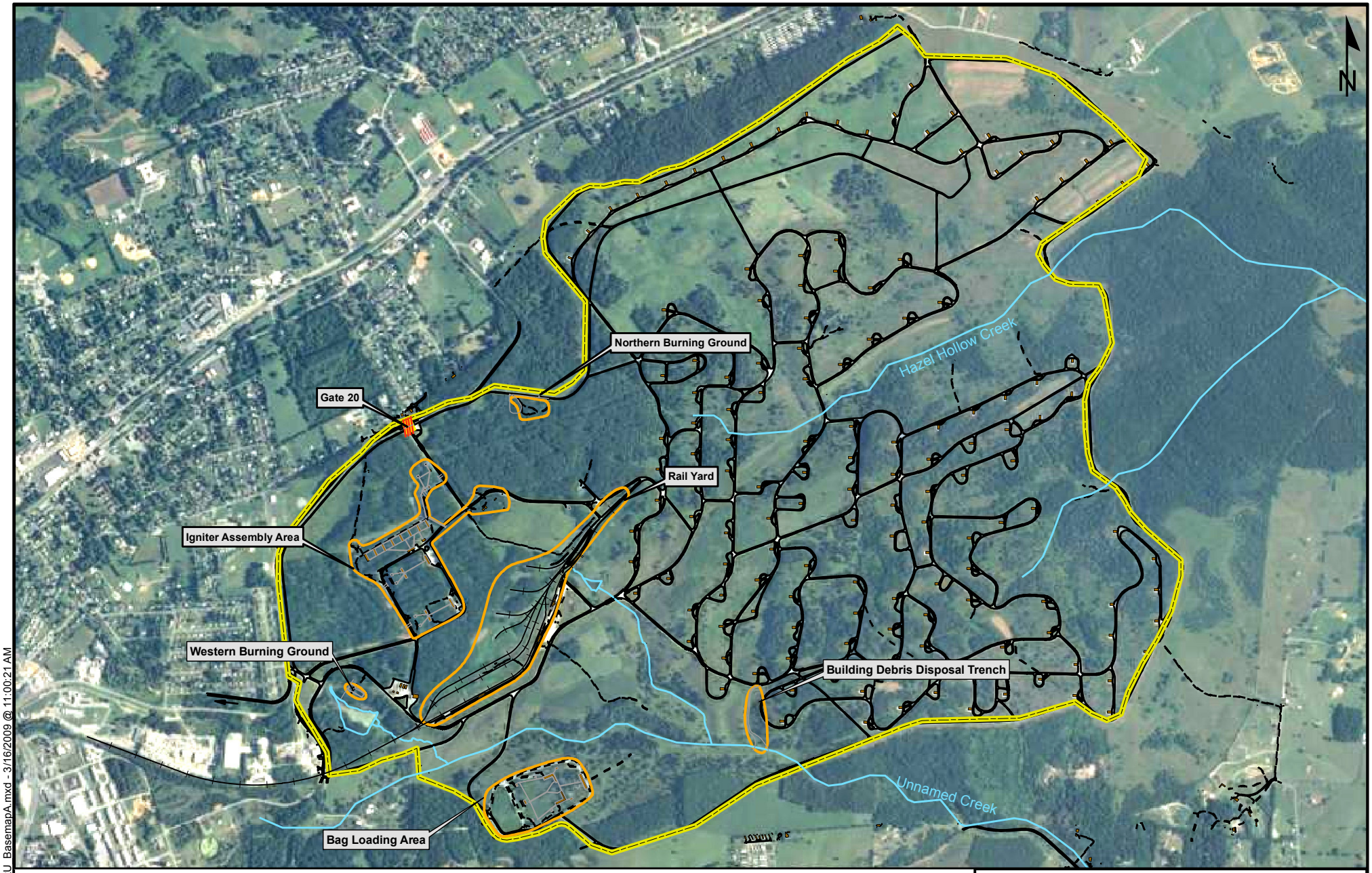

LEGEND

- SITE FEATURES
- RAIL SPUR
- SURFACE WATER
- PAVED ROADS
- DIRT ROADS
- STUDY AREA
- NRU BOUNDARY
- BUILDINGS

NOTES:

1. GIS SPATIAL LAYERS OBTAINED FROM SHAW ENVIRONMENTAL, INC. AS REFERENCED IN THEIR REPORT TITLED NRU ADDITIOANL CHARACTERIZATION SAMPLING & GROUNDWATER INVESTIGATION DATA REPORT IN OCTOBER 2007.

0 900 1,800 Feet

GRAPHIC SCALE

RADFORD ARMY AMMUNITION PLANT
RADFORD, VA

NEW RIVER UNIT STUDY AREAS

ARCADIS

FIGURE 1-2

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N

NBGSD01
NBG-MW-02
NBGSD03
NBGSD02
NBGSB32
NBGSD04
NBGSB4
NBGSB26
NBGSB15
NBGSB2
NBGDW3
NBGSB25
SS-02
NBGSB30
NBGDW11
NBGDW10
NBGDW4
NBGSB9
NBGSB21
NBGDW1
NBGSB24
NBGSB27
NBGDW5
NBGSB8
NBGSB14
NBGDW13
NBGDW2
NBGDW7
NBGDW12
NBGDW6
NBGSB20
NBGSB3
NBGSB23
NBGDW9
NBGSB1
NBGSB13
NBGSB7
NBGSB33
NBGSB10
NBGSB11
NBGSB16
NBGSB12
NBGDW8
NBG-MW-01
NBGSB17
NBGSB22
NBGSB29
SS-01
NBGSB31
NBGSB18
NBGSB19
NBGSB6
NBGSB28
NBGSB5

Legend

- HISTORICAL SOIL SAMPLE LOCATIONS
- GROUNDWATER LOCATIONS
- PAVED ROADS
- DIRT ROADS
- LOW AREA
- DRAINAGE DITCH
- CULVERT
- STUDY AREA
- NRU BOUNDARY

0 60 120 Feet

GRAPHIC SCALE

THE NORTHERN BURNING GROUND AT THE NEW RIVER UNIT
RADFORD ARMY AMMUNITION PLANT
RADFORD, VA

NORTHERN BURNING GROUND SITE LAYOUT

ARCADIS

FIGURE 1-3

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NBGSB21

Depth(Feet)	(0 – 0.5')	(1 – 3')	(3 – 5')	(5 – 7')
Date	7/20/2004	7/20/2004	7/20/2004	7/20/2004
PCBs				
Aroclor–1254	1.3	<0.041	0.18	<0.044
Inorganics				
Arsenic	<6.60	6.50	4.90	13.3
Chromium	1,090	32.9	352	53.1
Lead	16,500	30.4	4,090	24.7
Zinc	6,090	29.6	647	23.1

NBGSB14

Depth(Feet)	(0 – 0.5')	(1 – 3')
Date	6/12/2002	6/19/2002
Dioxin/Furan		
2,3,4,7,8–PeCDF	<0.00000104	<0.00000005
2,3,7,8–TCDF	0.00000725	<0.00000004
OCDD	0.003884	0.01645 J
PCBs		
Aroclor–1254	0.97	<0.040
Inorganics		
Arsenic	9.97	5.69 L
Chromium	3,110 J	33.1 L
Lead	20,500 K	30.4
Zinc	3,570 J	18.5 J

NBGDW10

Depth(Feet)	(0 – 4')
Date	8/19/1999
Inorganics	
Arsenic	14.5 K
Chromium	54.2
Lead	20.7
Zinc	35.4
Inorganics–TCLP	
Lead	0.0299

NBGSB15

Depth(Feet)	(0 – 0.5')	(1 – 3')
Date	6/12/2002	6/19/2002
Dioxin/Furan		
2,3,4,7,8–PeCDF	<0.00000104	0.00000061 J
2,3,7,8–TCDF	<0.00000151	<0.00000016 J
OCDD	0.002064	0.004063 J
PCBs		
Aroclor–1254	<0.030	<0.030
Inorganics		
Arsenic	3.78	4.14 L
Chromium	123 J	22.7 L
Lead	1,200 K	82.0
Zinc	3,820 J	129 J

NBGDW11

Depth(Feet)	(0 – 4')
Date	8/19/1999
Inorganics–TCLP	
Lead	63.3

NBGDW3

Depth(Feet)	(0 – 4')
Date	8/18/1999
Inorganics–TCLP	
Lead	0.0112

NBGSD02

Depth(Feet)	(0 – 0.5')
Date	7/14/2004
PCBs	
Aroclor–1254	0.068
Inorganics	
Arsenic	8.90
Chromium	38.3
Lead	146
Zinc	208

NBGSB32

Depth(Feet)	(0 – 0.5')
Date	7/19/2004
PCBs	
Aroclor–1254	<0.042
Inorganics	
Arsenic	8.90
Chromium	39.9
Lead	159
Zinc	204

NBGSD01

Depth(Feet)	(0 – 0.5')
Date	6/18/2002
Dioxin/Furan	
2,3,4,7,8–PeCDF	0.00000024 [<0.00000025]
2,3,7,8–TCDF	0.00000038 [0.00000022 J]
OCDD	0.002629 J [0.003003 J]
PAHs	
Benzo(a)anthracene	0.19 [0.49]
Benzo(a)pyrene	0.21 [0.53]
Benzo(b)fluoranthene	0.31 [0.73]
Dibenzo(a,h)anthracene	0.036 [0.084]
Indeno(1,2,3–cd)pyrene	0.18 [0.4]
PCBs	
Aroclor–1254	0.14 [<0.040]
Inorganics	
Arsenic	5.56 J [5.75 J]
Chromium	41.1 J [35.3 J]
Lead	159 [132]
Zinc	473 J [405 J]

NBGSD03

Depth(Feet)	(0 – 0.5')
Date	7/16/2004
PCBs	
Aroclor–1254	<0.039
Inorganics	
Arsenic	6.80
Chromium	397
Lead	3,500
Zinc	4,220

NBGSD04

Depth(Feet)	(0 – 0.5')
Date	7/16/2004
PCBs	
Aroclor–1254	0.15
Inorganics	
Arsenic	5.10
Chromium	151
Lead	2,200
Zinc	2,630

NBGSB25

Depth(Feet)	(0 – 0.5')	(1 – 3')	(3 – 5')	(5 – 7')
Date	7/20/2004	7/20/2004	7/20/2004	7/20/2004
PCBs				
Aroclor–1254	0.56	<0.037	<0.040	<0.040
Inorganics				
Arsenic	6.50	4.30	12.7	6.10
Chromium	494	14.9	29.6	24.0
Lead	5,610 J	63.5	24.1	11.1
Zinc	4,040	650	20.7	17.8

SS–02

Depth(Feet)	(0.5 – 0.7')
Date	6/3/1997
Inorganics	
Arsenic	6.30
Chromium	44.2
Lead	199
Zinc	1,210

NBGSB4

Depth(Feet)	(0.5 – 1.5')	(5 – 6')
Date	8/4/1998	8/4/1998
SVOCs		
Benzo(a)anthracene	<0.38	<0.45
Benzo(a)pyrene	<0.38	<0.45
Benzo(b)fluoranthene	<0.38	<0.45
Dibenzo(a,h)anthracene	<0.38	<0.45
Indeno(1,2,3–cd)pyrene	<0.38	<0.45
Inorganics		
Arsenic	6.00 K	8.10 K
Chromium	30.0	42.3
Lead	76.2	20.0
Zinc	67.8 B	28.3 B

NBGDW4

Depth(Feet)	(0 – 4')
Date	8/17/1999
Inorganics–TCLP	
Lead	0.0933

NBGSB26

Depth(Feet)	(0 – 0.5')
Date	7/20/2004
PCBs	
Aroclor–1254	<0.039
Inorganics	
Arsenic	5.20
Chromium	24.8
Lead	80.1
Zinc	95.4

NBGSB9

Depth(Feet)	(0 – 0.5')
Date	5/27/1999
PAHs	
Benzo(a)anthracene	<0.02
Benzo(a)pyrene	<0.02
Benzo(b)fluoranthene	<0.03
Dibenzo(a,h)anthracene	<0.03
Indeno(1,2,3–cd)pyrene	<0.01
Inorganics	
Arsenic	5.60 B
Chromium	16.0
Lead	28.4
Zinc	45.8

NBGSB30

Depth(Feet)	(0 – 0.5')
Date	7/21/2004
PCBs	
Aroclor–1254	<0.041
Inorganics	
Arsenic	11.0
Chromium	36.8
Lead	51.0
Zinc	34.8

NBGDW13

Depth(Feet)	(0 – 4')
Date	8/19/1999
Inorganics	
Arsenic	8.70 K
Chromium	94.5
Lead	707
Zinc	706
Inorganics–TCLP	
Lead	5.1

NBGDW1

Depth(Feet)	(0 – 4')
Date	5/26/1999
SVOCs	
Benzo(a)anthracene	<0.37
Benzo(a)pyrene	<0.37
Benzo(b)fluoranthene	<0.37
Dibenzo(a,h)anthracene	<0.37 J
Indeno(1,2,3–cd)pyrene	<0.37 J
Inorganics–TCLP	
Lead	6.4

NBGSB8

Depth(Feet)	(0 – 0.5')	(3.5 – 4')
Date	5/27/1999	5/27/1999
PAHs		
Benzo(a)anthracene	<0.02 [<0.02]	<0.02
Benzo(a)pyrene	<0.02 [<0.02]	<0.02
Benzo(b)fluoranthene	<0.03 [<0.03]	<0.03
Dibenzo(a,h)anthracene	<0.02 [<0.02]	<0.02
Indeno(1,2,3–cd)pyrene	<0.01 [<0.01]	<0.01
Inorganics		
Arsenic	5.40 B [7.90]	6.00 B
Chromium	15.4 [20.3]	14.8
Lead	24.3 [22.8]	17.6
Zinc	37.6 [47.6]	27.2

NBGSB33

Depth(Feet)	(0 – 0.5')
Date	7/21/2004
PCBs	
Aroclor–1254	<0.039
Inorganics	
Arsenic	8.10
Chromium	28.0
Lead	20.8
Zinc	38.3

NBGSB20

Depth(Feet)	(0 – 0.5')	(1 – 3')	(3 – 5')	(5 – 7')
Date	7/20/2004	7/20/2004	7/20/2004	7/20/2004
PCBs				
Aroclor–1254	0.23	<0.043	<0.046 [<0.046]	<0.048
Inorganics				
Arsenic	6.80 J	10.4	16.1 [15.7]	17.5
Chromium	1,000	42.6	54.8 [60.8]	55.8
Lead	11,200	15.9	34.0 [33.3]	40.1
Zinc	1,700	19.7	31.9 [32.9]	31.1

NBGSB1

Depth(Feet)	(0.5 – 1.5')	(8 – 10')	(53 – 55')
Date	8/4/1998	8/4/1998	8/4/1998
SVOCs			
Benzo(a)anthracene	<0.39	<0.46 [<0.38]	<0.46
Benzo(a)pyrene	<0.39	<0.46 [<0.38]	<0.46
Benzo(b)fluoranthene	<0.39	<0.46 [<0.38]	<0.46
Dibenzo(a,h)anthracene	<0.39	<0.46 [<0.38]	<0.46
Indeno(1,2,3–cd)pyrene	<0.39	<0.46 [<0.38]	<0.46
Inorganics			
Arsenic	4.20 K	7.00 K [7.30 K]	9.20 K
Chromium	31.8	75.3 [53.7]	35.0
Lead	127	226 [155]	29.5
Zinc	61.0 B	67.4 B [50.2 B]	60.4 B

NBGDW9

Depth(Feet)	(0 – 4')
Date	8/19/1999
Inorganics–TCLP	
Lead	1.21

NBGSB24

Depth(Feet)	(0 – 0.5')	(1 – 3')	(3 – 5')	(5 – 7')
Date	7/20/2004	7/20/2004	7/20/2004	7/20/2004
PCBs				
Aroclor–1254	0.14	<0.040 [<0.039]	<0.039	<0.039
Inorganics				
Arsenic	5.60	7.20 [5.70]	3.90	3.60
Chromium	174	26.0 [20.4]	16.1	18.0
Lead	1,710 J	27.4 J [29.2 J]	23.2 J	10.0 J
Zinc	875	34.8 [39.8]	20.1	11.1

NBGSB27

Depth(Feet)	(0 – 0.5')
Date	7/22/2004
PCBs	
Aroclor–1254	<0.043 [<0.043]
Inorganics	
Arsenic	4.00 [3.80]
Chromium	21.7 [31.8]
Lead	110 [172]
Zinc	99.5 [107]

NBGDW5

Depth(Feet)	(0 – 4')
Date	8/19/1999
Inorganics–TCLP	
Lead	0.0343

NBGSB2

Depth(Feet)	(0 – 2')	(5 – 6')
Date	8/4/1998	8/4/1998
SVOCs		
Benzo(a)anthracene	<0.38	<0.43
Benzo(a)pyrene	<0.38	<0.43
Benzo(b)fluoranthene	<0.38	<0.43
Dibenzo(a,h)anthracene	<0.38	<0.43
Indeno(1,2,3–cd)pyrene	<0.38	<0.43
Inorganics		
Arsenic	8.50 K	10.5 K
Chromium	1,620	53.4
Lead	23,400	19.5
Zinc	3,760	22.8 B

NBGDW2

Depth(Feet)	(0 – 4')
Date	5/26/1999
Inorganics–TCLP	
Lead	0.0434

NBGDW6

Depth(Feet)	(0 – 4')
Date	8/19/1999
Inorganics–TCLP	
Lead	0.035

NBGSB23

Depth(Feet)	(0 – 0.5')	(1 – 3')	(3 – 5')	(5 – 7')
Date	7/20/2004	7/20/2004	7/20/2004	7/20/2004
PCBs				
Aroclor–1254	<0.039	<0.040	<0.040	<0.040
Inorganics				
Arsenic	6.30	7.80	7.30	4.50
Chromium	50.8	54.3	31.8	26.9
Lead	348 J	147 J	50.1 J	10.0 J
Zinc	159	31.1	23.0	8.90

NBGSB29

Depth(Feet)	(0 – 0.5')
Date	7/20/2004
PCBs	
Aroclor–1254	<0.040
Inorganics	
Arsenic	2.40 B
Chromium	26.4
Lead	79.5
Zinc	158

NBGSB3

Depth(Feet)	(0.5 – 1.5')	(5 – 6')
Date	8/4/1998	8/4/1998
SVOCs		
Benzo(a)anthracene	<0.37	<0.40
Benzo(a)pyrene	<0.37	<0.40
Benzo(b)fluoranthene	<0.37	<0.40
Dibenzo(a,h)anthracene	<0.37	<0.40
Indeno(1,2,3–cd)pyrene	<0.37	<0.40
Inorganics		
Arsenic	3.20 K	4.30 K
Chromium	20.2	21.9
Lead	104	10.8
Zinc	132 B	15.4 B

NBGDW7

Depth(Feet)	(0 – 4')
Date	8/19/1999
Inorganics–TCLP	
Lead	1.92

NBGSB13

Depth(Feet)	(0 – 0.5')	(1 – 3')
Date	6/12/2002	6/19/2002
Dioxin/Furan		
2,3,4,7,8–PeCDF	0.0000101 J	<0.00000008
2,3,7,8–TCDF	0.00006188 J	<0.00000008
OCDD	0.002165 J	0.0033 J
PCBs		
Aroclor–1254	3.4	0.060
Inorganics		
Arsenic	24.1	2.35 L
Chromium	10,700 J	30.8 L
Lead	65,300 K	82.7
Zinc	19,600 J	64.8 J

NBGSB11

Depth(Feet)	(0 – 0.5')	(1 – 3')	(3 – 5')
Date	6/12/2002	6/19/2002	6/19/2002
Dioxin/Furan			
2,3,4,7,8–PeCDF	0.0000169 J	<0.00000007	0.00000038 J
2,3,7,8–TCDF	0.0001246 J	<0.0000001	0.00000234 J
OCDD	0.00224 J	0.004805 J	0.0005022 J
PCBs			
Aroclor–1254	3.4	0.020 J	0.070
Inorganics			
Arsenic	64.1	2.61 L	14.1 L
Chromium	25,700 J	25.4 L	172 L
Lead	91,400 K	63.6	903
Zinc	39,000 J	22.8 J	211 J

NBGSB12

Depth(Feet)	(0 – 0.5')	(1 – 3')	(3 – 5')
Date	6/12/2002	6/19/2002	6/19/2002
Dioxin/Furan			
2,3,4,7,8–PeCDF	<0.00000116	<0.00000007	<0.00000008
2,3,7,8–TCDF	<0.00000197	<0.0000001	<0.00000011
OCDD	0.002977	0.003495 J	0.0008244 J
PCBs			
Aroclor–1254	2.5	<0.030	<0.040
Inorganics			
Arsenic	3.31	5.87 L	11.3 L
Chromium	253 J	28.1 L	38.5 L
Lead	3,640 K	12.0	20.9
Zinc	1,280 J	18.2 J	32.0 J

NBGSB22

Depth(Feet)	(0 – 0.5')	(1 – 3')	(3 – 5')	(5 – 7')
Date	7/20/2004	7/20/2004	7/20/2004	7/20/2004
PCBs				
Aroclor–1254	4.6	<0.039 [<0.039]	<0.041	<0.046
Inorganics				
Arsenic	36.6 J	4.10 [3.70]	10.2	10.1
Chromium	9,690	23.0 [18.0]	53.6	41.3
Lead	111,000	27.6 [16.6]	143 J	34.9 J
Zinc	15,800	14.2 [12.3]	45.5	31.0

NBGSB31

Depth(Feet)	(0 – 0.5')
Date	7/22/2004
PCBs	
Aroclor–1254	<0.044
Inorganics	
Arsenic	5.90
Chromium	23.6
Lead	53.9
Zinc	143

NBGDW12

Depth(Feet)	(0 – 4')
Date	8/19/1999
Inorganics–TCLP	
Lead	0.384

NBGDW8

Depth(Feet)	(0 – 4')
Date	8/19/1999
Inorganics–TCLP	
Lead	0.387

NBGSB28

Depth(Feet)	(0 – 0.5')
Date	7/21/2004
PCBs	
Aroclor–1254	<0.042
Inorganics	
Arsenic	4.30
Chromium	25.8
Lead	124
Zinc	199

NBGSB16

Depth(Feet)	(0 – 0.5')	(2')	(6')	(10 – 12')
Date	6/12/2002	6/19/2002	6/19/2002	6/19/2002
Dioxin/Furan				
2,3,4,7,8–PeCDF	<0.00000074	<0.00000006	<0.00000007	<0.00000009
2,3,7,8–TCDF	<0.00000119	<0.00000008	<0.0000001	<0.00000011
OCDD	0.002352	0.0004363 J	0.0004122 J	0.0008114 J
PCBs				
Aroclor–1254	<0.030	<0.030	<0.040	<0.040
Inorganics				
Arsenic	2.25	5.38 L	6.28 L	7.75 L
Chromium	118 J	21.9 L	32.4 L	58.4 L
Lead	931 K	13.5	14.0	25.7
Zinc	464 J	7.87 J	16.7 J	26.0 J

NBGSB10

Depth(Feet)	(2 – 4')	(4 – 6')	(6 – 8')	(8 – 10')	(10 – 12')
Date	5/26/1999	5/26/1999	5/26/1999	5/26/1999	5/26/1999
SVOCs					
Benzo(a)anthracene	<0.40	<0.44	<0.43	<0.44	<0.44
Benzo(a)pyrene	<0.40	<0.44	<0.43	<0.44	<0.44
Benzo(b)fluoranthene	<0.40	<0.44	<0.43	<0.44	<0.44
Dibenzo(a,h)anthracene	<0.40 J	<0.44 J	<0.43 J	<0.44 J	<0.44 J
Indeno(1,2,3–cd)pyrene	<0.40 J	<0.44 J	<0.43 J	<0.44 J	<0.44 J
Inorganics					
Arsenic	10.6	15.1	16.3	14.5	17.5
Chromium	43.9	58.1	64.8	57.3	69.3
Lead	10.4	19.6	30.3	31.2	30.9
Zinc	19.1	37.6	37.6	29.9	31.8

NBGSB17

Depth(Feet)	(0 – 0.5')	(1 – 3')
Date	6/12/2002	6/19/2002
Dioxin/Furan		
2,3,4,7,8–PeCDF	<0.00000087	<0.00000003
2,3,7,8–TCDF	<0.00000129	<0.00000003
OCDD	0.00172	0.0009594 J
PCBs		
Aroclor–1254	<0.030	<0.040
Inorganics		
Arsenic	5.92	8.20 L
Chromium	29.3 J	68.8 L
Lead	38.9 K	16.2
Zinc	143 J	19.2 J

SS–01

Depth(Feet)	(0.5 – 0.7')
Date	6/3/1997
Inorganics	
Arsenic	7.60
Chromium	32.2
Lead	55.4
Zinc	294

NBGSB7

Depth(Feet)	(0 – 0.5')	(3.5 – 4')
Date	5/27/1999	5/27/1999
PAHs		
Benzo(a)anthracene	<0.02	<0.02
Benzo(a)pyrene	<0.02	<0.02
Benzo(b)fluoranthene	<0.03	<0.03
Dibenzo(a,h)anthracene	<0.02	<0.02
Indeno(1,2,3–cd)pyrene	<0.01	<0.01
Inorganics		
Arsenic	7.00 B	6.50 B
Chromium	22.3	19.6
Lead	17.7	12.3
Zinc	29.3	29.2

NBGSB6

Depth(Feet)	(0 – 0.5')	(3.5 – 4')
Date	5/27/1999	5/27/1999
PAHs		
Benzo(a)anthracene	<0.02	<0.02
Benzo(a)pyrene	<0.02	<0.03
Benzo(b)fluoranthene	<0.01	<0.03
Dibenzo(a,h)anthracene	<0.02	<0.03
Indeno(1,2,3–cd)pyrene	<0.02	<0.02
Inorganics		
Arsenic	2.20 B	5.40 B
Chromium	7.10	22.3
Lead	16.5	13.8
Zinc	18.1	24.7

NBGSB18

Depth(Feet)	(0 – 0.5')	(1 – 3')
Date	6/12/2002	6/19/2002
Dioxin/Furan		
2,3,4,7,8–PeCDF	<0.00000079	<0.00000004
2,3,7,8–TCDF	<0.00000107	<0.00000003
OCDD	0.003185	0.002096 J
PCBs		
Aroclor–1254	<0.040	<0.040
Inorganics		
Arsenic	8.37	10.4 L
Chromium	44.5 J	54.9 L
Lead	21.5 K	25.1
Zinc	34.9 J	40.8 J

NBGSB19

Depth(Feet)	(0 – 0.5')	(1 – 3')
Date	6/12/2002	6/19/2002
Dioxin/Furan		
2,3,4,7,8–PeCDF	<0.0000008 [<0.00000098]	<0.00000005
2,3,7,8–TCDF	<0.00000119 [<0.00000128]	<0.00000003
OCDD	0.01964 [0.01094]	0.0008243 J
PCBs		
Aroclor–1254	<0.040 [<0.030]	<0.040
Inorganics		
Arsenic	4.73 [3.45]	16.5 J
Chromium	28.4 J [19.7 J]	51.2
Lead	36.2 K [32.7 K]	23.2
Zinc	78.6 J [51.8 J]	40.3 J

NBGSB5

Depth(Feet)	(0.5 – 1.5')	(5 – 6')
Date	8/4/1998	8/4/1998
SVOCs		
Benzo(a)anthracene	<0.38	<0.47
Benzo(a)pyrene	<0.38	<0.47
Benzo(b)fluoranthene	<0.38	<0.47
Dibenzo(a,h)anthracene	<0.38	<0.47
Indeno(1,2,3–cd)pyrene	<0.38	<0.47
Inorganics		
Arsenic	4.50 K	17.0 K
Chromium	16.4	52.4
Lead	19.3	20.2
Zinc	22.1 B	45.0 B

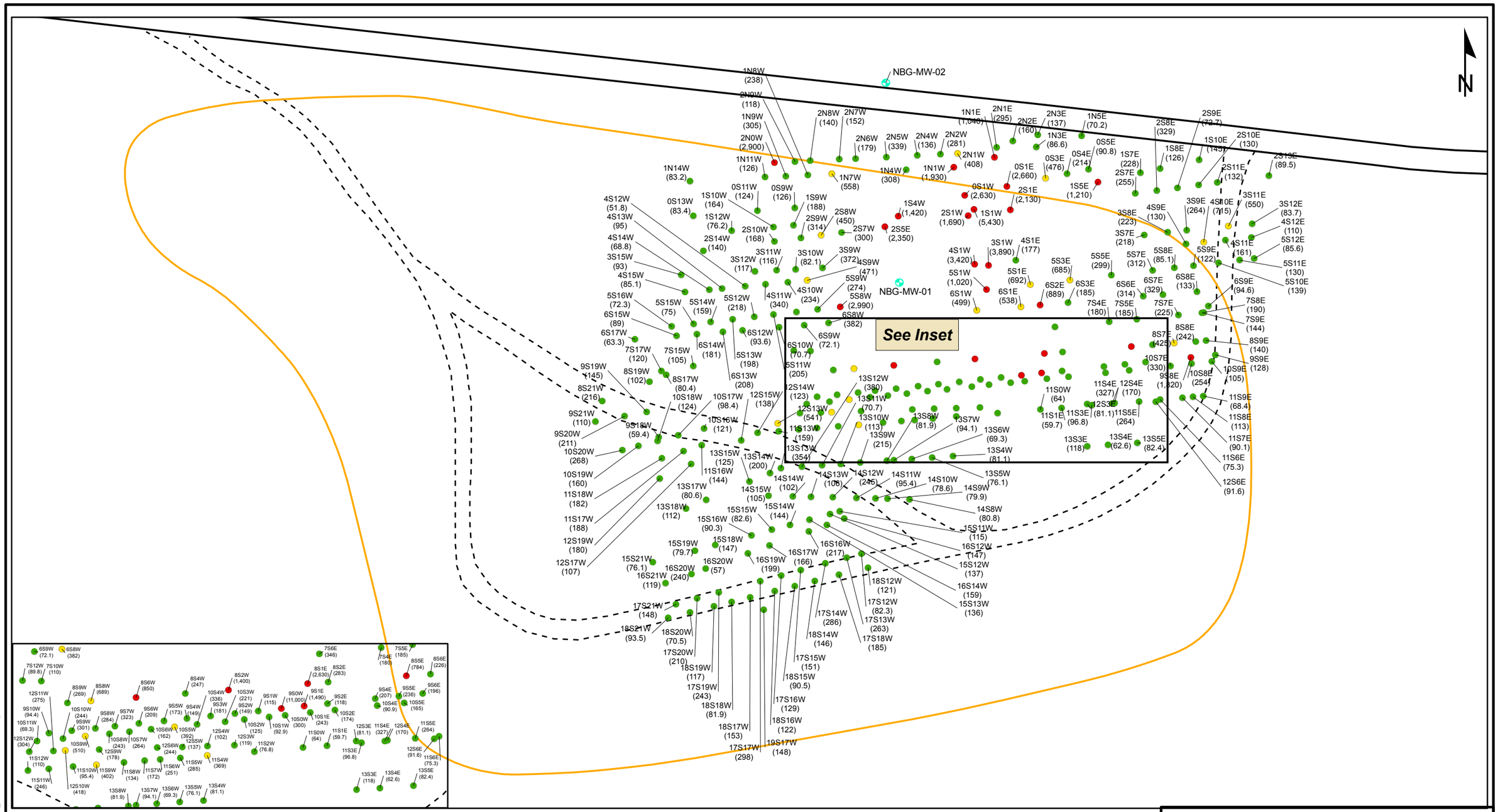
RADFORD ARMY AMMUNITION PLANT
RADFORD, VA
EE/CA

NORTHERN BURNING GROUND SOIL SAMPLING RESULTS

ARCADIS

FIGURE 2-1

CITY:NOVI DIV/GROUP:ENV DB: PIC: PM: TM: TR: PROJECT NUMBER: G:\CAD\Radford\Radford_SiteLayout.dwg LAYOUT: DATA_NGB_SOIL SAVED: 1/13/2009 11:43 AM ACADVER: 17.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ARCADIS NOVI.CTB PLOTTED: 3/16/2009 12:48 PM BY: YARBROUGH, TOBI



LEGEND

XRF LEAD SCREENING RESULT

- <400 MG/KG
- 400 - 750 MG/KG
- >750 MG/KG

MONITORING WELLS

PAVED ROADS

DIRT ROADS

NRU BOUNDARY

STUDY AREA

NOTE:
- MG/KG - MILLIGRAMS PER KILOGRAM
- 7S12W (89.8) XRF SAMPLE LOCATION LEAD RESULT IN MG/KG

0 45 90 Feet

GRAPHIC SCALE

THE NORTHERN BURNING GROUND AT THE NEW RIVER UNIT
RADFORD ARMY AMMUNITION PLANT
RADFORD, VA

NORTHERN BURNING GROUND XRF SCREENING RESULTS

ARCADIS

FIGURE 2-2

NYC: SER 4/AIT: DB: TBR LD: TBR PIC: TL
Radford (GP08RAAP.00PM)
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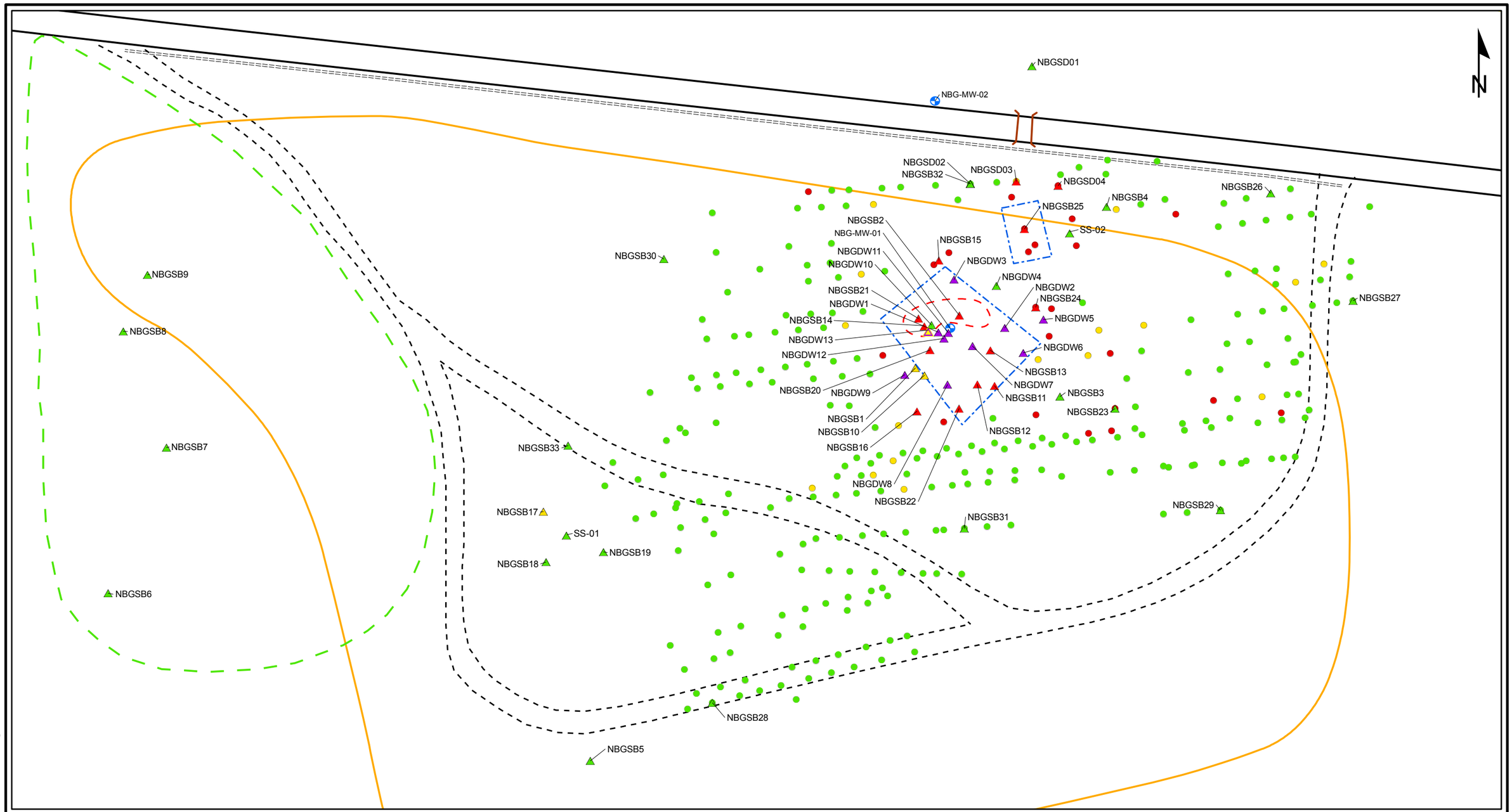

Legend

- HISTORICAL SAMPLE LOCATION
- HISTORICAL SAMPLE LOCATION EXCEEDING RESIDENTIAL CRITERIA
- HISTORICAL SAMPLE LOCATION EXCEEDING INDUSTRIAL CRITERIA
- INORGANIC TCLP SAMPLE

XRF LEAD SCREENING RESULT

- <400 MG/KG
- 400 - 750 MG/KG
- >750 MG/KG
- GROUNDWATER LOCATIONS

- ESTIMATED EXCAVATION TO DEPTH OF 1 FOOT
- ESTIMATED EXCAVATION TO DEPTH OF 2 FEET
- STUDY AREA
- NRU BOUNDARY

- LOW AREA
- DRAINAGE DITCH
- CULVERT
- PAVED ROADS
- DIRT ROADS

0 40 80 Feet
GRAPHIC SCALE

THE NORTHERN BURNING GROUND AT THE NEW RIVER UNIT
RADFORD ARMY AMMUNITION PLANT
RADFORD, VA

ESTIMATED FOOTPRINT OF EXCAVATION FOR ALTERNATIVE 2

ARCADIS

FIGURE
4-1

NYC: SER 4/AIT: DB: TBR LD: TBR PIC: TL
Radford (GP08RAAP.00PM)
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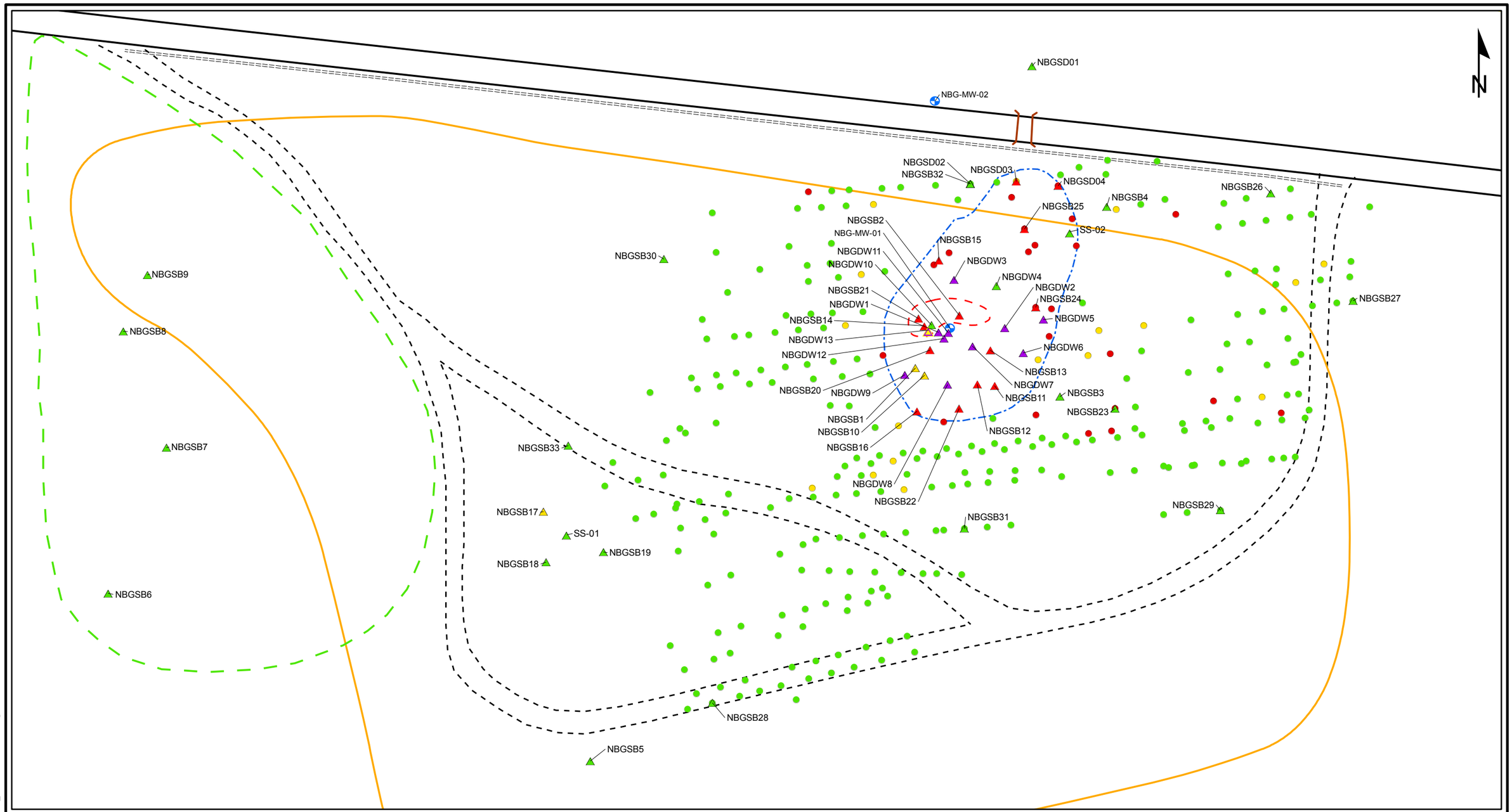

Legend

HISTORICAL SAMPLE LOCATION

HISTORICAL SAMPLE LOCATION EXCEEDING RESIDENTIAL CRITERIA

HISTORICAL SAMPLE LOCATION EXCEEDING INDUSTRIAL CRITERIA

INORGANIC TCLP SAMPLE

XRF LEAD SCREENING RESULT

<400 MG/KG

400 - 750 MG/KG

>750 MG/KG

GROUNDWATER LOCATIONS

ESTIMATED EXCAVATION TO DEPTH OF 1 FOOT

ESTIMATED EXCAVATION TO DEPTH OF 4 FEET

STUDY AREA

NRU BOUNDARY

LOW AREA

DRAINAGE DITCH

CULVERT

PAVED ROADS

DIRT ROADS

0 40 80 Feet

GRAPHIC SCALE

THE NORTHERN BURNING GROUND AT THE NEW RIVER UNIT
RADFORD ARMY AMMUNITION PLANT
RADFORD, VA

ESTIMATED FOOTPRINT OF EXCAVATION FOR ALTERNATIVE 3

ARCADIS

FIGURE
4-2

NYC: SER 4/AIT: DB: TBR LD: TBR PIC: TL
Radford (GP08RAAP.00PM)
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Appendix A

NBG Historical Data

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID: / Sample Depth(Feet): / Date Collected:	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	NBGDW1 0 - 4 05/26/99	NBGDW2 0 - 4 05/26/99	NBGDW3 0 - 4 08/18/99	NBGDW4 0 - 4 08/17/99	NBGDW5 0 - 4 08/19/99	NBGDW6 0 - 4 08/19/99	NBGDW7 0 - 4 08/19/99	NBGDW8 0 - 4 08/19/99	NBGDW9 0 - 4 08/19/99	NBGDW10 0 - 4 08/19/99	NBGDW11 0 - 4 08/19/99	NBGDW12 0 - 4 08/19/99	NBGDW13 0 - 4 08/19/99	NBGSB1 0.5 - 1.5 08/04/98	NBGSB1 8 - 10 08/04/98	NBGSB1 53 - 55 08/04/98	NBGSB2 0 - 2 08/04/98	NBGSB2 5 - 6 08/04/98	NBGSB3 0.5 - 1.5 08/04/98	NBGSB3 5 - 6 08/04/98
Dioxin/Furan																									
1,2,3,4,6,7,8-HpCDD [a]	0.00039	0.0016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-PeCDD [e]	0.0000039	0.000016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-PeCDF	0.00011	0.00038	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,7,8-PeCDF	0.000011	0.000038	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDD	0.0000045	0.000018	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDF	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDD	0.013	0.053	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDF	0.011	0.038	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total TCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total TCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Explosives																									
None Detected	- -	- -	- -	- -	- -	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	- -	- - [- -]	- -	- -	- -	- -	- -
Herbicides																									
2,4,5-T	610	6,200	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-D	690	7,700	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-DB	490	4,900	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dalapon	1,800	18,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dicamba	1,800	18,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MCPP	61	620	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Organochlorine Pesticides																									
4,4'-DDD	2	7.2	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	1.4	5.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	1.7	7	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	0.03	0.11	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan II [f]	370	3,700	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Aldehyde [g]	18	180	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAHs																									
2-Methylnaphthalene	310	4,100	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	150	670	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCBs																									
Aroclor-1254	0.22	0.74	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Volatile Organics																									
1,1-Dichloroethene	250	1,100	- -	- -	mg/kg	<0.0024	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0020	<0.0030 [<0.0020]	<0.0030	<0.0020	<0.0020	<0.0020	<0.0020
1,2,4-Trimethylbenzene	67	280	- -	- -	mg/kg	<0.0020	0.0056	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0020	<0.0020 [<0.0020]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
2-Butanone	28,000	190,000	- -	- -	mg/kg	R	R	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0060 J	<0.0070 [<0.0060]	<0.0070	<0.0060 J	<0.0060	R	<0.0060
Acetone	61,000	610,000	- -	- -	mg/kg	R	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0060 J	<0.0070 [<0.0060]	<0.0070	<0.0060 J	<0.0060	<0.0060	<0.0060
Benzene	1.1	5.6	- -	- -	mg/kg	<0.0012	<0.0012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0010	<0.0010 [<0.0010]	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Carbon Disulfide	670	3,000	- -	- -	mg/kg	<0.0062	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0060	<0.0070 [<0.0060]	<0.0070	<0.0060	<0.0060	<0.0060	<0.0060
Chlorobenzene	310	1,500	- -	- -	mg/kg	<0.0014	<0.0013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0010	<0.0020 [<0.0010]	<0.0020	<0.0010	<0.0010	<0.0010	<0.0010
d-Limonene	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	11	54	- -	- -	mg/kg	<0.0012 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0010	<0.0010 [<0.0010]	<0.0010	0.0030	<0.0010	0.0030	<0.0010
tert-Butylbenzene	- -	- -	- -	- -	mg/kg	<0.0015	0.0030	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0010	<0.0020 [<0.0010]	<0.0020	<0.0010	<0.0020	<0.0010	<0.0010
Toluene	5,000	46,000	- -	- -	mg/kg	<0.0015	<0.0015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0020	<0.0020 [<0.0010]	<0.0020	<0.0010	<0.0020	<0.0010	<0.0020
Trichloroethene	2.8	14	- -	- -	mg/kg	<0.0032	<0.0031	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0030	<0.0040 [<0.0030]	<0.0040	<0.0030	<0.0030	<0.0030	<0.0030

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID: / Sample Depth(Feet): / Date Collected:	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	NBGDW1 0 - 4 05/26/99	NBGDW2 0 - 4 05/26/99	NBGDW3 0 - 4 08/18/99	NBGDW4 0 - 4 08/17/99	NBGDW5 0 - 4 08/19/99	NBGDW6 0 - 4 08/19/99	NBGDW7 0 - 4 08/19/99	NBGDW8 0 - 4 08/19/99	NBGDW9 0 - 4 08/19/99	NBGDW10 0 - 4 08/19/99	NBGDW11 0 - 4 08/19/99	NBGDW12 0 - 4 08/19/99	NBGDW13 0 - 4 08/19/99	NBGSB1 0.5 - 1.5 08/04/98	NBGSB1 8 - 10 08/04/98	NBGSB1 53 - 55 08/04/98	NBGSB2 0 - 2 08/04/98	NBGSB2 5 - 6 08/04/98	NBGSB3 0.5 - 1.5 08/04/98	NBGSB3 5 - 6 08/04/98
Semivolatile Organics																									
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Anthracene	17,000	170,000	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	<0.37 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	<0.37 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
bis(2-Ethylhexyl)phthalate	35	120	- -	- -	mg/kg	0.040 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	0.070 J	<0.43	<0.37	<0.40
Carbazole	24	86	- -	- -	mg/kg	<0.37 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Chrysene	15	210	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Diethylphthalate	49,000	490,000	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Di-n-Butylphthalate	6,100	62,000	- -	- -	mg/kg	0.080 B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Fluoranthene	2,300	22,000	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Fluorene	2,300	22,000	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	<0.37 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Pyrene	1,700	17,000	- -	- -	mg/kg	<0.37	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.39	<0.46 [<0.38]	<0.46	<0.38	<0.43	<0.37	<0.40
Inorganics																									
Aluminum	77,000	990,000	**40,041**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	37,000	NA	NA	25,200	10,800	27,400 [22,700]	13,100	8,270	27,500	9,810	15,800
Antimony	31	410	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.30 B	NA	NA	2.40 B	<0.580	<0.690 [<0.560]	<0.670	<0.560	<0.620	<0.540	<0.590
Arsenic	0.39	1.6	**15.8**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	14.5 K	NA	NA	8.70 K	4.20 K	7.00 K [7.30 K]	9.20 K	8.50 K	10.5 K	3.20 K	4.30 K
Barium	15,000	190,000	**209**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	25.0 J	NA	NA	66.4	41.0 K	18.7 B [14.0 B]	30.5 K	81.9 K	18.1 B	38.9 K	9.60 B
Beryllium	160	2,000	**1.02**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.370 J	NA	NA	0.390 J	<0.120	0.230 J [0.190 J]	**1.90**	<0.110	0.330 J	0.110 J	<0.120
Cadmium	70	810	**0.69**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.130	NA	NA	0.210 J	<0.120	<0.140 [<0.110]	0.220 J	**0.920**	<0.120	<0.110	<0.120
Calcium	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,190	NA	NA	3,650	1,580 B	928 B [526 B]	857 B	4,040 B	840 B	2,570 B	371 B
Chromium [k]	230	1,460	**65.3**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	54.2	NA	NA	**94.5**	31.8	**75.3 [53.7]**	35.0	**1,620**	53.4	20.2	21.9
Cobalt	- -	- -	**72.3**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.40 J	NA	NA	6.80	4.50 K	3.50 K [3.60 K]	9.80 K	23.9 K	3.10 K	4.20 K	2.10 K
Copper	3,100	41,000	**53.5**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	26.4	NA	NA	24.5	5.50 B	18.4 K [15.1 B]	21.0 K	52.7	12.9 B	9.20 B	6.20 B
Iron	55,000	720,000	**50,962**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	**51,100**	NA	NA	29,100	18,500	45,900 [36,800]	29,700	12,900	**52,000**	12,100	19,200
Lead	400	750	**26.8**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	20.7	NA	NA	**707**	**127**	**226 [155]**	**29.5**	**23,400**	19.5	**104**	10.8
Magnesium	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	953	NA	NA	2,110	605 B	719 B [557 B]	11,900	1,520 B	1,010 B	1,350 B	278 B
Manganese	1,800	23,000	**2,543**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	95.5	NA	NA	281	204	68.1 [55.1]	594	158	58.9	182	21.8 K
Mercury	6.7	28	**0.13**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	**0.270**	NA	NA	<0.120	<0.120	<0.140 [<0.110]	<0.140	<0.110	**0.570**	<0.110	<0.120
Nickel	1,600	20,000	**62.8**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	12.2	NA	NA	10.7	3.80 B	8.90 K [8.30 K]	30.4 K	5.60 B	8.50 K	4.50 B	3.80 B
Potassium	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	964	NA	NA	812	352 B	601 B [516 B]	3,240 K	324 B	873 K	473 B	489 B
Selenium	390	5,100	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.640	NA	NA	<0.610	<0.580	<0.690 [<0.560]	<0.670	<0.560	<0.620	0.560 K	<0.590
Silver	390	5,100	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.130	NA	NA	<0.120	<0.230 L	<0.280 L [<0.220 L]	<0.270 L	0.230 B	<0.250 L	<0.220 L	<0.240 L
Sodium	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	88.7 B	NA	NA	133 J	136 B	146 B [116 B]	103 B	113 B	104 B	125 B	106 B
Thallium	5.1	66	**2.11**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.890 J	NA	NA	<0.850 J	0.420 B	1.50 B [<0.220 L]	<0.270 L	0.460 B	<0.250 L	<0.220 L	<0.240 L
Vanadium [l]	390	5,200	**108**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	97.4	NA	NA	57.6	33.1 J	83.1 J [66.8 J]	49.5 J	23.4 J	79.1 J	21.9 J	32.1 J
Zinc	23,000	310,000	**202**	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	35.4	NA	NA	**706**	61.0 B	67.4 B [50.2 B]	60.4 B	**3,760**	22.8 B	132 B	15.4 B
Inorganics-TCLP																									
Arsenic	- -	- -	- -	5.0	mg/L	0.0088	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	0.0068	<0.006	<0.006	<0.006	<0.006	<0.006	NA	NA	NA	NA	NA	NA	NA
Barium	- -	- -	- -	100	mg/L	0.601	0.146	0.233	0.219	0.272	0.18	0.238	0.181	0.239	0.118	0.564	0.14	0.474	NA	NA	NA	NA	NA	NA	NA
Cadmium	- -	- -	- -	1.0	mg/L	0.0207	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0115	<0.001	0.0052	NA	NA	NA	NA	NA	NA	NA
Chromium [k]	- -	- -	- -	5.0	mg/L	0.0068	0.0356	<0.001	0.0023	0.0174	<0.001	0.0232	0.0241	0.0286	0.0013	0.0695	0.0192	0.133	NA	NA	NA	NA	NA	NA	NA
Lead	- -	- -	- -	5.0	mg/L	6.4	0.0434	0.0112	0.0933	0.0343	0.035	1.92	0.387	1.21	0.0299	63.3	0.384	5.1	NA	NA	NA	NA	NA	NA	NA
Selenium	- -	- -	- -	1.0	mg/L	<0.004	0.0049	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0057	<0.005	<0.005	<0.005	<0.005	NA	NA	NA	NA	NA	NA	NA
Silver	- -	- -	- -	5.0	mg/L	0.0012	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA	NA	NA	NA	NA	NA	NA
Miscellaneous																									
Percent Solids	- -	- -	- -	- -	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
pH	- -	- -	- -	- -	pH Units	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes

[a]	RSL unavailable; RSL for Total HpCDD used as a surrogate.
[b]	RSL unavailable; RSL for Total HpCDF used as a surrogate.
[c]	RSL unavailable; RSL for Total HxCDD used as a surrogate.
[d]	RSL unavailable; RSL for Total HxCDF used as a surrogate.
[e]	RSL unavailable; RSL for Total PeCDD used as a surrogate.
[f]	RSL unavailable; RSL for Endosulfan used as a surrogate.
[g]	RSL unavailable; RSL for Endrin used as a surrogate.
[h]	RSL unavailable; RSL for Acenaphthalene used as a surrogate.
[i]	RSL unavailable; RSL for Pyrene used as a surrogate.
[j]	RSL unavailable; RSL for Anthracene used as a surrogate.
[k]	RSL for Chromium VI (particulates).
[l]	RSL for Vanadium and compounds.
B (Inorganics)	Constituent concentration quanitified as estimated.
B (Organics)	Constituent was detected in the associated method blank.
J	Constituent concentration quanitified as estimated.
K	Estimated concentration bias high.
L	Estimated concentration bias low.
R	Constituent concentration rejected.
NA	Not Analyzed.
ND	Not Detected (no detection limit given).
24,400	Highlighted cell indicates constituent concentration exceeds Soil RSL (Residential).
10.6 J	Highlighted cell indicates constituent concentration exceeds Soil RSL (Industrial).
127	Bolded value indicates constituent concentration exceeds 95% UTLs developed for facility-wide background estimate
6.4	Highlighted cell indicates constituent concentration exceeds TCLP standard.

Note: Inorganics Facility-Wide Background Point Estimate taken from *Facility-Wide Background Study Report*, IT Corporation, 2001.

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID:	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	NBGSB4	NBGSB4	NBGSB5	NBGSB5	NBGSB6	NBGSB6	NBGSB7	NBGSB7	NBGSB8	NBGSB8	NBGSB9	NBGSB10	NBGSB10	NBGSB10	NBGSB10	NBGSB10	NBGSB11	NBGSB11	NBGSB11
Sample Depth(Feet):						0.5 - 1.5	5 - 6	0.5 - 1.5	5 - 6	0 - 0.5	3.5 - 4	0 - 0.5	3.5 - 4	0 - 0.5	3.5 - 4	0 - 0.5	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12	0 - 0.5	1 - 3	3 - 5
Date Collected:						08/04/98	08/04/98	08/04/98	08/04/98	05/27/99	05/27/99	05/27/99	05/27/99	05/27/99	05/27/99	05/27/99	05/26/99	05/26/99	05/26/99	05/26/99	05/26/99	06/12/02	06/19/02	06/19/02
Dioxin/Furan																								
1,2,3,4,6,7,8-HpCDD [a]	0.00039	0.0016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00008921 J	0.00003037	0.00000328 J
1,2,3,4,6,7,8-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00002183 J	<0.0000001	0.00000044 J
1,2,3,4,7,8,9-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00000219	<0.00000013	<0.00000006
1,2,3,4,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00000302	<0.00000018	<0.00000009
1,2,3,4,7,8-HxCDD [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00002445 J	<0.00000009	0.00000047 J
1,2,3,6,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00000236	<0.00000014	<0.00000007
1,2,3,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0000096 J	<0.00000009	0.00000025 J
1,2,3,7,8,9-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00000229	0.0000005	<0.00000008
1,2,3,7,8,9-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00000216	<0.0000001	<0.00000007
1,2,3,7,8-PeCDD [e]	0.0000039	0.000016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00000463	<0.00000014	<0.00000016
1,2,3,7,8-PeCDF	0.00011	0.00038	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00001225 J	<0.00000007	0.00000016 J
2,3,4,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00000257 J	<0.0000001	0.00000009 J
2,3,4,7,8-PeCDF	0.000011	0.000038	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0000169 J	<0.00000007	0.00000038 J
2,3,7,8-TCDD	0.0000045	0.000018	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00000165	<0.00000012	<0.00000006
2,3,7,8-TCDF	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0001246 J	<0.0000001	0.00000234 J
OCDD	0.013	0.053	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00224 J	0.004805 J	0.0005022 J
OCDF	0.011	0.038	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00008762 J	<0.00000025 J	0.00000142 B
Total HpCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0001613 J	0.00005671	0.00000744 J
Total HpCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00007406 J	<0.0000001	0.0000009 J
Total HxCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00000229	0.00000176	<0.00000007
Total HxCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00005829 J	<0.00000009	0.00000123 J
Total PeCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00000463	<0.00000014	<0.00000016
Total PeCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0001008 J	<0.00000007	0.00000202 J
Total TCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00000165	<0.00000012	<0.00000006
Total TCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0003194 J	<0.0000001	0.00001017 J
Explosives																								
None Detected	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- - [- -]	- -	- -	- -	- -	- -	- -	- -	NA	NA	NA
Herbicides																								
2,4,5-T	610	6,200	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00719 J	NA	NA
2,4-D	690	7,700	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.195	NA	NA
2,4-DB	490	4,900	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0596 B	NA	NA
Dalapon	1,800	18,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.12	NA	NA
Dicamba	1,800	18,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00321 K	NA	NA
MCPP	61	620	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<12	NA	NA
Organochlorine Pesticides																								
4,4'-DDD	2	7.2	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00933 J	NA	NA
4,4'-DDE	1.4	5.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.07	NA	NA
4,4'-DDT	1.7	7	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.24	NA	NA
Dieldrin	0.03	0.11	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00798 L	NA	NA
Endosulfan II [f]	370	3,700	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00798	NA	NA
Endrin Aldehyde [g]	18	180	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00798 L	NA	NA
PAHs																								
2-Methylnaphthalene	310	4,100	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	<0.03 J	<0.03 J	<0.03 J	<0.03 J	<0.03 J [<0.03 J]	<0.03 J	<0.03 J	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	<0.03	<0.03	<0.03	<0.03	<0.03 [<0.03]	<0.03	<0.03	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02 [<0.02]	<0.02	<0.02	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02 [<0.02]	<0.02	<0.02	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	<0.02	<0.03	<0.02	<0.02	<0.02 [<0.02]	<0.02	<0.02	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	<0.01	<0.03	<0.03	<0.03	<0.03 [<0.03]	<0.03	<0.03	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	<0.02	<0.03	0.04	<0.03	<0.03 [<0.03]	<0.03	<0.03	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	NA	NA	NA	NA	<0.03	<0.03	<0.03	<0.02	<0.02 [<0.03]	<0.02	<0.03	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02 [<0.02]	<0.02	<0.02	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	<0.02	<0.03	<0.02	<0.02	<0.02 [<0.02]	<0.02	<0.03	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02 [<0.02]	<0.02	<0.02	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	<0.03	<0.03	<0.03	<0.03	<0.03 [<0.03]	<0.03	<0.03	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	<0.02	<0.02	<0.01	<0.01	<0.01 [<0.01]	<0.01	<0.01	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	150	670	- -	- -	mg/kg	NA	NA	NA	NA	<0.04	<0.04	<0.04	<0.04	<0.04 [<0.04]	<0.04	<0.04	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02 [<0.02]	<0.02	<0.02	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	<0.02	<0.02	<0.02	<0.02	<0.02 [<0.02]	<0.02	<0.02	NA	NA	NA	NA	NA	NA	NA	NA
PCBs																								
Aroclor-1254	0.22	0.74	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.4	0.020 J	0.070
Volatile Organics																								
1,1-Dichloroethene	250	1,100	- -	- -	mg/kg	<0.0020	<0.0030	<0.0020 J	<0.0030	NA	<0.0025	<0.0024	<0.0023	NA	<0.0023	<0.0025	<0.0026	<0.0028	<0.0028	<0.0029	<0.0028	NA	NA	NA
1,2,4-Trimethylbenzene	67	280	- -	- -	mg/kg	<0.0020	<0.0020	<0.0020 J	<0.0020	NA	<0.0021	<0.0020	<0.0020	NA	<0.0020	<0.0021	<0.0022	<0.0024	<0.0023	<0.0024	<0.0024	NA	NA	NA
2-Butanone	28,000	190,000	- -	- -	mg/kg	<0.0060	<0.0070	R	R	NA	R	R	<0.0061	NA	R	<0.0064	R	R	R	R	R	NA	NA	NA
Acetone	61,000	610,000	- -	- -	mg/kg	<0.0060	<0.0070	<0.0060 J	<0.0070	NA	R	R	<0.0061	NA	<0.0061	<0.0064	R	R	R	R	R	NA	NA	NA
Benzene	1.1	5.6	- -	- -	mg/kg	<0.0010	<0.0010	<0.0010 J	<0.0010	NA	<0.0013	<0.0013	<0.0012	NA	<0.0012	<0.0013	<0.0014	<0.0015	<0.0014	<0.0015	<0.0015	NA	NA	NA
Carbon Disulfide	670	3,000	- -	- -	mg/kg	<0.0060	<0.0070	<0.0060 J	<0.0070	NA	<0.0066	<0.0063	<0.0061	NA	R	<0.0064	<0.0068	<0.0074	<0.0072	<0.0075	<0.0074	NA	NA	NA
Chlorobenzene	310	1,500	- -	- -	mg/kg	<0.0010	<0.0020	<0.0010 J	<0.0020	NA	<0.0014	<0.0014	<0.0013	NA	<0.0013	<0.0014	<0.0015	<0.0016	<0.0016	<0.0016	<0.0016	NA	NA	NA
d-Limonene	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	11	54	- -	- -	mg/kg	<0.0010	0.0050	0.0030 J	0.0040	NA	<0.0013 J	<0.0013 J	<0.0012	NA	<0.0012 J	<0.0013 J	<0.0014	<0.0015	<0.0014	<0.0015	<0.0015	NA	NA	NA
tert-Butylbenzene	- -	- -	- -	- -	mg/kg	<0.0010	<0.0020	<0.0010 J	<0.0020	NA	<0.0016	<0.0015	<0.0015	NA	<0.0015	<0.0015	<0.0016	<0.0018	<0.0017	<0.0018	<0.0018	NA	NA	NA
Toluene	5,000	46,000	- -	- -	mg/kg	<0.0010	<0.0020	<0.0010 J	<0.0020	NA	<0.0016	<0.0016	<0.0015	NA	<0.0015	<0.0016	<0.0017	<0.0018	<0.0018	<0.0019	<0.0018	NA	NA	NA
Trichloroethene	2.8	14	- -	- -	mg/kg	<0.0030	<0.0040	<0.0030 J	<0.0040	NA	<0.0034	<0.0032	<0.0031	NA	<0.0031	<0.0033	<0.0035	<0.0038	<0.0037	<0.0039	<0.0038	NA	NA	NA

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID:						NBGSB4	NBGSB4	NBGSB5	NBGSB5	NBGSB6	NBGSB6	NBGSB7	NBGSB7	NBGSB8	NBGSB8	NBGSB9	NBGSB10	NBGSB10	NBGSB10	NBGSB10	NBGSB10	NBGSB11	NBGSB11	NBGSB11
Sample Depth(Feet):	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	0.5 - 1.5	5 - 6	0.5 - 1.5	5 - 6	0 - 0.5	3.5 - 4	0 - 0.5	3.5 - 4	0 - 0.5	3.5 - 4	0 - 0.5	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12	0 - 0.5	1 - 3	3 - 5
Date Collected:						08/04/98	08/04/98	08/04/98	08/04/98	05/27/99	05/27/99	05/27/99	05/27/99	05/27/99	05/27/99	05/27/99	05/26/99	05/26/99	05/26/99	05/26/99	05/26/99	06/12/02	06/19/02	06/19/02
Semivolatile Organics																								
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40 J	<0.44 J	<0.43 J	<0.44 J	<0.44 J	NA	NA	NA
bis(2-Ethylhexyl)phthalate	35	120	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	0.060 J	<0.39	0.050	<0.36	<0.37 [<0.38]	<0.36	0.13	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Carbazole	24	86	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	<0.37	<0.39	<0.37	<0.36	<0.37 [<0.38]	<0.36	<0.38	<0.40 J	<0.44 J	<0.43 J	<0.44 J	<0.44 J	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Diethylphthalate	49,000	490,000	- -	- -	mg/kg	<0.38	<0.45	<0.38	0.10 J	0.060 B	0.050 B	0.070 B	0.13 B	0.24 [<0.38]	<0.36	<0.38	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Di-n-Butylphthalate	6,100	62,000	- -	- -	mg/kg	0.090 J	<0.45	<0.38	<0.47	<0.37	<0.39	<0.37	<0.36	<0.37 [<0.38]	<0.36	<0.38	0.060 B	0.080 B	0.060 B	0.090 B	0.050 J	NA	NA	NA
Fluoranthene	2,300	22,000	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40 J	<0.44 J	<0.43 J	<0.44 J	<0.44 J	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	<0.38	<0.45	<0.38	<0.47	NA	NA	NA	NA	NA	NA	NA	<0.40	<0.44	<0.43	<0.44	<0.44	NA	NA	NA
Inorganics																								
Aluminum	77,000	990,000	**40,041**	- -	mg/kg	18,400	28,400	10,400	30,400	4,670	9,420	7,800	5,930	6,150 [7,260]	5,680	5,980	22,200	31,200	26,700	30,600	29,800	13,900	15,400	34,900
Antimony	31	410	- -	- -	mg/kg	<0.560	<0.660	<0.560	<0.680	<0.620	<0.660	<0.620	<0.590	<0.590 [<0.610]	<0.610	<0.620	<0.650	<0.700	0.800 B	<0.740	<0.740	41.8 L	<0.590 L	0.320 B
Arsenic	0.39	1.6	**15.8**	- -	mg/kg	6.00 K	8.10 K	4.50 K	**17.0 K**	2.20 B	5.40 B	7.00 B	6.50 B	5.40 B [7.90]	6.00 B	5.60 B	10.6	15.1	**16.3**	14.5	**17.5**	**64.1**	2.61 L	14.1 L
Barium	15,000	190,000	**209**	- -	mg/kg	41.7 K	21.7 B	34.0 K	13.2 B	40.8	19.0	23.0	10.5	39.5 [39.3]	32.6	45.6	22.5 J	15.7 J	16.4	19.2 J	20.7 J	**562**	44.5	20.7
Beryllium	160	2,000	**1.02**	- -	mg/kg	0.260 J	0.290 J	0.190 J	0.460 J	0.280 B	0.380 B	0.430 B	0.460 B	0.580 B [0.800 B]	0.400 B	0.570 B	0.350 B	0.560 B	0.530 B	0.510 B	0.600 B	<0.590	<0.590	0.420 B
Cadmium	70	810	**0.69**	- -	mg/kg	<0.110	<0.130	<0.110	<0.140	<0.120	<0.130	<0.120	<0.120	<0.120 [0.160]	<0.120	<0.120	0.380	0.620 J	0.660 J	0.500 J	0.620 J	**11.4**	<0.110	<0.130
Calcium	- -	- -	- -	- -	mg/kg	1,780 B	673 B	2,800 B	469 B	637	635 J	684	529 J	1,330 [1,180]	974	1,420	1,500	343 J	826	301 J	266 J	28,500 J	557	684
Chromium [k]	230	1,460	**65.3**	- -	mg/kg	30.0	42.3	16.4	52.4	7.10	22.3	22.3	19.6	15.4 [20.3]	14.8	16.0	43.9	58.1	64.8	57.3	**69.3**	**25,700 J**	25.4 L	**172 L**
Cobalt	- -	- -	**72.3**	- -	mg/kg	4.90 K	4.20 K	6.70 K	4.00 K	4.60 K	23.0	21.7	24.3	26.6 [28.1]	22.3	28.0	2.30 K	5.00 K	3.50 K	3.90 K	4.10 K	**190 J**	6.20	4.00 J
Copper	3,100	41,000	**53.5**	- -	mg/kg	11.4 B	15.6 B	4.90 B	24.2 K	8.80 K	20.9	18.2	19.3	18.7 [20.6]	15.5	17.5	23.5	36.3	40.4	34.4	38.2	**569 L**	4.63	29.0
Iron	55,000	720,000	**50,962**	- -	mg/kg	23,300	41,900	16,100	**60,600**	8,270	28,800	30,100	29,600	21,200 [27,900]	21,800	21,300	39,500	**56,500**	**63,100**	**54,500**	**62,300**	**59,800 J**	14,500 J	50,500 J
Lead	400	750	**26.8**	- -	mg/kg	**76.2**	20.0	19.3	20.2	16.5	13.8	17.7	12.3	24.3 [22.8]	17.6	**28.4**	10.4	19.6	**30.3**	**31.2**	**30.9**	**91,400 K**	**63.6**	**903**
Magnesium	- -	- -	- -	- -	mg/kg	977 B	661 B	1,300 B	382 B	193 J	472 J	285 J	214 J	395 J [409 J]	299 J	402 J	670	488 J	479 J	488 J	364 J	12,100	648	655
Manganese	1,800	23,000	**2,543**	- -	mg/kg	317	53.3	393	73.5	410	89.9	470	380	710 [709]	401	926	35.3	62.9	71.4	79.6	99.2	855 J	323	62.9
Mercury	6.7	28	**0.13**	- -	mg/kg	<0.120	<0.130	<0.110	**0.620**	<0.120	<0.130	<0.120	<0.120	**0.170 [<0.130]**	<0.120	<0.120	**0.260**	**0.220**	**0.350**	**0.220**	<0.150	<0.0500	0.0300 J	**0.200**
Nickel	1,600	20,000	**62.8**	- -	mg/kg	7.60 K	12.5 K	4.10 B	14.4 K	3.50 K	14.3 K	11.0 K	13.6 K	12.5 K [17.4]	12.7 K	12.4 K	6.80 K	20.6	14.2 K	11.9 K	14.6 K	39.6	8.16	15.3
Potassium	- -	- -	- -	- -	mg/kg	635 K	1,300 K	425 B	1,030 K	149 J	307 J	362 J	199 J	385 J [393 J]	178 J	378 J	684	758	861	723 J	583 J	1,270	476	798
Selenium	390	5,100	- -	- -	mg/kg	<0.560	<0.660	<0.560	<0.680	0.550 K	<0.530	<0.500	<0.470	<0.470 [<0.490]	<0.490	<0.490	1.30 K	<0.560	<0.580	<0.590	<0.590	<1.20 L	<1.19 L	<1.34 L
Silver	390	5,100	- -	- -	mg/kg	<0.220 L	<0.260 L	<0.220 L	<0.270 L	<0.120	<0.130	<0.120	<0.120	<0.120 [<0.120]	<0.120	<0.120	0.270 K	0.480 K	0.490 K	0.660 K	0.640 K	2.74 L	<1.19	<1.34
Sodium	- -	- -	- -	- -	mg/kg	115 B	137 B	94.1 B	111 B	100 B	105 B	102 B	106 B	100 B [98.9 B]	101 B	112 J	189	183 J	198 J	165 J	177 J	273	14.0 B	11.0 B
Thallium	5.1	66	**2.11**	- -	mg/kg	1.10 B	<0.260 L	0.280 B	<0.270 L	<0.860 J	<0.920 J	<0.870 J	<0.830 J	<0.830 J [<0.860 J]	0.920 J	<0.860 J	<0.910 J	<0.990 J	<1.00 J	<1.00 J	<1.00 J	0.270 J	0.110 J	0.230 J
Vanadium [l]	390	5,200	**108**	- -	mg/kg	39.7 J	76.4 J	27.9 J	91.0 J	14.9	37.4	51.9	45.1	36.5 [44.2]	34.7	36.9	77.9	**112**	**127**	**118**	**125**	**121 J**	29.2 L	74.7 L
Zinc	23,000	310,000	**202**	- -	mg/kg	67.8 B	28.3 B	22.1 B	45.0 B	18.1	24.7	29.3	29.2	37.6 [47.6]	27.2	45.8	19.1	37.6	37.6	29.9	31.8	**39,000 J**	22.8 J	**211 J**
Inorganics-TCLP																								
Arsenic	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	- -	- -	- -	100	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	- -	- -	- -	1.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium [k]	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	- -	- -	- -	1.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Miscellaneous																								
Percent Solids	- -	- -	- -	- -	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
pH	- -	- -	- -	- -	pH Units	NA	NA	NA	NA	6.5	7.4	6.85	7.55	6.05 [7.15]	6.75	7.25	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	1,799	2,376	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes

[a]	RSL unavailable; RSL for Total HpCDD used as a surrogate.
[b]	RSL unavailable; RSL for Total HpCDF used as a surrogate.
[c]	RSL unavailable; RSL for Total HxCDD used as a surrogate.
[d]	RSL unavailable; RSL for Total HxCDF used as a surrogate.
[e]	RSL unavailable; RSL for Total PeCDD used as a surrogate.
[f]	RSL unavailable; RSL for Endosulfan used as a surrogate.
[g]	RSL unavailable; RSL for Endrin used as a surrogate.
[h]	RSL unavailable; RSL for Acenaphthalene used as a surrogate.
[i]	RSL unavailable; RSL for Pyrene used as a surrogate.
[j]	RSL unavailable; RSL for Anthracene used as a surrogate.
[k]	RSL for Chromium VI (particulates).
[l]	RSL for Vanadium and compounds.
B (Inorganics)	Constituent concentration quanitified as estimated.
B (Organics)	Constituent was detected in the associated method blank.
J	Constituent concentration quanitified as estimated.
K	Estimated concentration bias high.
L	Estimated concentration bias low.
R	Constituent concentration rejected.
NA	Not Analyzed.
ND	Not Detected (no detection limit given).
24,400	Highlighted cell indicates constituent concentration exceeds Soil RSL (Residential).
10.6 J	Highlighted cell indicates constituent concentration exceeds Soil RSL (Industrial).
127	Bolded value indicates constituent concentration exceeds 95% UTLs developed for faci
6.4	Highlighted cell indicates constituent concentration exceeds TCLP standard.

Note: Inorganics Facility-Wide Background Point Estimate taken from *Facility-Wide Background Study Report*, IT Corporation, 2001.

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID: / Sample Depth(Feet): / Date Collected:	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	NBGSB12 0 - 0.5 06/12/02	NBGSB12 1 - 3 06/19/02	NBGSB12 3 - 5 06/19/02	NBGSB13 0 - 0.5 06/12/02	NBGSB13 1 - 3 06/19/02	NBGSB14 0 - 0.5 06/12/02	NBGSB14 1 - 3 06/19/02	NBGSB15 0 - 0.5 06/12/02	NBGSB15 1 - 3 06/19/02	NBGSB16 0 - 0.5 06/12/02	NBGSB16 2 06/19/02	NBGSB16 6 06/19/02	NBGSB16 10 - 12 06/19/02	NBGSB17 0 - 0.5 06/12/02	NBGSB17 1 - 3 06/19/02	NBGSB18 0 - 0.5 06/12/02
Dioxin/Furan																					
1,2,3,4,6,7,8-HpCDD [a]	0.00039	0.0016	- -	- -	mg/kg	0.0000481	0.00001449	0.00000379	0.00004898 J	0.00003946	0.00008469	0.00009242 J	0.00004404	0.00004759 J	0.00003343	0.00000222	0.00000219	0.00000528	0.00001618	0.00000501	0.00002162
1,2,3,4,6,7,8-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	<0.00000097	<0.00000009	<0.00000011	0.00001327 J	0.00000035	0.00000812	0.00000018 J	0.00000475	0.00000795 J	0.00000304	<0.00000009	<0.00000009	<0.00000013	<0.00000109	0.00000012	<0.00000114
1,2,3,4,7,8,9-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	<0.00000125	<0.00000012	<0.00000015	<0.00000274	<0.00000016	<0.00000195	<0.00000005	<0.00000184	0.00000071 J	<0.00000118	<0.00000011	<0.00000012	<0.00000017	<0.00000141	<0.00000004	<0.00000148
1,2,3,4,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	<0.00000206	<0.00000019	<0.0000002	<0.00000301	0.00000053	<0.00000216	<0.00000009	<0.00000231	0.00000118 J	<0.00000171	<0.00000017	<0.00000018	<0.00000023	<0.00000174	<0.00000008	<0.00000174
1,2,3,4,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	<0.00000135	<0.00000008	<0.00000009	0.0000226 J	<0.00000008	<0.00000156	<0.00000004	<0.00000127	0.00000205 J	<0.00000092	<0.00000006	<0.00000008	<0.00000007	<0.00000101	<0.00000003	<0.0000012
1,2,3,6,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	<0.00000162	<0.00000015	<0.00000016	<0.00000236	0.00000083	<0.00000169	<0.00000007	<0.00000181	0.00000237 J	<0.00000134	<0.00000013	<0.00000014	<0.00000018	<0.00000136	<0.00000006	<0.00000136
1,2,3,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	<0.00000131	<0.00000007	<0.00000008	0.00000948 J	<0.00000008	<0.00000151	<0.00000004	<0.00000124	0.00000271 J	<0.0000009	<0.00000006	<0.00000007	<0.00000007	<0.00000099	<0.00000003	<0.00000117
1,2,3,7,8,9-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	<0.00000157	<0.00000014	<0.00000015	<0.00000229	0.00000093	<0.00000164	0.00000077 J	<0.00000175	0.000003 J	<0.00000013	<0.00000012	<0.00000013	<0.00000018	<0.00000132	<0.00000006	<0.00000132
1,2,3,7,8,9-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	<0.00000155	<0.00000009	<0.0000001	0.00000179	<0.00000009	<0.00000178	<0.00000006	<0.00000146	0.00000034 J	<0.00000106	<0.00000007	<0.00000009	<0.00000008	<0.00000116	<0.00000004	<0.00000138
1,2,3,7,8-PeCDD [e]	0.0000039	0.000016	- -	- -	mg/kg	<0.0000027	<0.00000011	<0.00000017	<0.00000432	<0.00000021	<0.00000199	<0.00000008	<0.00000185	0.00000058 J	<0.0000014	<0.0000001	<0.0000001	<0.00000013	<0.00000153	<0.00000007	<0.0000013
1,2,3,7,8-PeCDF	0.00011	0.00038	- -	- -	mg/kg	<0.00000111	<0.00000007	<0.00000008	0.00000714 J	<0.00000008	<0.000001	<0.00000004	<0.000001	0.00000029 J	<0.0000007	<0.00000006	<0.00000007	<0.00000009	<0.00000083	<0.00000003	<0.00000076
2,3,4,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	<0.00000154	<0.00000009	<0.0000001	0.00000294 J	<0.00000009	<0.00000177	<0.00000005	<0.00000145	0.00000108 J	<0.00000105	<0.00000007	<0.00000009	<0.00000008	<0.00000116	<0.00000004	<0.00000137
2,3,4,7,8-PeCDF	0.000011	0.000038	- -	- -	mg/kg	<0.00000116	<0.00000007	<0.00000008	0.0000101 J	<0.00000008	<0.00000104	<0.00000005	<0.00000104	0.00000061 J	<0.00000074	<0.00000006	<0.00000007	<0.00000009	<0.00000087	<0.00000003	<0.00000079
2,3,7,8-TCDD	0.0000045	0.000018	- -	- -	mg/kg	<0.00000141	<0.00000013	<0.00000014	<0.00000181	<0.00000006	<0.00000151	<0.00000006	<0.00000162	<0.00000005	<0.00000128	<0.0000001	<0.00000013	<0.00000014	<0.00000146	<0.00000005	<0.00000133
2,3,7,8-TCDF	0.000032	0.00011	- -	- -	mg/kg	<0.00000197	<0.0000001	<0.00000011	0.00006188 J	<0.00000008	0.00000725	<0.00000004	<0.00000151	<0.00000016 J	<0.00000119	<0.00000008	<0.0000001	<0.00000011	<0.00000129	<0.00000003	<0.00000107
OCDD	0.013	0.053	- -	- -	mg/kg	0.002977	0.003495 J	0.0008244 J	0.002165 J	0.0033 J	0.003884	0.01645 J	0.002064	0.004063 J	0.002352	0.0004363 J	0.0004122 J	0.0008114 J	0.00172	0.0009594 J	0.003185
OCDF	0.011	0.038	- -	- -	mg/kg	<0.00000225	0.00000266 J	0.0000021 J	0.0000191 B	0.00000114 J	0.00002918 B	0.00000863 J	<0.00000386	0.00000529 J	<0.00000178	<0.00000029 J	0.00000128 J	0.0000022 J	<0.00000289	0.00000102 B	<0.00000292
Total HpCDDs	- -	- -	- -	- -	mg/kg	0.0001243	0.0000262	0.00000941	0.0001208 J	0.00009885	0.000178	0.0001458 J	0.0001053	0.0001147 J	0.00007269	0.00000508	0.00000513	0.00001071	0.00003714	0.00001344	0.00002162
Total HpCDFs	- -	- -	- -	- -	mg/kg	<0.00000097	<0.00000009	<0.00000011	0.00002477 J	0.00000035	0.00003418	0.00000053 J	0.00000475	0.00001225 J	0.00000304	<0.00000009	<0.00000009	0.00000076	<0.00000109	0.00000012	<0.00000114
Total HxCDDs	- -	- -	- -	- -	mg/kg	<0.00000157	0.00000047	<0.00000015	<0.00000229	0.00000719	0.00000983	0.00000188 J	0.00001125	0.00002469 J	<0.0000013	<0.00000012	<0.00000013	<0.00000018	<0.00000132	<0.00000006	<0.00000132
Total HxCDFs	- -	- -	- -	- -	mg/kg	<0.00000131	<0.00000007	<0.00000008	0.00006751 J	<0.00000008	<0.00000151	<0.00000004	<0.00000124	0.00001394 J	<0.0000009	<0.00000006	<0.00000007	<0.00000007	<0.00000099	<0.00000003	<0.00000117
Total PeCDDs	- -	- -	- -	- -	mg/kg	<0.0000027	<0.00000011	<0.00000017	<0.00000432	<0.00000021	<0.00000199	<0.00000008	<0.00000185	0.00000199 J	<0.0000014	<0.0000001	<0.0000001	<0.00000013	<0.00000153	<0.00000007	<0.0000013
Total PeCDFs	- -	- -	- -	- -	mg/kg	<0.00000111	<0.00000007	<0.00000008	0.00007985 J	<0.00000008	<0.000001	<0.00000004	<0.000001	0.00000838 J	<0.0000007	<0.00000006	<0.00000007	<0.00000009	<0.00000083	<0.00000003	<0.00000076
Total TCDDs	- -	- -	- -	- -	mg/kg	<0.00000141	<0.00000013	<0.00000014	<0.00000181	<0.00000006	<0.00000151	<0.00000006	0.00000468	0.00000047 J	<0.00000128	<0.0000001	<0.00000013	<0.00000014	<0.00000146	<0.00000005	<0.00000133
Total TCDFs	- -	- -	- -	- -	mg/kg	<0.00000197	<0.0000001	<0.00000011	0.0001714 J	<0.00000008	0.00000725	<0.00000004	<0.00000151	0.00000731 J	<0.00000119	<0.00000008	<0.0000001	<0.00000011	<0.00000129	<0.00000003	<0.00000107
Explosives																					
None Detected	- -	- -	- -	- -	- -	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Herbicides																					
2,4,5-T	610	6,200	- -	- -	mg/kg	<0.0121	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0116	NA	NA
2,4-D	690	7,700	- -	- -	mg/kg	0.146	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0232	NA	NA
2,4-DB	490	4,900	- -	- -	mg/kg	<0.121	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.116	NA	NA
Dalapon	1,800	18,000	- -	- -	mg/kg	0.0814 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0759 J	NA	NA
Dicamba	1,800	18,000	- -	- -	mg/kg	<0.0241	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0232	NA	NA
MCPP	61	620	- -	- -	mg/kg	<12.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.3 J	NA	NA
Organochlorine Pesticides																					
4,4'-DDD	2	7.2	- -	- -	mg/kg	0.00495 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00773	NA	NA
4,4'-DDE	1.4	5.1	- -	- -	mg/kg	0.0289	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00773	NA	NA
4,4'-DDT	1.7	7	- -	- -	mg/kg	0.0854	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00773	NA	NA
Dieldrin	0.03	0.11	- -	- -	mg/kg	<0.00805 L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00773 L	NA	NA
Endosulfan II [f]	370	3,700	- -	- -	mg/kg	<0.00805	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00773	NA	NA
Endrin Aldehyde [g]	18	180	- -	- -	mg/kg	0.00645 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.00773 L	NA	NA
PAHs																					
2-Methylnaphthalene	310	4,100	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	150	670	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCBs																					
Aroclor-1254	0.22	0.74	- -	- -	mg/kg	2.5	<0.030	<0.040	3.4	0.060	0.97	<0.040	<0.030	<0.030	<0.030	<0.030	<0.040	<0.040	<0.030	<0.040	<0.040
Volatile Organics																					
1,1-Dichloroethene	250	1,100	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0046	<0.0054	<0.0064
1,2,4-Trimethylbenzene	67	280	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	28,000	190,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0046	<0.0054	0.011 K
Acetone	61,000	610,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0046	<0.0054	0.12 B
Benzene	1.1	5.6	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0046	<0.0054	<0.0064
Carbon Disulfide	670	3,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0046	0.00044 B	<0.0064
Chlorobenzene	310	1,500	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0046	<0.0054	<0.0064
d-Limonene	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.023 J
Methylene Chloride	11	54	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0046	<0.0054	<0.0064
tert-Butylbenzene	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	5,000	46,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0046	<0.0054	<0.0064
Trichloroethene	2.8	14	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.0046	<0.0054	<0.0064

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID: / Sample Depth(Feet): / Date Collected:	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	NBGSB12 0 - 0.5 06/12/02	NBGSB12 1 - 3 06/19/02	NBGSB12 3 - 5 06/19/02	NBGSB13 0 - 0.5 06/12/02	NBGSB13 1 - 3 06/19/02	NBGSB14 0 - 0.5 06/12/02	NBGSB14 1 - 3 06/19/02	NBGSB15 0 - 0.5 06/12/02	NBGSB15 1 - 3 06/19/02	NBGSB16 0 - 0.5 06/12/02	NBGSB16 2 06/19/02	NBGSB16 6 06/19/02	NBGSB16 10 - 12 06/19/02	NBGSB17 0 - 0.5 06/12/02	NBGSB17 1 - 3 06/19/02	NBGSB18 0 - 0.5 06/12/02
Semivolatile Organics																					
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	35	120	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbazole	24	86	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diethylphthalate	49,000	490,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-Butylphthalate	6,100	62,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Inorganics																					
Aluminum	77,000	990,000	**40,041**	- -	mg/kg	12,700	24,200	26,400	14,400	12,700	26,100	23,600	15,100	13,900	15,500	13,900	24,400	36,500	19,700	18,800	35,500
Antimony	31	410	- -	- -	mg/kg	0.780 L	<0.590 L	<0.670 L	22.0 L	0.220 B	2.46 L	<0.610 L	1.33 L	0.450 L	0.470 L	<0.570 L	<0.600 L	<0.690 L	0.370 B	0.270 B	<0.630 L
Arsenic	0.39	1.6	**15.8**	- -	mg/kg	3.31	5.87 L	11.3 L	**24.1**	2.35 L	9.97	5.69 L	3.78	4.14 L	2.25	5.38 L	6.28 L	7.75 L	5.92	8.20 L	8.37
Barium	15,000	190,000	**209**	- -	mg/kg	67.1	31.9	15.4	**342**	49.7	89.4	29.6	**295**	95.4	52.5	20.9	28.3	32.5	65.9	15.7	21.4
Beryllium	160	2,000	**1.02**	- -	mg/kg	0.450 B	<0.590	0.430 B	0.590 B	0.380 B	0.560 B	<0.610	0.640 K	0.440 B	0.480 B	<0.570	<0.600	<0.690	<0.570	<0.600	0.490 B
Cadmium	70	810	**0.69**	- -	mg/kg	0.580	<0.110	<0.130	**5.72**	0.0900 J	**0.870**	<0.120	**2.89**	0.160	0.140	<0.110	<0.120	<0.140	<0.110	<0.120	<0.120
Calcium	- -	- -	- -	- -	mg/kg	5,420 J	731	371	17,000 J	745	9,810 J	1,190	57,800 J	46,600	41,600 J	228	358	164	75,100 J	649	670 J
Chromium [k]	230	1,460	**65.3**	- -	mg/kg	**253 J**	28.1 L	38.5 L	**10,700 J**	30.8 L	**3,110 J**	33.1 L	**123 J**	22.7 L	**118 J**	21.9 L	32.4 L	58.4 L	29.3 J	**68.8 L**	44.5 J
Cobalt	- -	- -	**72.3**	- -	mg/kg	6.95 J	3.90 J	4.60 J	**80.4 J**	5.90 J	26.1 J	2.20 J	8.85 J	7.61	7.01 J	1.90 J	2.10 J	3.60 J	7.34 J	2.60 J	3.40 J
Copper	3,100	41,000	**53.5**	- -	mg/kg	43.6 L	10.8	25.7	**307 L**	6.21	**218 L**	12.7	**58.7 L**	36.2	13.2 L	4.44	10.9	23.8	14.8 L	11.1	22.0 L
Iron	55,000	720,000	**50,962**	- -	mg/kg	15,200 J	24,300 J	38,900 J	24,900 J	13,200 J	31,600 J	27,100 J	17,500 J	14,300 J	13,300 J	13,400 J	25,200 J	40,800 J	17,600 J	29,800 J	44,800 J
Lead	400	750	**26.8**	- -	mg/kg	**3,640 K**	12.0	20.9	**65,300 K**	**82.7**	**20,500 K**	**30.4**	**1,200 K**	**82.0**	**931 K**	13.5	14.0	25.7	**38.9 K**	16.2	21.5 K
Magnesium	- -	- -	- -	- -	mg/kg	3,220	794	801	9,500	545	5,650	708	30,700	25,200	29,200	347	529	1,450	38,100	492	723
Manganese	1,800	23,000	**2,543**	- -	mg/kg	328 J	50.4	61.2	469 J	203	168 J	55.2	264 J	316	250 J	19.5	23.0	50.4	144 J	148	64.3 J
Mercury	6.7	28	**0.13**	- -	mg/kg	0.0400 J	0.0700	**0.220**	0.0400 J	0.0300 J	0.0500 J	0.0700	0.0700	0.0200 J	0.0400 J	0.0400 J	0.0800	0.0700	0.0400 J	0.0900	0.130
Nickel	1,600	20,000	**62.8**	- -	mg/kg	7.12	10.4	20.8	16.7	7.24	17.8	7.78	11.9	10.6	11.1	3.20 J	8.47	15.0	11.1	4.93	17.9
Potassium	- -	- -	- -	- -	mg/kg	663	865	981	1,010	400	1,790	607	2,060	1,830	1,990	416	579	1,250	2,930	496	835
Selenium	390	5,100	- -	- -	mg/kg	<1.21 L	<1.19 L	<1.35 L	<1.19 L	<1.22 L	<1.20 L	<1.22 L	<1.15 L	<1.17 L	<1.16 L	<1.15 L	<1.21 L	<1.40 L	<1.16 L	<1.20 L	<1.28 L
Silver	390	5,100	- -	- -	mg/kg	<1.21 L	<1.19	<1.35	1.27 L	<1.22	<1.20 L	<1.22	<1.15 L	<1.17	<1.16 L	<1.15	<1.21	<1.40	<1.16 L	<1.20	<1.28 L
Sodium	- -	- -	- -	- -	mg/kg	33.5	18.0 B	11.0 B	117	12.0 B	55.0	11.0 B	87.8	66.3	89.2	7.50 B	16.0 B	22.0 B	115	9.30 B	23.0 B
Thallium	5.1	66	**2.11**	- -	mg/kg	0.180 J	0.140 J	0.220 J	0.220 J	0.140 J	0.190 J	0.170 J	0.150 J	0.130 J	0.150 J	0.100 J	0.200 J	0.230 J	0.140 J	0.110 J	0.210 J
Vanadium [l]	390	5,200	**108**	- -	mg/kg	29.1 J	44.8 L	69.0 L	70.4 J	28.5 L	62.0 J	48.8 L	34.4 J	29.6 L	27.1 J	24.7 L	42.3 L	78.2 L	36.7 J	50.4 L	76.0 J
Zinc	23,000	310,000	**202**	- -	mg/kg	**1,280 J**	18.2 J	32.0 J	**19,600 J**	64.8 J	**3,570 J**	18.5 J	**3,820 J**	129 J	**464 J**	7.87 J	16.7 J	26.0 J	143 J	19.2 J	34.9 J
Inorganics-TCLP																					
Arsenic	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	- -	- -	- -	100	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	- -	- -	- -	1.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium [k]	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	- -	- -	- -	1.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Miscellaneous																					
Percent Solids	- -	- -	- -	- -	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
pH	- -	- -	- -	- -	pH Units	6.82 J	NA	4.68 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	- -	- -	- -	- -	mg/kg	29,100 K	NA	1,200 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes

[a]	RSL unavailable; RSL for Total HpCDD used as a surrogate.
[b]	RSL unavailable; RSL for Total HpCDF used as a surrogate.
[c]	RSL unavailable; RSL for Total HxCDD used as a surrogate.
[d]	RSL unavailable; RSL for Total HxCDF used as a surrogate.
[e]	RSL unavailable; RSL for Total PeCDD used as a surrogate.
[f]	RSL unavailable; RSL for Endosulfan used as a surrogate.
[g]	RSL unavailable; RSL for Endrin used as a surrogate.
[h]	RSL unavailable; RSL for Acenaphthalene used as a surrogate.
[i]	RSL unavailable; RSL for Pyrene used as a surrogate.
[j]	RSL unavailable; RSL for Anthracene used as a surrogate.
[k]	RSL for Chromium VI (particulates).
[l]	RSL for Vanadium and compounds.
B (Inorganics)	Constituent concentration quanitified as estimated.
B (Organics)	Constituent was detected in the associated method blank.
J	Constituent concentration quanitified as estimated.
K	Estimated concentration bias high.
L	Estimated concentration bias low.
R	Constituent concentration rejected.
NA	Not Analyzed.
ND	Not Detected (no detection limit given).
24,400	Highlighted cell indicates constituent concentration exceeds Soil RSL (Residential).
10.6 J	Highlighted cell indicates constituent concentration exceeds Soil RSL (Industrial).
127	Bolded value indicates constituent concentration exceeds 95% UTLs developed for faci
6.4	Highlighted cell indicates constituent concentration exceeds TCLP standard.

Note: Inorganics Facility-Wide Background Point Estimate taken from *Facility-Wide Background Study Report*, IT Corporation, 2001.

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID: / Sample Depth(Feet): / Date Collected:	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	NBGSB18 1 - 3 06/19/02	NBGSB19 0 - 0.5 06/12/02	NBGSB19 1 - 3 06/19/02	NBGSB20 0 - 0.5 07/20/04	NBGSB20 1 - 3 07/20/04	NBGSB20 3 - 5 07/20/04	NBGSB20 5 - 7 07/20/04	NBGSB21 0 - 0.5 07/20/04	NBGSB21 1 - 3 07/20/04	NBGSB21 3 - 5 07/20/04	NBGSB21 5 - 7 07/20/04	NBGSB22 0 - 0.5 07/20/04	NBGSB22 1 - 3 07/20/04	NBGSB22 3 - 5 07/20/04	NBGSB22 5 - 7 07/20/04	NBGSB23 0 - 0.5 07/20/04	NBGSB23 1 - 3 07/20/04
Dioxin/Furan																						
1,2,3,4,6,7,8-HpCDD [a]	0.00039	0.0016	- -	- -	mg/kg	0.00000852 J	0.0001025 [0.00005895]	0.00000466	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	0.00000016 J	0.00000244 [<0.00000153]	0.00000015 B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	<0.00000004	<0.00000161 [<0.00000198]	<0.00000005	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	<0.00000007	<0.00000158 [<0.0000023]	<0.00000008	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	<0.00000004	<0.00000106 [<0.00000119]	<0.00000005	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	<0.00000006	<0.00000123 [<0.0000018]	<0.00000006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	<0.00000004	<0.00000103 [<0.00000116]	<0.00000005	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	0.00000028 J	<0.0000012 [<0.00000174]	<0.00000007	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	<0.00000006	<0.00000121 [<0.00000137]	<0.00000007	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-PeCDD [e]	0.0000039	0.000016	- -	- -	mg/kg	<0.00000007	<0.00000132 [<0.00000161]	<0.00000006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-PeCDF	0.00011	0.00038	- -	- -	mg/kg	<0.00000004	<0.00000076 [<0.00000094]	<0.00000004	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	<0.00000005	<0.00000121 [<0.00000136]	<0.00000006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,7,8-PeCDF	0.000011	0.000038	- -	- -	mg/kg	<0.00000004	<0.0000008 [<0.00000098]	<0.00000005	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDD	0.0000045	0.000018	- -	- -	mg/kg	<0.00000005	<0.00000128 [<0.00000152]	<0.00000005	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDF	0.000032	0.00011	- -	- -	mg/kg	<0.00000003	<0.00000119 [<0.00000128]	<0.00000003	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDD	0.013	0.053	- -	- -	mg/kg	0.002096 J	0.01964 [0.01094]	0.0008243 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDF	0.011	0.038	- -	- -	mg/kg	0.00000096 B	0.00001394 B [<0.00000316]	0.00000137 B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDDs	- -	- -	- -	- -	mg/kg	0.00001799 J	0.0002014 [0.0001255]	0.00001208	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDFs	- -	- -	- -	- -	mg/kg	0.0000003 J	0.00000244 [<0.00000153]	0.00000063	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDDs	- -	- -	- -	- -	mg/kg	0.00000028 J	0.0000063 [<0.00000174]	<0.00000006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDFs	- -	- -	- -	- -	mg/kg	<0.00000004	<0.00000103 [<0.00000116]	<0.00000005	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDDs	- -	- -	- -	- -	mg/kg	<0.00000007	<0.00000132 [<0.00000161]	<0.00000006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDFs	- -	- -	- -	- -	mg/kg	<0.00000004	<0.00000076 [<0.00000094]	0.00000027	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total TCDDs	- -	- -	- -	- -	mg/kg	<0.00000005	<0.00000128 [<0.00000152]	<0.00000005	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total TCDFs	- -	- -	- -	- -	mg/kg	<0.00000003	<0.00000119 [<0.00000128]	<0.00000003	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Explosives																						
None Detected	- -	- -	- -	- -	- -	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Herbicides																						
2,4,5-T	610	6,200	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-D	690	7,700	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-DB	490	4,900	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dalapon	1,800	18,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dicamba	1,800	18,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MCPP	61	620	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Organochlorine Pesticides																						
4,4'-DDD	2	7.2	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	1.4	5.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	1.7	7	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	0.03	0.11	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan II [f]	370	3,700	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Aldehyde [g]	18	180	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAHs																						
2-Methylnaphthalene	310	4,100	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	150	670	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCBs																						
Aroclor-1254	0.22	0.74	- -	- -	mg/kg	<0.040	<0.040 [<0.030]	<0.040	0.23	<0.043	<0.046 [<0.046]	<0.048	1.3	<0.041	0.18	<0.044	4.6	<0.039 [<0.039]	<0.041	<0.046	<0.039	<0.040
Volatile Organics																						
1,1-Dichloroethene	250	1,100	- -	- -	mg/kg	<0.0067	<0.0054 [<0.0050]	<0.0066	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	67	280	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	28,000	190,000	- -	- -	mg/kg	<0.0067	<0.0054 [<0.0050]	<0.0066	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetone	61,000	610,000	- -	- -	mg/kg	<0.0067	<0.0054 [<0.0050]	<0.0066	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	1.1	5.6	- -	- -	mg/kg	<0.0067	<0.0054 [<0.0050]	<0.0066	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Disulfide	670	3,000	- -	- -	mg/kg	0.00052 B	<0.0054 [<0.0050]	<0.0066	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene	310	1,500	- -	- -	mg/kg	<0.0067	<0.0054 [<0.0050]	<0.0066	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
d-Limonene	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	11	54	- -	- -	mg/kg	<0.0067	<0.0054 [<0.0050]	<0.0066	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
tert-Butylbenzene	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	5,000	46,000	- -	- -	mg/kg	<0.0067	<0.0054 [<0.0050]	<0.0066	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethene	2.8	14	- -	- -	mg/kg	<0.0067	<0.0054 [<0.0050]	<0.0066	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID: / Sample Depth(Feet): / Date Collected:	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	NBGSB18 1 - 3 06/19/02	NBGSB19 0 - 0.5 06/12/02	NBGSB19 1 - 3 06/19/02	NBGSB20 0 - 0.5 07/20/04	NBGSB20 1 - 3 07/20/04	NBGSB20 3 - 5 07/20/04	NBGSB20 5 - 7 07/20/04	NBGSB21 0 - 0.5 07/20/04	NBGSB21 1 - 3 07/20/04	NBGSB21 3 - 5 07/20/04	NBGSB21 5 - 7 07/20/04	NBGSB22 0 - 0.5 07/20/04	NBGSB22 1 - 3 07/20/04	NBGSB22 3 - 5 07/20/04	NBGSB22 5 - 7 07/20/04	NBGSB23 0 - 0.5 07/20/04	NBGSB23 1 - 3 07/20/04
Semivolatile Organics																						
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	35	120	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbazole	24	86	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diethylphthalate	49,000	490,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-Butylphthalate	6,100	62,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Inorganics																						
Aluminum	77,000	990,000	**40,041**	- -	mg/kg	**59,500**	21,300 [16,600]	**47,600**	15,000	33,000	**51,400 [56,300]**	**48,800**	17,000	15,500	16,400	36,900	12,700	13,700 [15,100]	33,400	**54,900**	17,300	26,400
Antimony	31	410	- -	- -	mg/kg	<0.670 L	<0.600 L [<0.550 L]	0.410 B	<3.30 L	<0.320	0.820 J [<0.660]	<0.670	<5.70	0.390 J	0.880 J	0.960 J	25.5 B	0.370 J [0.270 J]	0.710 J	0.680 L	0.860 B	0.530 J
Arsenic	0.39	1.6	**15.8**	- -	mg/kg	10.4 L	4.73 [3.45]	**16.5 J**	6.80 J	10.4	**16.1 [15.7]**	**17.5**	<6.60	6.50	4.90	13.3	**36.6 J**	4.10 [3.70]	10.2	10.1	6.30	7.80
Barium	15,000	190,000	**209**	- -	mg/kg	31.3	58.0 [46.0]	26.3	90.6	20.6	22.8 [23.9]	20.6	176	46.5	41.6	25.9	**618**	25.9 [27.1]	23.8	24.1	36.6	21.1
Beryllium	160	2,000	**1.02**	- -	mg/kg	0.520 B	0.460 B [0.500 B]	<0.650	0.540	0.450	0.720 [0.740]	0.780	0.540	0.470	0.260	0.590	0.470	0.290 [0.300]	0.580	**1.20**	0.360	0.370
Cadmium	70	810	**0.69**	- -	mg/kg	<0.130	<0.120 [<0.110]	<0.130	**0.760**	0.450 J	**0.780 [0.650 J]**	**0.750 J**	**2.40**	0.270 J	0.370 J	0.580 J	**10.6**	0.190 J [0.190 J]	<0.0290	<0.0390	<0.0300	<0.0310
Calcium	- -	- -	- -	- -	mg/kg	344	39,300 J [98,900 J]	690 J	14,600	545	277 [453]	79.2 J	21,800	774	766	347	15,000	820 [891]	996	76.1 B	1,930	440
Chromium [k]	230	1,460	**65.3**	- -	mg/kg	54.9 L	28.4 J [19.7 J]	51.2	**1,000**	42.6	54.8 [60.8]	55.8	**1,090**	32.9	**352**	53.1	**9,690**	23.0 [18.0]	53.6	41.3	50.8	54.3
Cobalt	- -	- -	**72.3**	- -	mg/kg	5.20 J	5.60 J [4.70 J]	3.80 J	14.6	3.00	6.80 [5.90]	6.60	17.8	4.50	4.60	3.50	**85.2**	4.10 [3.10]	3.30	6.50	3.90	3.70
Copper	3,100	41,000	**53.5**	- -	mg/kg	27.5	16.3 L [11.1 L]	23.6	43.0	17.3	30.8 [28.6]	29.0	**69.5**	9.10	16.1	17.6	**567**	4.00 [4.70]	16.2	30.0	10.8	10.6
Iron	55,000	720,000	**50,962**	- -	mg/kg	**52,300 J**	21,200 J [16,100 J]	45,500	19,500	39,400	**55,200 [58,400]**	**55,600**	20,300	19,700	17,700	46,400	40,400	16,700 [16,700]	38,500	45,400	20,400	27,400
Lead	400	750	**26.8**	- -	mg/kg	25.1	**36.2 K [32.7 K]**	23.2	**11,200**	15.9	**34.0 [33.3]**	**40.1**	**16,500**	**30.4**	**4,090**	24.7	**111,000**	**27.6 [16.6]**	**143 J**	**34.9 J**	**348 J**	**147 J**
Magnesium	- -	- -	- -	- -	mg/kg	800	29,700 [8,370]	659	5,530 J	690 J	755 J [836 J]	669 J	11,300 J	547 J	878 J	864 J	8,340 J	575 J [580 J]	1,100	1,120	1,330	683
Manganese	1,800	23,000	**2,543**	- -	mg/kg	83.8	161 J [136 J]	74.1	499	55.1	135 [125]	156	422	621	47.7	62.1	435	182 [167]	63.4	74.6	110	39.2
Mercury	6.7	28	**0.13**	- -	mg/kg	**0.270**	0.0400 J [0.0400 J]	**0.170 K**	0.0450	**0.170**	**0.160 [0.230]**	0.130	0.0390	0.0290 J	0.0400	**0.250**	0.0310 J	0.0390 [0.0280 J]	**0.200 J**	0.100 J	0.0350 J	0.0890 J
Nickel	1,600	20,000	**62.8**	- -	mg/kg	27.0	12.9 [8.76]	22.2	11.0	11.3	24.2 [22.3]	25.5	10.8	7.90	5.50	13.9	21.0	4.20 [5.20]	12.7	23.2	7.50	9.70
Potassium	- -	- -	- -	- -	mg/kg	1,400	2,140 [1,080]	1,190	827 K	878	1,250 [1,260]	969	1,050	405	608	939	1,190	514 [535]	1,080	1,080	691	864
Selenium	390	5,100	- -	- -	mg/kg	<1.34 L	<1.20 L [<1.11 L]	<1.32 L	<0.630	1.20 J	1.30 J [1.90 J]	<1.30	<0.560	0.720 J	0.560 J	1.40 J	<0.570	0.680 J [0.710 J]	<0.530	<0.710	<0.540	0.680 J
Silver	390	5,100	- -	- -	mg/kg	<1.34	<1.20 L [<1.11 L]	<1.32	<0.130	<0.130	<0.140 [<0.130]	<0.260	<0.110	<0.110	<0.110	0.130 B	0.990	<0.120 [<0.100]	<0.110	<0.140	<0.110	<0.120
Sodium	- -	- -	- -	- -	mg/kg	24.0 B	85.4 [34.8]	22.0 B	390 B	70.2 B	72.1 B [76.8 B]	79.1 B	937 B	77.0 B	<141	84.7 B	2,020 B	73.7 B [57.6 B]	52.1 B	60.4 B	104 B	65.5 B
Thallium	5.1	66	**2.11**	- -	mg/kg	0.210 J	0.190 J [0.160 J]	0.300 J	0.630 J	<0.380	<0.420 [<0.780]	<0.790	<6.80	<0.330	0.460 J	<0.400	<17.2	<0.360 [<0.310]	1.20 B	0.710 B	<0.330	<0.350
Vanadium [l]	390	5,200	**108**	- -	mg/kg	94.8 L	41.5 J [30.9 J]	81.1 J	34.6	78.1	**103 [109]**	96.6	35.9	38.6	37.5	86.5	40.5 J	35.3 [33.6]	76.8	84.9	42.9	56.1
Zinc	23,000	310,000	**202**	- -	mg/kg	40.8 J	78.6 J [51.8 J]	40.3 J	**1,700**	19.7	31.9 [32.9]	31.1	**6,090**	29.6	**647**	23.1	**15,800**	14.2 [12.3]	45.5	31.0	159	31.1
Inorganics-TCLP																						
Arsenic	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	- -	- -	- -	100	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	- -	- -	- -	1.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium [k]	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	- -	- -	- -	1.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Miscellaneous																						
Percent Solids	- -	- -	- -	- -	%	NA	NA	NA	84	78	72 [72]	70	83	81	84	76	83	85 [85]	81	72	86	84
pH	- -	- -	- -	- -	pH Units	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes

[a]	RSL unavailable; RSL for Total HpCDD used as a surrogate.
[b]	RSL unavailable; RSL for Total HpCDF used as a surrogate.
[c]	RSL unavailable; RSL for Total HxCDD used as a surrogate.
[d]	RSL unavailable; RSL for Total HxCDF used as a surrogate.
[e]	RSL unavailable; RSL for Total PeCDD used as a surrogate.
[f]	RSL unavailable; RSL for Endosulfan used as a surrogate.
[g]	RSL unavailable; RSL for Endrin used as a surrogate.
[h]	RSL unavailable; RSL for Acenaphthalene used as a surrogate.
[i]	RSL unavailable; RSL for Pyrene used as a surrogate.
[j]	RSL unavailable; RSL for Anthracene used as a surrogate.
[k]	RSL for Chromium VI (particulates).
[l]	RSL for Vanadium and compounds.
B (Inorganics)	Constituent concentration quanitified as estimated.
B (Organics)	Constituent was detected in the associated method blank.
J	Constituent concentration quanitified as estimated.
K	Estimated concentration bias high.
L	Estimated concentration bias low.
R	Constituent concentration rejected.
NA	Not Analyzed.
ND	Not Detected (no detection limit given).
24,400	Highlighted cell indicates constituent concentration exceeds Soil RSL (Residential).
10.6 J	Highlighted cell indicates constituent concentration exceeds Soil RSL (Industrial).
127	Bolded value indicates constituent concentration exceeds 95% UTLs developed for faci
6.4	Highlighted cell indicates constituent concentration exceeds TCLP standard.

Note: Inorganics Facility-Wide Background Point Estimate taken from *Facility-Wide Background Study Report*, IT Corporation, 2001.

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID: / Sample Depth(Feet): / Date Collected:	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	NBGSB23 3 - 5 07/20/04	NBGSB23 5 - 7 07/20/04	NBGSB24 0 - 0.5 07/20/04	NBGSB24 1 - 3 07/20/04	NBGSB24 3 - 5 07/20/04	NBGSB24 5 - 7 07/20/04	NBGSB25 0 - 0.5 07/20/04	NBGSB25 1 - 3 07/20/04	NBGSB25 3 - 5 07/20/04	NBGSB25 5 - 7 07/20/04	NBGSB26 0 - 0.5 07/20/04	NBGSB27 0 - 0.5 07/22/04	NBGSB28 0 - 0.5 07/21/04	NBGSB29 0 - 0.5 07/20/04	NBGSB30 0 - 0.5 07/21/04	NBGSB31 0 - 0.5 07/22/04	NBGSB32 0 - 0.5 07/19/04	NBGSB33 0 - 0.5 07/21/04
Dioxin/Furan																							
1,2,3,4,6,7,8-HpCDD [a]	0.00039	0.0016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-PeCDD [e]	0.0000039	0.000016	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8-PeCDF	0.00011	0.00038	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4,7,8-PeCDF	0.000011	0.000038	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDD	0.0000045	0.000018	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDF	0.000032	0.00011	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDD	0.013	0.053	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDF	0.011	0.038	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total TCDDs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total TCDFs	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Explosives																							
None Detected	- -	- -	- -	- -	- -	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Herbicides																							
2,4,5-T	610	6,200	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-D	690	7,700	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-DB	490	4,900	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dalapon	1,800	18,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dicamba	1,800	18,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MCPP	61	620	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Organochlorine Pesticides																							
4,4'-DDD	2	7.2	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	1.4	5.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	1.7	7	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	0.03	0.11	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan II [f]	370	3,700	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Aldehyde [g]	18	180	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAHs																							
2-Methylnaphthalene	310	4,100	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	150	670	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCBs																							
Aroclor-1254	0.22	0.74	- -	- -	mg/kg	<0.040	<0.040	0.14	<0.040 [<0.039]	<0.039	<0.039	0.56	<0.037	<0.040	<0.040	<0.039	<0.043 [<0.043]	<0.042	<0.040	<0.041	<0.044	<0.042	<0.039
Volatile Organics																							
1,1-Dichloroethene	250	1,100	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	67	280	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	28,000	190,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetone	61,000	610,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	1.1	5.6	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Disulfide	670	3,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene	310	1,500	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
d-Limonene	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	11	54	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
tert-Butylbenzene	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	5,000	46,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethene	2.8	14	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID:						NBGSB23	NBGSB23	NBGSB24	NBGSB24	NBGSB24	NBGSB24	NBGSB25	NBGSB25	NBGSB25	NBGSB25	NBGSB26	NBGSB27	NBGSB28	NBGSB29	NBGSB30	NBGSB31	NBGSB32	NBGSB33
Sample Depth(Feet):	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	3 - 5	5 - 7	0 - 0.5	1 - 3	3 - 5	5 - 7	0 - 0.5	1 - 3	3 - 5	5 - 7	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Date Collected:						07/20/04	07/20/04	07/20/04	07/20/04	07/20/04	07/20/04	07/20/04	07/20/04	07/20/04	07/20/04	07/20/04	07/22/04	07/21/04	07/20/04	07/21/04	07/22/04	07/19/04	07/21/04
Semivolatile Organics																							
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	35	120	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbazole	24	86	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diethylphthalate	49,000	490,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-Butylphthalate	6,100	62,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Inorganics																							
Aluminum	77,000	990,000	**40,041**	- -	mg/kg	21,000	18,000	13,000	13,500 [14,100]	13,200	16,000	17,100	11,500	11,600	20,300	14,500	10,500 [11,000]	17,700	15,000	26,600	16,500	22,800	17,500
Antimony	31	410	- -	- -	mg/kg	0.510 J	0.330 J	0.750 B	0.530 J [<0.280]	<0.280	0.410 J	2.60 B	<0.280	0.420 J	0.430 J	0.790 B	<0.360 L [0.410 B]	0.830 B	0.370 B	0.650 B	0.410 B	0.680 B	0.390 B
Arsenic	0.39	1.6	**15.8**	- -	mg/kg	7.30	4.50	5.60	7.20 [5.70]	3.90	3.60	6.50	4.30	12.7	6.10	5.20	4.00 [3.80]	4.30	2.40 B	11.0	5.90	8.90	8.10
Barium	15,000	190,000	**209**	- -	mg/kg	16.2	14.6	97.1	48.1 [50.1]	52.4	27.3	202	73.8	27.4	26.0	52.9	52.8 K [55.7 K]	126	158	35.1	40.6	47.0	34.1
Beryllium	160	2,000	**1.02**	- -	mg/kg	0.300	0.250	0.470	0.540 [0.520]	0.630	0.290	0.530	0.510	0.400	0.390	0.530	0.470 [0.480]	0.570	0.740	0.710	0.390	0.680	0.450
Cadmium	70	810	**0.69**	- -	mg/kg	<0.0310	<0.0320	0.280 J	<0.0320 [<0.0300]	<0.0300	<0.0300	**1.40**	**0.860**	0.440 J	0.260 J	0.240 J	0.0860 J [0.150 J]	0.520 J	0.420 J	0.190 J	0.240 J	0.290 J	0.150 J
Calcium	- -	- -	- -	- -	mg/kg	122	27.1 B	9,580	777 [804]	608	414	37,700	4,170	941	1,010	978	1,450 [1,420]	81,900	129,000	1,370	22,500	2,640	2,790
Chromium [k]	230	1,460	**65.3**	- -	mg/kg	31.8	26.9	**174**	26.0 [20.4]	16.1	18.0	**494**	14.9	29.6	24.0	24.8	21.7 [31.8]	25.8	26.4	36.8	23.6	39.9	28.0
Cobalt	- -	- -	**72.3**	- -	mg/kg	3.30	2.80	6.80	5.90 [5.90]	10.6	3.30	9.70	13.4	4.00	2.80	5.20	7.50 [7.90]	6.70	8.30	5.10	3.20	6.80	4.00
Copper	3,100	41,000	**53.5**	- -	mg/kg	8.50	6.70	37.9	8.50 [8.90]	5.10	5.80	**95.4**	**313**	8.60	12.0	10.2	8.90 [8.90]	26.9	39.7	16.9	11.0	22.8	11.3
Iron	55,000	720,000	**50,962**	- -	mg/kg	25,700	16,900	13,700	23,400 [16,600]	12,500	15,100	19,900	38,600	42,300	23,400	17,900 J	11,700 J [11,400 J]	16,800 J	16,100 J	34,300 J	19,100 J	31,400 J	23,200 J
Lead	400	750	**26.8**	- -	mg/kg	**50.1 J**	10.0 J	**1,710 J**	**27.4 J [29.2 J]**	23.2 J	10.0 J	**5,610 J**	**63.5**	24.1	11.1	**80.1**	**110 [172]**	**124**	**79.5**	**51.0**	**53.9**	**159**	20.8
Magnesium	- -	- -	- -	- -	mg/kg	372	296	4,850	526 [552]	688	646	19,700	2,800 J	658 J	779 J	908	983 K [950 K]	39,900	58,500	1,220	11,800	1,840	2,150
Manganese	1,800	23,000	**2,543**	- -	mg/kg	63.7	36.2	407	471 [474]	501	110	290	675	221	63.9	409	252 K [280 K]	221	204	116	122	211	137
Mercury	6.7	28	**0.13**	- -	mg/kg	0.0410 J	0.0400 J	0.0360 J	0.0380 J [0.0380 J]	0.0580 J	0.0310 J	0.0400 J	0.0210 J	0.0600	0.0780	0.0310 J	0.0480 [0.0390]	0.0410	0.0450	0.0700	0.0610	0.0970	0.0490
Nickel	1,600	20,000	**62.8**	- -	mg/kg	8.00	6.70	8.10	7.70 [8.30]	6.60	6.10	13.8	7.30	4.80	8.70	8.20	7.20 [7.30]	13.1	15.4	13.8	7.80	14.8	8.90
Potassium	- -	- -	- -	- -	mg/kg	580	369	604	444 [466]	507	649	1,430	701	469	793	458	509 K [523 K]	2,210	3,680	732	856	764	1,010
Selenium	390	5,100	- -	- -	mg/kg	0.650 J	<0.580	<0.530	<0.590 [<0.550]	<0.540	<0.560	<0.530	1.40 J	1.50 J	<0.570	<0.620	<0.710 [<0.590]	<0.630	<0.560	0.940 J	<0.600	<0.660	0.580 J
Silver	390	5,100	- -	- -	mg/kg	<0.110	<0.120	<0.540	<0.120 [<0.220]	<0.110	<0.110	<0.110	<0.110	<0.110	<0.120	<0.130	<0.140 [<0.120]	<0.130	<0.110	<0.120	<0.120	<0.130	<0.120
Sodium	- -	- -	- -	- -	mg/kg	41.3 B	56.8 B	137 B	74.5 B [46.4 B]	52.9 B	47.3 B	404 B	142 B	69.7 B	77.4 B	69.3 B	79.9 B [65.0 B]	187 B	210 B	65.0 B	126 B	99.0 B	59.4 B
Thallium	5.1	66	**2.11**	- -	mg/kg	<0.340	<0.350	<0.320	<0.360 [<0.330]	<0.330	<0.340	<0.330	<0.330	<0.330	<0.350	<0.380	<0.430 [<0.360]	<0.390	<0.340	<0.370	<0.370	<0.400	<0.350
Vanadium [l]	390	5,200	**108**	- -	mg/kg	48.2	34.0	29.2	42.3 [34.2]	28.1	32.8	35.4	23.9	62.1	46.3	37.6	23.8 [24.0]	35.7	35.5	66.2	40.4	59.1	46.3
Zinc	23,000	310,000	**202**	- -	mg/kg	23.0	8.90	**875**	34.8 [39.8]	20.1	11.1	**4,040**	**650**	20.7	17.8	95.4	99.5 [107]	199	158	34.8	143	**204**	38.3
Inorganics-TCLP																							
Arsenic	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	- -	- -	- -	100	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	- -	- -	- -	1.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium [k]	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	- -	- -	- -	1.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Miscellaneous																							
Percent Solids	- -	- -	- -	- -	%	84	84	88	84 [86]	85	87	91	89	84	83	85	77 [78]	80	84	81	77	80	87
pH	- -	- -	- -	- -	pH Units	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes

[a]	RSL unavailable; RSL for Total HpCDD used as a surrogate.
[b]	RSL unavailable; RSL for Total HpCDF used as a surrogate.
[c]	RSL unavailable; RSL for Total HxCDD used as a surrogate.
[d]	RSL unavailable; RSL for Total HxCDF used as a surrogate.
[e]	RSL unavailable; RSL for Total PeCDD used as a surrogate.
[f]	RSL unavailable; RSL for Endosulfan used as a surrogate.
[g]	RSL unavailable; RSL for Endrin used as a surrogate.
[h]	RSL unavailable; RSL for Acenaphthalene used as a surrogate.
[i]	RSL unavailable; RSL for Pyrene used as a surrogate.
[j]	RSL unavailable; RSL for Anthracene used as a surrogate.
[k]	RSL for Chromium VI (particulates).
[l]	RSL for Vanadium and compounds.
B (Inorganics)	Constituent concentration quanitified as estimated.
B (Organics)	Constituent was detected in the associated method blank.
J	Constituent concentration quanitified as estimated.
K	Estimated concentration bias high.
L	Estimated concentration bias low.
R	Constituent concentration rejected.
NA	Not Analyzed.
ND	Not Detected (no detection limit given).
24,400	Highlighted cell indicates constituent concentration exceeds Soil RSL (Residential).
10.6 J	Highlighted cell indicates constituent concentration exceeds Soil RSL (Industrial).
127	Bolded value indicates constituent concentration exceeds 95% UTLs developed for faci
6.4	Highlighted cell indicates constituent concentration exceeds TCLP standard.

Note: Inorganics Facility-Wide Background Point Estimate taken from *Facility-Wide Background Study Report*, IT Corporation, 2001.

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID: Sample Depth(Feet): Date Collected:	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	NBGSD01 0 - 0.5 06/18/02	NBGSD02 0 - 0.5 07/14/04	NBGSD03 0 - 0.5 07/16/04	NBGSD04 0 - 0.5 07/16/04	SS-01 0.5 - 0.7 06/03/97	SS-02 0.5 - 0.7 06/03/97
Dioxin/Furan											
1,2,3,4,6,7,8-HpCDD [a]	0.00039	0.0016	- -	- -	mg/kg	0.00004075 [0.00004256]	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	0.00000464 [0.00000474]	NA	NA	NA	NA	NA
1,2,3,4,7,8,9-HpCDF [b]	0.00032	0.0011	- -	- -	mg/kg	0.00000041 [<0.00000016]	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	0.00000053 [<0.0000004]	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	0.00000071 [0.00000073]	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	0.00000141 [0.00000124]	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	0.00000162 J [0.00000151 J]	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDD [c]	0.000039	0.00016	- -	- -	mg/kg	0.00000136 [0.00000142]	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	<0.00000014 [<0.00000021]	NA	NA	NA	NA	NA
1,2,3,7,8-PeCDD [e]	0.0000039	0.000016	- -	- -	mg/kg	<0.00000014 [<0.00000028]	NA	NA	NA	NA	NA
1,2,3,7,8-PeCDF	0.00011	0.00038	- -	- -	mg/kg	0.00000021 [<0.00000024]	NA	NA	NA	NA	NA
2,3,4,6,7,8-HxCDF [d]	0.000032	0.00011	- -	- -	mg/kg	0.00000029 [0.00000036]	NA	NA	NA	NA	NA
2,3,4,7,8-PeCDF	0.000011	0.000038	- -	- -	mg/kg	0.00000024 [<0.00000025]	NA	NA	NA	NA	NA
2,3,7,8-TCDD	0.0000045	0.000018	- -	- -	mg/kg	0.00000047 J [<0.00000015]	NA	NA	NA	NA	NA
2,3,7,8-TCDF	0.000032	0.00011	- -	- -	mg/kg	0.00000038 [0.00000022 J]	NA	NA	NA	NA	NA
OCDD	0.013	0.053	- -	- -	mg/kg	0.002629 J [0.003003 J]	NA	NA	NA	NA	NA
OCDF	0.011	0.038	- -	- -	mg/kg	0.0000342 J [0.00003042 J]	NA	NA	NA	NA	NA
Total HpCDDs	- -	- -	- -	- -	mg/kg	0.00008126 [0.00008569]	NA	NA	NA	NA	NA
Total HpCDFs	- -	- -	- -	- -	mg/kg	0.00002337 [0.00002231]	NA	NA	NA	NA	NA
Total HxCDDs	- -	- -	- -	- -	mg/kg	0.00000802 [0.00000717]	NA	NA	NA	NA	NA
Total HxCDFs	- -	- -	- -	- -	mg/kg	0.00000747 [0.00000747]	NA	NA	NA	NA	NA
Total PeCDDs	- -	- -	- -	- -	mg/kg	<0.00000014 [<0.00000028]	NA	NA	NA	NA	NA
Total PeCDFs	- -	- -	- -	- -	mg/kg	0.00000336 [0.00000191]	NA	NA	NA	NA	NA
Total TCDDs	- -	- -	- -	- -	mg/kg	0.00000114 [0.00000118]	NA	NA	NA	NA	NA
Total TCDFs	- -	- -	- -	- -	mg/kg	0.00000151 [0.00000034]	NA	NA	NA	NA	NA
Explosives											
None Detected	- -	- -	- -	- -	- -	- - [- -]	NA	NA	NA	NA	NA
Herbicides											
2,4,5-T	610	6,200	- -	- -	mg/kg	<0.121 [<0.121]	NA	NA	NA	NA	NA
2,4-D	690	7,700	- -	- -	mg/kg	<0.242 [<0.242]	NA	NA	NA	NA	NA
2,4-DB	490	4,900	- -	- -	mg/kg	<1.21 [<1.21]	NA	NA	NA	NA	NA
Dalapon	1,800	18,000	- -	- -	mg/kg	<1.21 [<1.21]	NA	NA	NA	NA	NA
Dicamba	1,800	18,000	- -	- -	mg/kg	<0.242 [<0.242]	NA	NA	NA	NA	NA
MCPP	61	620	- -	- -	mg/kg	<121 [<121]	NA	NA	NA	NA	NA
Organochlorine Pesticides											
4,4'-DDD	2	7.2	- -	- -	mg/kg	0.00244 [0.00034 J]	NA	NA	NA	NA	NA
4,4'-DDE	1.4	5.1	- -	- -	mg/kg	0.00085 B [<0.0008]	NA	NA	NA	NA	NA
4,4'-DDT	1.7	7	- -	- -	mg/kg	0.00421 [0.00072 B]	NA	NA	NA	NA	NA
Dieldrin	0.03	0.11	- -	- -	mg/kg	0.00185 [<0.0008]	NA	NA	NA	NA	NA
Endosulfan II [f]	370	3,700	- -	- -	mg/kg	0.00176 [<0.0008]	NA	NA	NA	NA	NA
Endrin Aldehyde [g]	18	180	- -	- -	mg/kg	<0.0008 [<0.0008]	NA	NA	NA	NA	NA
PAHs											
2-Methylnaphthalene	310	4,100	- -	- -	mg/kg	<0.0025 [0.0037 B]	NA	NA	NA	NA	NA
Acenaphthene	3,400	33,000	- -	- -	mg/kg	0.0086 B [0.0052 B]	NA	NA	NA	NA	NA
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	0.052 [0.083]	NA	NA	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	0.029 [0.032]	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	0.19 [0.49]	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	0.21 [0.53]	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	0.31 [0.73]	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	0.18 [0.37]	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	0.11 [0.24]	NA	NA	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	0.16 [0.37]	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	0.015	0.21	- -	- -	mg/kg	0.036 [0.084]	NA	NA	NA	NA	NA
Fluoranthene	2,300	22,000	- -	- -	mg/kg	0.33 [0.53]	NA	NA	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	0.01 [0.01]	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	0.18 [0.4]	NA	NA	NA	NA	NA
Naphthalene	150	670	- -	- -	mg/kg	0.0053 B [0.0085]	NA	NA	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	0.15 [0.15]	NA	NA	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	0.25 [0.5]	NA	NA	NA	NA	NA
PCBs											
Aroclor-1254	0.22	0.74	- -	- -	mg/kg	0.14 [<0.040]	0.068	<0.039	0.15	NA	NA
Volatile Organics											
1,1-Dichloroethene	250	1,100	- -	- -	mg/kg	<0.0061 [<0.0060]	NA	NA	NA	0.0020 J	ND
1,2,4-Trimethylbenzene	67	280	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA
2-Butanone	28,000	190,000	- -	- -	mg/kg	<0.0061 [<0.0060]	NA	NA	NA	NA	NA
Acetone	61,000	610,000	- -	- -	mg/kg	<0.0061 [<0.0060]	NA	NA	NA	0.0030 B	ND
Benzene	1.1	5.6	- -	- -	mg/kg	<0.0061 [<0.0060]	NA	NA	NA	0.0010 J	ND
Carbon Disulfide	670	3,000	- -	- -	mg/kg	<0.0061 [<0.0060]	NA	NA	NA	NA	NA
Chlorobenzene	310	1,500	- -	- -	mg/kg	<0.0061 [<0.0060]	NA	NA	NA	0.0010 J	ND
d-Limonene	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA
Methylene Chloride	11	54	- -	- -	mg/kg	<0.0061 [<0.0060]	NA	NA	NA	0.0020 B	0.0020 B
tert-Butylbenzene	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA
Toluene	5,000	46,000	- -	- -	mg/kg	<0.0061 [<0.0060]	NA	NA	NA	0.0010 J	ND
Trichloroethene	2.8	14	- -	- -	mg/kg	<0.0061 [<0.0060]	NA	NA	NA	0.0010 J	ND

Table A-1
Historical Soil Sampling Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Location ID: Sample Depth(Feet): Date Collected:	Regional Screening Level (Residential)	Regional Screening Level (Industrial)	Facility-Wide Background	TCLP Standards	Units	NBGSD01 0 - 0.5 06/18/02	NBGSD02 0 - 0.5 07/14/04	NBGSD03 0 - 0.5 07/16/04	NBGSD04 0 - 0.5 07/16/04	SS-01 0.5 - 0.7 06/03/97	SS-02 0.5 - 0.7 06/03/97
Semivolatile Organics											
Acenaphthylene [h]	3,400	33,000	- -	- -	mg/kg	0.040 J [0.035 J]	NA	NA	NA	NA	NA
Anthracene	17,000	170,000	- -	- -	mg/kg	0.018 J [0.028 J]	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.15	2.1	- -	- -	mg/kg	0.22 [0.21]	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.015	0.21	- -	- -	mg/kg	0.28 [0.25]	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	0.15	2.1	- -	- -	mg/kg	0.37 [0.31]	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene [i]	1,700	17,000	- -	- -	mg/kg	0.16 J [0.22]	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	1.5	21	- -	- -	mg/kg	0.13 J [0.12 J]	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	35	120	- -	- -	mg/kg	0.18 B [0.12 B]	NA	NA	NA	0.20 J	0.10 J
Carbazole	24	86	- -	- -	mg/kg	0.022 J [0.021 J]	NA	NA	NA	NA	NA
Chrysene	15	210	- -	- -	mg/kg	0.23 [0.22]	NA	NA	NA	NA	NA
Diethylphthalate	49,000	490,000	- -	- -	mg/kg	<0.21 [<0.21]	NA	NA	NA	NA	NA
Di-n-Butylphthalate	6,100	62,000	- -	- -	mg/kg	<0.21 [<0.21]	NA	NA	NA	ND	0.040 J
Fluoranthene	2,300	22,000	- -	- -	mg/kg	0.37 [0.38]	NA	NA	NA	NA	NA
Fluorene	2,300	22,000	- -	- -	mg/kg	<0.21 [0.010 J]	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.15	2.1	- -	- -	mg/kg	0.17 J [0.21]	NA	NA	NA	NA	NA
Phenanthrene [j]	17,000	170,000	- -	- -	mg/kg	0.12 J [0.16 J]	NA	NA	NA	NA	NA
Pyrene	1,700	17,000	- -	- -	mg/kg	0.34 [0.32]	NA	NA	NA	NA	NA
Inorganics											
Aluminum	77,000	990,000	**40,041**	- -	mg/kg	17,900 [16,600]	21,400	19,500	13,200	18,200	28,900
Antimony	31	410	- -	- -	mg/kg	0.360 B [0.480 L]	0.380 B	1.60 B	2.10 B	NA	NA
Arsenic	0.39	1.6	**15.8**	- -	mg/kg	5.56 J [5.75 J]	8.90	6.80	5.10	7.60	6.30
Barium	15,000	190,000	**209**	- -	mg/kg	55.4 [53.0]	44.2	123	142	79.3 J	80.3 J
Beryllium	160	2,000	**1.02**	- -	mg/kg	0.500 B [0.530 B]	0.670 J	0.640 J	0.480 J	0.500	0.600
Cadmium	70	810	**0.69**	- -	mg/kg	0.270 [0.290]	0.0830 J	**1.70**	**1.10**	ND	**0.800**
Calcium	- -	- -	- -	- -	mg/kg	3,300 J [11,600 J]	2,680	35,700	12,200	62,700	55,700
Chromium [k]	230	1,460	**65.3**	- -	mg/kg	41.1 J [35.3 J]	38.3	**397**	**151**	32.2	44.2
Cobalt	- -	- -	**72.3**	- -	mg/kg	5.60 J [5.10 J]	6.20	8.90	7.50	7.70	7.50
Copper	3,100	41,000	**53.5**	- -	mg/kg	22.1 L [26.2 L]	20.5	41.5	46.7	18.4	38.6
Iron	55,000	720,000	**50,962**	- -	mg/kg	22,600 J [22,200 J]	31,700	24,800	14,500	28,000	26,700
Lead	400	750	**26.8**	- -	mg/kg	**159 [132]**	**146**	**3,500**	**2,200**	**55.4**	**199**
Magnesium	- -	- -	- -	- -	mg/kg	2,570 J [7,410 J]	1,820	19,000	7,930	28,300	26,000
Manganese	1,800	23,000	**2,543**	- -	mg/kg	204 J [201 J]	215	334	319	208	156
Mercury	6.7	28	**0.13**	- -	mg/kg	0.0700 J [0.0600 J]	0.100	0.0480	0.0510	NA	NA
Nickel	1,600	20,000	**62.8**	- -	mg/kg	10.3 [9.19]	14.3	13.1	10.0	13.8	17.3
Potassium	- -	- -	- -	- -	mg/kg	999 [901]	655	1,530	899	2,060	2,310
Selenium	390	5,100	- -	- -	mg/kg	<1.21 L [<1.21 L]	0.840 J	<0.550	<0.520	NA	NA
Silver	390	5,100	- -	- -	mg/kg	<1.21 [<1.21]	<0.120	<0.110	<0.110	NA	NA
Sodium	- -	- -	- -	- -	mg/kg	15.0 B [19.0 B]	79.9 B	<560	345 B	NA	NA
Thallium	5.1	66	**2.11**	- -	mg/kg	0.180 J [0.170 J]	<0.360	<0.340	<0.320	0.200	0.200
Vanadium [l]	390	5,200	**108**	- -	mg/kg	40.6 J [39.5 J]	55.8	46.3	29.0	64.6	70.0
Zinc	23,000	310,000	**202**	- -	mg/kg	**473 J [405 J]**	**208**	**4,220**	**2,630**	**294**	**1,210**
Inorganics-TCLP											
Arsenic	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA
Barium	- -	- -	- -	100	mg/L	NA	NA	NA	NA	NA	NA
Cadmium	- -	- -	- -	1.0	mg/L	NA	NA	NA	NA	NA	NA
Chromium [k]	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA
Lead	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA
Selenium	- -	- -	- -	1.0	mg/L	NA	NA	NA	NA	NA	NA
Silver	- -	- -	- -	5.0	mg/L	NA	NA	NA	NA	NA	NA
Miscellaneous											
Percent Solids	- -	- -	- -	- -	%	NA	81	87	82	NA	NA
pH	- -	- -	- -	- -	pH Units	NA	NA	NA	NA	NA	NA
Total Organic Carbon	- -	- -	- -	- -	mg/kg	NA	NA	NA	NA	NA	NA

Notes

[a]	RSL unavailable; RSL for Total HpCDD used as a surrogate.
[b]	RSL unavailable; RSL for Total HpCDF used as a surrogate.
[c]	RSL unavailable; RSL for Total HxCDD used as a surrogate.
[d]	RSL unavailable; RSL for Total HxCDF used as a surrogate.
[e]	RSL unavailable; RSL for Total PeCDD used as a surrogate.
[f]	RSL unavailable; RSL for Endosulfan used as a surrogate.
[g]	RSL unavailable; RSL for Endrin used as a surrogate.
[h]	RSL unavailable; RSL for Acenaphthalene used as a surrogate.
[i]	RSL unavailable; RSL for Pyrene used as a surrogate.
[j]	RSL unavailable; RSL for Anthracene used as a surrogate.
[k]	RSL for Chromium VI (particulates).
[l]	RSL for Vanadium and compounds.
B (Inorganics)	Constituent concentration quanitified as estimated.
B (Organics)	Constituent was detected in the associated method blank.
J	Constituent concentration quanitified as estimated.
K	Estimated concentration bias high.
L	Estimated concentration bias low.
R	Constituent concentration rejected.
NA	Not Analyzed.
ND	Not Detected (no detection limit given).
24,400	Highlighted cell indicates constituent concentration exceeds Soil RSL (Residential).
10.6 J	Highlighted cell indicates constituent concentration exceeds Soil RSL (Industrial).
127	Bolded value indicates constituent concentration exceeds 95% UTLs developed for faci
6.4	Highlighted cell indicates constituent concentration exceeds TCLP standard.

Note: Inorganics Facility-Wide Background Point Estimate taken from *Facility-Wide Background Study Report*, IT Corporation, 2001.

Table A-2
XRF Field Screening Results, Northern Burning Ground
New River Unit, Radford Army Ammunition Plant, Radford Virginia

Row ID	Sample_ID	XRF Lead Concentration (mg/kg)
Row 2N	2N0W	2900
	2N1E	295
	2N1W	408
	2N2E	160
	2N2W	281
	2N3E	137
	2N4W	136
	2N5W	339
	2N6W	179
	2N7W	152
	2N8W	140
	2N9W	118
Row 1N	1N11W	126
	1N14W	83.2
	1N1E	1040
	1N1W	1930
	1N3E	86.6
	1N4W	308
	1N5E	70.2
	1N7W	558
	1N8W	238
	1N9W	305
Row 0	0S11W	124
	0S13W	83.4
	0S1E	2660
	0S1W	2630
	0S3E	476
	0S4E	214
	0S5E	90.8
	0S8W	205
	0S9W	126
Row 1S	1S10E	145
	1S10W	164
	1S12W	76.2
	1S1W	5430
	1S4W	1420
	1S5E	1210
	1S7E	228
	1S8E	126
	1S9W	188
Row 2S	2S10E	130
	2S10W	168
	2S11E	132
	2S13E	89.5
	2S14W	140
	2S1E	2130
	2S1W	1690
	2S5E	2350
	2S7E	255
	2S7W	300
	2S8E	329
	2S8W	450
	2S9E	72.7
	2S9W	314

Row ID	Sample_ID	XRF Lead Concentration (mg/kg)
Row 3S	3S10W	82.1
	3S11E	550
	3S11W	116
	3S12E	83.7
	3S12W	117
	3S15W	93
	3S1W	3890
	3S7E	218
	3S8E	223
	3S9E	264
	3S9W	372
Row 4S	4S10E	715
	4S10W	234
	4S11E	161
	4S11W	340
	4S12E	110
	4S12W	51.8
	4S13W	95
	4S14W	68.8
	4S15W	85.1
	4S1E	177
	4S1W	3420
	4S9E	130
	4S9W	471
Row 5S	5S10E	139
	5S10W	207
	5S11E	130
	5S11W	205
	5S12E	85.6
	5S12W	218
	5S13W	198
	5S14W	159
	5S15W	75
	5S16W	72.3
	5S1E	692
	5S1W	1020
	5S3E	685
	5S5E	299
	5S7E	312
	5S8E	85.1
	5S8W	2990
	5S9E	122
	5S9W	274
Row 6S	6S10W	70.7
	6S12W	93.6
	6S13W	208
	6S14W	181
	6S15W	89
	6S17W	63.3
	6S1E	538
	6S1W	499
	6S2E	889
	6S3E	185
	6S6E	314

Row ID	Sample_ID	XRF Lead Concentration (mg/kg)
Row 6S (cont'd)	6S7E	329
	6S8E	133
	6S8W	382
	6S9E	94.6
	6S9W	72.1
Row 7S	7S10W	110
	7S12W	89.8
	7S15W	105
	7S17W	120
	7S4E	180
	7S5E	185
	7S6E	346
	7S7E	225
	7S8E	190
	7S9E	144
Row 8S	8S17W	80.4
	8S19W	102
	8S1E	2630
	8S21W	216
	8S22W	128
	8S2E	283
	8S2W	1400
	8S4E	266
	8S4W	247
	8S5E	784
	8S6E	226
	8S6W	850
	8S7E	425
	8S8E	242
	8S8W	689
	8S9E	140
	8S9W	269
Row 9S	9S0W	11000
	9S10W	94.4
	9S18W	59.4
	9S19W	145
	9S1E	1490
	9S1W	115
	9S20W	211
	9S21W	110
	9S22W	134
	9S2E	118
	9S2W	149
	9S3W	181
	9S4E	207
	9S4W	149
	9S5E	236
	9S5W	173
	9S6E	196
	9S6W	209
	9S7W	323
	9S8E	1820
	9S8W	284
	9S9E	128
	9S9W	301

Row ID	Sample_ID	XRF Lead Concentration (mg/kg)
Row 10S	10S0W	300
	10S10W	244
	10S11W	69.3
	10S16W	121
	10S17W	98.4
	10S18W	124
	10S19W	160
	10S1E	243
	10S1W	92.9
	10S20W	268
	10S2E	174
	10S2W	125
	10S3W	221
	10S4E	90.9
	10S4W	336
	10S5E	165
	10S5W	392
	10S6W	162
	10S7E	330
	10S7W	264
	10S8E	254
	10S8W	243
	10S9E	105
	10S9W	510
Row 11S	11S0W	64
	11S10W	95.4
	11S11W	246
	11S12W	110
	11S13W	159
	11S16W	144
	11S17W	188
	11S18W	182
	11S1E	59.7
	11S2W	76.8
	11S3E	96.8
	11S4E	327
	11S4W	369
	11S5E	264
	11S5W	285
	11S6E	75.3
	11S6W	251
	11S7E	90.1
	11S7W	172
	11S8E	113
	11S8W	134
	11S9E	68.4
	11S9W	402
Row 12S	12S10W	418
	12S11W	275
	12S12W	304
	12S13W	541
	12S14W	123
	12S15W	138
	12S17W	107
	12S19W	180

Row ID	Sample_ID	XRF Lead Concentration (mg/kg)
Row 12S (cont'd)	12S3E	81.1
	12S3W	119
	12S4E	170
	12S4W	102
	12S5W	137
	12S6E	91.6
	12S6W	244
	12S9W	178
Row 13S	13S10W	113
	13S11W	70.7
	13S12W	380
	13S13W	354
	13S14W	200
	13S15W	125
	13S17W	80.6
	13S18W	112
	13S3E	118
	13S4E	62.6
	13S4W	81.1
	13S5E	82.4
	13S5W	76.1
	13S6W	69.3
	13S7W	94.1
	13S8W	81.9
	13S9W	215
Row 14S	14S10W	78.6
	14S11W	95.4
	14S12W	245
	14S13W	106
	14S14W	102
	14S15W	105
	14S8W	80.8
	14S9W	79.9
Row 15S	15S11W	115
	15S12W	137
	15S13W	136
	15S14W	144
	15S15W	82.6
	15S16W	90.3
	15S18W	147
	15S19W	79.7
	15S21W	76.1
Row 16S	16S12W	147
	16S14W	159
	16S16W	217
	16S17W	166
	16S19W	199
	16S20W	57
	16S20W	240
	16S21W	119
Row 17S	17S12W	82.3
	17S13W	263
	17S14W	286
	17S15W	151
	17S16W	129

Row ID	Sample_ID	XRF Lead Concentration (mg/kg)
Row 17S (cont'd)	17S17W	298
	17S18W	185
	17S19W	243
	17S20W	210
	17S21W	148
Row 18S	18S12W	121
	18S14W	146
	18S15W	90.5
	18S16W	122
	18S17W	153
	18S18W	81.9
	18S19W	117
	18S20W	70.5
	18S21W	93.5
	19S17W	148

Table A-3. Groundwater Monitoring Well Construction Details and Water-Level Measurements, RFAAP-NRU, Radford Army Ammunition Plant, Radford, Virginia.

Monitor Well	General Well Location	Northing[1] (ft)	Easting[1] (ft)	Ground Elevation (ft amsl)	Total Depth (ft bls)	Well Bottom (ft amsl)	TOC Elevation (ft amsl)	Depth to Water (ft btoc)	6/27/2007[2]		9/25/2008[3]	
									Depth to Water (ft btoc)	Water Level Elevation (ft amsl)	Depth to Water (ft btoc)	Water Level Elevation (ft amsl)
NBGMW01	Near the center of former burning area, in area with highest lead concentrations in soil	3569777.80	10851810.48	2115.79	98.0	2015.24	2118.34	94.20	93.58	2024.76	94.20	2024.14
NBGMW02	North of former burning area, near NRU installation boundary	3569872.47	10851804.11	2110.05	103.4	2004.08	2112.67	98.54	97.65	2015.02	98.54	2014.13

1 Coordinates in NAD 1983, US State Plane (Virginia South).
2 Depth to Water Measurements collected by Shaw.
3 Depth to Water Measurements collected by ARCADIS.
ft Feet.
ft bls Feet below land surface.
ft amsl Feet above mean sea level.
ft btoc Feet below top of casing.

Appendix B

Human Health Risk Assessment

Appendix B – Human Health Risk Assessment

Northern Burning Ground

Engineering Evaluation/Cost Analysis (EE/CA)

Radford Army Ammunition Plant,
Radford, Virginia

June 2009

Tables

Figures

Attachments

1. Human Health Risk Assessment

This screening-level human health risk assessment (HHRA) was developed in support of an Engineering Evaluation and Cost Analysis (EE/CA) for a response action at the Northern Burning Ground at the Radford Army Ammunition Plant (RFAAP). The Northern Burning Ground (NBG) is located within the New River Unit (NRU) near the town of Dublin, Virginia.

The EE/CA HHRA is not comprehensive and does not present all potential exposure pathways or potential health risks from cumulative site-related exposures usually evaluated in a Remedial Investigation/Feasibility Study (RI/FS). The quantitative analysis presented here is limited to the response action and evaluation of the reduction in exposure and of risk associated with potential future use.

The HHRA was conducted consistent with methods recommended by the U.S. Environmental Protection Agency (USEPA) and USEPA Region 3 (USEPA 1989; USEPA 2007a). The purpose of this risk assessment is to evaluate the potential current and future risks and potential hazards to human health associated with constituents detected in surface and subsurface soil at the NBG site.

The human health risk assessment is organized into the following subsections:

- Site Description – Provides the background for the human health risk assessment.
- Constituent Characterization – Summarizes the data used in the risk assessment, and presents the rationale for the selection of the constituents of potential concern (COPCs), methodology used for evaluating the analytical data, and the results of the data evaluation;
- Exposure Assessment – Discusses the evaluation of exposure settings, potentially exposed populations, complete or potentially complete exposure pathways; and estimates exposure point concentrations and human intake doses;
- Risk Characterization – Provides estimations of pathway-specific excess lifetime carcinogenic risks and noncarcinogenic hazards to human health using a screening level approach;
- Summary and Conclusions – Provides a summary of the HHRA and a general risk management strategy.

2. Site Description

This section summarizes the site location and history.

2.1 Site Location

The NBG is located in the northwest portion of the RFAAP-NRU, east of Gate 20, along Guard Road (Figure 1-2 of the main report). A dirt road follows the outer perimeter of the NBG and defines the outermost boundary of the site. A drainage ditch parallels Guard Road on the north side of the site. The approximate area of investigation at the NBG is 500 ft long by 300 ft wide.

The majority of the area identified as the NBG is heavily wooded, with the exception of a small area in the central portion of the site where burning operations are believed to have been performed. This central portion of the site has a grass and shrub groundcover and a few small trees. Little to no visible evidence of past burning activities is apparent. A site map depicting the layout of the NBG is presented in Figure 1-3 of the main report.

Although there is significant topographic relief across the RFAAP-NRU, the NBG is relatively level. Surface water runoff from the NBG flows toward the drainage ditch that runs parallel to the paved surface road on the northern boundary of the site.

2.2 Site History

The RFAAP-NRU was established in 1940, and was originally known as the New River Ordinance Works (NROW). The NROW was incorporated into the RFAAP in 1945. The RFAAP-NRU facility operated as a bag manufacturing and loading plant for artillery, cannon, and mortar projectiles during World War II. Although active manufacturing activities at the RFAAP-NRU were reported to have ceased in the 1940s after World War II, portions of the RFAAP-NRU are still utilized as storage facilities for operations at the MMA.

The NBG was temporarily utilized as a burning ground for the facility. Anecdotal evidence suggests that the burning operations may have been conducted to remove energetics from metal components used in the former manufacturing activities at the site. No buildings have existed at the NBG site; burning operations were conducted directly on the ground surface.

3. Constituent Characterization

The focus of this HHRA is the soil and sediment collected during soil sampling events in 1997, 1998, 1999, 2002, and 2004; and drainage ditch sediment sampling events in 2002 and 2004. The 2004 soil investigation included on-site screening of soils with X-Ray Fluorescence (XRF) in addition to laboratory analysis for metals (Shaw 2007). Soil and sediment sampling activities occurring prior to 2004 are summarized in the February 2004 Draft New River Unit Investigation Report: BDDT, BLA, IAA, NBG, RY & WBG (Shaw 2004).

Between 1997 and 2004, approximately 96 soil samples were collected at the NBG and submitted for laboratory analysis to delineate the extent of impacts associated with the former burning ground operations. The majority of these samples (47 surface soil samples and 45 subsurface soil samples) were collected within, or on the boundary of the area defined as the NBG. Four surface soil/sediment samples were also collected from the dry drainage ditch located to the north of the NBG along Guard Road. All of the soil data collected at the New Burn Area was used in the risk assessment. The sediment data collected from the drainage areas was combined with the samples designated as soil.

3.1 Data Evaluation

The data were evaluated as outlined below to identify the datasets to be used in the human health risk assessment.

3.1.1 Sample Type

The following criteria were employed to determine whether a particular sample result is usable for risk assessment purposes:

- All soil sample types were considered usable for the risk assessment regardless of date collected.

- Analytical results from soil samples collected from different depths at the same sampling location during the same sampling event were evaluated as independent samples.

- Analytical results from duplicate samples collected from the same sampling location during the same sampling event were generally considered usable for risk

assessment. During statistical analysis of the data, duplicate samples were treated as follows. Where a constituent was detected in both the original sample and the duplicate sample, the higher of the two results was used in the risk assessment. For sample locations where one sample result showed no detectable concentration and a duplicate sample showed a detected concentration, only the detected concentration was included in the dataset. If a constituent was not detected in either the original sample or the duplicate sample, then the lowest reporting limit from the two samples was used to estimate the concentration for that sample.

3.1.2 Evaluation of Data Qualifiers

The data were reviewed and those samples considered to be detected at either an estimated concentration or a concentration above the reporting limit was considered to be usable for this risk assessment.

The following criteria were employed to determine whether a particular sample result is usable for risk assessment purposes:

- Sample results rejected during data validation were not considered usable for risk assessment. These data, indicated by an "R" data qualifier, would have been eliminated from the dataset, although it was not necessary for this dataset.

Laboratory-qualified data with the following data qualifiers were retained within the dataset:

- J – concentration is estimated
- B – for organic chemicals, analyte was also detected in the blank, and for metals, analyte concentration is estimated
- K – estimated concentration is biased high (may overestimate concentration)
- L – estimated concentration is biased low (may underestimate concentration)
- U – the analyte was not detected at the reporting limit.

3.1.3 Evaluation of Vertical and Spatial Data Distribution

Site soil data are usually subdivided into "risk-assessment datasets" based on vertical and spatial distribution for the various exposure scenarios. For this risk assessment, all of the soil data, both surface and subsurface soil, were included in the screening level risk assessment. Additionally, samples designated as sediment were considered to be soil samples as the drainage ditches from which they were collected only have water in them following a precipitation event. Water is not present in the drainage ditches on a regular basis. None of these samples were collected following a rainfall event, and so the soil designated as sediment is not considered to be true sediment.

3.2 Selection of Constituents of Potential Concern

Data were evaluated for usability in risk assessment by evaluating the sample type, the data qualifiers, the detection limits for non-detect results, and the spatial and vertical distribution of the data. Upon completion of that evaluation, the risk assessment datasets identified were summarized. The data summaries include the number of samples, the number of detections, the frequency of detection, the minimum and maximum detected concentration, and the exposure point concentration (EPC).

The focus of this evaluation is on the current conditions at the site. Surface and subsurface soil and sediment data from the entire site are summarized in Table B-1. The objective of the constituents of potential concern (COPCs) evaluation is to identify the most toxic, persistent, and prevalent constituents at the site that are expected to contribute the majority of potential exposure and risk, consistent with USEPA (1989) guidance. COPCs were identified to focus the HHRA on those constituents present as a result of past activities at the site and to be of potential concern to human health. The maximum detected concentration of a constituent was compared to the USEPA Regional Screening Levels (RSLs; USEPA 2008).

RSLs based on non-cancer effects were conservatively adjusted by a factor of 10 to account for cumulative effects following USEPA (2007a) Region 3 guidance. Maximum concentrations in soil and sediment were compared to residential RSLs. Constituents present at concentrations exceeding the RSLs that were not essential nutrients were considered COPCs. The COPC selection is presented in Table B-2.

The COPCs for current soil and sediment are: 2,3,4,7,8-pentachlorodibenzofuran (2,3,4,7,8-PeCDF); 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF); octachlorodibenzodioxin (OCDD); benzo(a)anthracene; benzo(b)fluroanthene;

benzo(a)pyrene; dibenzo(a,h)anthracene; indeno(1,2,3-cd)pyrene; Aroclor 1254; tert-butylbenzene; d-limonene; antimony; aluminum; antimony; arsenic; cadmium; chromium; cobalt; copper; iron; lead; manganese; thallium; vanadium; and zinc.

Background screening levels (IT Corporation 2001) are included in Tables B-2 for the inorganic constituents for comparative purposes only. Manganese and thallium were detected at maximum concentrations above the screening levels but below background.

4. Exposure Assessment

Exposure pathways have been identified based on an evaluation of the site characterization information and the fate and transport properties of the constituents of interest. The exposure pathways evaluated identify likely points where human receptors may contact affected media under current or potential future conditions at the site. The principal pathways by which exposure could occur are identified and presented in this section.

An exposure pathway is defined by the following four elements: (1) a source and mechanism of constituent release to the environment; (2) an environmental transport medium for the released constituent; (3) a point of potential contact with the contaminated medium (the exposure point); and (4) an exposure route at the exposure point. The purpose of the exposure assessment is to estimate the ways a population may potentially be exposed to constituents at a site. This typically involves projecting concentrations along potential pathways between sources and receptors. The projection usually is accomplished using site-specific data and, when necessary, mathematical modeling. Exposure can occur only when the potential exists for a receptor to directly contact released constituents or when there is a mechanism for released constituents to be transported to a receptor. Without exposure there is no risk; therefore, the exposure assessment is a critical component of the risk assessment.

The NBG covers an area that is approximately 500 feet long by 300 feet wide. The majority of the area identified as the NBG is heavily wooded, with the exception of a small area in the central portion of the site where burning operations are believed to have been performed. This central portion of the site has a grass and shrub groundcover and a few small trees.

Currently, the area is not used and in the future, land use is not expected to change. It is possible that workers mowing the grass in one area of the site could contact impacted soil. The NBG is within the NRU which is part of the installation. Security at the installation includes strict security at the gates, guard towers, fences, etc. Thus, it is not likely that trespassers would enter the site. Nonetheless, as seen in Figure B-1, potential current receptors include site workers and trespassers.

In the future, it is possible that this area will be redeveloped. If this were to occur, then construction workers and residents could be exposed to constituents in the surface and subsurface soils. This is a purely hypothetical exposure scenario.

In this evaluation, an industrial site worker and a hypothetical future resident were evaluated for direct contact with combined surface and subsurface soil. The hypothetical future resident has a longer exposure duration and frequency than a potential trespasser or hypothetical future construction worker and is considered protective of these receptors. As a result, a potential trespasser and hypothetical future construction worker will not be further evaluated.

4.1 Exposure Point Concentration

The exposure point concentration (EPC) is the representative concentration of a constituent in an environmental medium that is potentially contacted by the receptor (USEPA 1989). The EPC is defined as "the arithmetic average of the concentration that is contacted over the exposure period" (USEPA 1989). To assure that the estimate of the arithmetic average is conservative and was not underestimated, the upper confidence limit on the mean (UCL) concentration was used as an estimate of the EPC (USEPA 1989; 2002a) for all constituents except lead. Calculation of UCLs was performed using the USEPA's ProUCL (Version 4.0; USEPA 2007b). The maximum concentration was retained as the EPC where the datasets were not of sufficient sample size and/or the frequency of detection was small, which precluded the estimation of the UCL via ProUCL4.0. It was recognized that this practice would result in risk estimates that are not representative of average conditions as stated by USEPA (2007b).

For lead, the EPC used was the arithmetic mean. This is the approach for evaluating lead that is recommended in USEPA guidance (1999).

EPCs were presented with the soil risk assessment dataset in Table B-1. The ProUCL output is included in Attachment A.

4.2 Exposure Assumptions

This screening level HHRA relies on the RSLs developed by the USEPA (2008) to evaluate exposure As such, it is also based on the assumptions and toxicity values that were used in developing those RSLs.

While the development of the RSLs themselves is not included in this evaluation, the exposure assumptions are provided to put the evaluation into context. Both site worker and resident exposure is evaluated in this HHRA. It is assumed that both potential receptors could contact surface and subsurface soil. The following are the exposure

assumptions used by USEPA (2008) to derive the RSLs used within the screening level risk assessment.

4.2.1 Site Worker

The outdoor worker is the potential receptor at the NBG. They may be exposed to site-related constituents by contact with soil through incidental ingestion, dermal contact and/or inhalation of particulates and vapors. The exposure assumptions used in deriving the RSLs for this receptor are:

- Adult body weight of 70 kilograms (kg);
- Exposure duration of 25 years;
- Exposure frequency of 250 days per year;
- Soil ingestion rate of 100 milligrams per day (mg/day);
- Skin surface area of 3,300 square centimeters (cm^2);
- Dermal adherence factor of 0.2 milligrams per square centimeter (mg/cm^2); and
- Exposure time of 8 hours per day.

4.2.2 Hypothetical Future Resident

If the NBG were redeveloped for residential uses, hypothetical future adult and child residents could be exposed to site-related constituents through contact with soil through incidental ingestion, dermal contact and/or inhalation of particulates and vapors. For noncarcinogenic COPCs, the RSLs were derived based on exposure of a young child while the RSLs for potential carcinogenic COPCs are based on an age-adjusted exposure. The exposure assumptions used to develop the noncancer RSLs for the child receptor are:

- Body weight of 15 kg for a young child;
- Exposure duration of 6 years;

- Exposure frequency of 350 days per year;
- Soil ingestion rate of 200 mg/day;
- Skin surface area of 2,800 cm^2;
- Dermal adherence factor of 0.2 mg/cm^2; and
- Exposure time of 24 hours per day.

The exposure assumptions used to develop the cancer-based RSLs for the combined adult and child receptor are:

- Resident soil, age-adjusted ingestion rate of 114 milligrams-year per kilogram-day (mg-year/kg-day);
- Resident soil age-adjusted dermal contact factor of 361 mg-year/kg-day;
- Exposure duration of 30 years; and
- Exposure frequency of 350 days per year.

5. Risk Characterization

Potential risks to human health are evaluated quantitatively by combining calculated exposure levels and toxicity data. A distinction is made between non-carcinogenic and carcinogenic endpoints, and two general criteria are used to describe the hazard quotient (HQ) for non-carcinogenic effects and excess lifetime cancer risk (ELCR) for constituents evaluated as human carcinogens. Risks and hazards were calculated for current site worker and hypothetical future residential exposures under current conditions.

5.1 Hazard Quotient for Noncancer Hazard

Exposure doses are averaged over the expected exposure period to evaluate non-carcinogenic effects. The HQ is the ratio of the estimated exposure dose and the non-cancer toxicity value. Thus, an HQ greater than 1 indicates that the estimated exposure level for that constituent exceeds the non-cancer toxicity value. This ratio does not provide the probability of an adverse effect. Although an HQ less than 1 indicates that health effects should not occur, an HQ that exceeds 1 does not imply that health effects will occur, but that health effects are potentially possible.

The sum of the HQs is the hazard index (HI). A limitation with the HI approach is that the assumption of dose additivity is applied to compounds that may induce different effects by different mechanisms of action. Consequently, the summing of HIs for a number of compounds that are not expected to induce the same type of effects or that do not act by the same mechanism may overestimate the potential for toxic effects. Consistent with USEPA risk assessment guidelines for chemical mixtures, in the event that the total HI for an exposure scenario exceeds 1, it is incumbent on a risk assessor to segregate HQs by target organ/critical effect (USEPA 1989). Therefore, if the calculated HI exceeds 1 as a consequence of summing several HQs for constituents not expected to induce the same type of effects or that do not act by the same mechanism, the HIs may be segregated by effect and mechanism of action to derive separate HIs for each target-organ/critical-effect group (USEPA 1989).

5.2 Excess Lifetime Cancer Risk

The ELCR is an estimate of the potential increased risk of cancer that results from lifetime exposure, at specified average daily dosages, to constituents detected in media at a site. Estimated doses or intakes for each constituent are averaged over the hypothesized lifetime of 70 years. It is assumed that a large dose received over a

short period is equivalent to a smaller dose received over a longer period, as long as the total doses are equal. The ELCR is calculated as the product of the exposure dose and the cancer toxicity value. The risk estimate is considered to be an upper-bound estimate; therefore, it is likely that the true risk is far less than that predicted by the model. The risk estimate is compared to USEPA's target risk range is from $1x10^{-4}$ to $1x10^{-6}$.

5.3 Receptor-Specific Excess Lifetime Risk and Hazard Evaluation

Screening level risk estimates were calculated using a ratio approach that is based on the USEPA RSLs and thus, by default, the USEPA exposure assumptions and toxicity values used by USEPA to derive those RSLs. Risk and hazard estimates derived for the site worker were based on USEPA's RSLs for industrial soil, and risk and hazard estimates derived for residents were based on USEPA's RSLs for residential exposure.

To estimate potential cancer risks associated with potentially carcinogenic COPCs, the following equation was used:

$$ELCR = \frac{EPC * TR}{cRSL}$$

Where:

ELCR = Estimated lifetime cancer risk based on current EPC (unitless)

EPC = The site- and COPC-specific exposure point concentration (mg/kg)

TR = Target risk of $1x10^{-6}$ (unitless)

cRSL = Regional Screening Level based on cancer risk (mg/kg)

To estimate potential noncancer hazards associated with the potentially noncarcinogenic COPCs, the following equation was used:

$$HI = \frac{EPC * THQ}{ncRSL}$$

Where:

HI = Estimated noncancer hazard index based on current EPC (unitless)

THQ = Target hazard quotient of 1 (unitless)

ncRSL = Regional Screening Level based on noncancer endpoint (mg/kg)

Constituent-specific ELCRs and HIs were summed to get a total ELCR and total HI for the receptor. Where the total HI exceeded one, target organ specific HI were calculated. Since several inorganic constituents were identified as COPCs, but had an EPC less than background, ELCRs and HIs excluding the background inorganics as COPCs, following USEPA (2002b) guidance, were also presented.

The preliminary risk evaluations for current conditions are presented in Tables B-3 and B-4 for the industrial and residential scenarios, respectively. The results of the preliminary risk evaluation are also summarized in Table B-5 and discussed by receptor below.

5.3.1 Site Workers

Industrial workers were assumed to contact surface and subsurface soil under current conditions. The industrial worker considered in this assessment was assumed to be an outdoor worker present at the site 250 days per year for 25 years. This type of exposure would be protective of a site worker or a utility worker. Exposure pathways included incidental soil ingestion, dermal contact with soil and inhalation of COPCs present in dust and vapors. The calculated ELCR for industrial work exposure to surface soil (1×10^{-5}) was within USEPA's target risk range, and the calculated HI was 1, equal to the benchmark of 1, as seen in Table B-3. Several of the detected inorganics were found at concentrations less than the background screening level. If the background inorganics are subtracted from the calculated ELCR and HI, the result is an ELCR of 7×10^{-6} and an HI of 1.

5.3.2 Residents

Hypothetical future residents were assumed to contact combined surface and subsurface soil. Exposure pathways included incidental soil ingestion, dermal contact with soil and inhalation of COCPs as vapors and adhered to dust. Exposure to soil could result in excess lifetime cancer risks of 9×10^{-5}. A number of the inorganics were found within background. Following USEPA (2002b) guidance, the risks associated with the exposure to arsenic were subtracted out, resulting in an ELCR of 5×10^{-5}, which

is within the target risk range. The calculated noncancer hazard 0f 15 was greater than the benchmark of 1. Following guidance, the hazard index was reevaluated looking at critical effects or target organs. The reevaluated HIs were at or below 1, as seen in Table B-4, for all of the effects except those related to chromium exposure. If the background inorganics are subtracted from the calculated ELCR and HI, the result is an ELCR of 6×10^{-5} and an HI of 13.

5.4 Exposure to Lead

Exposure to lead is evaluated differently than the other constituents. The residential RSL is based on an acceptable blood lead level rather than a comparison to the constituent's toxicity value(s). Therefore, while the screening assessment compared the RSLs to the exposure point concentration to evaluate risk, exposure to lead was evaluated slightly differently.

The residential soil RSL for lead is 400 mg/kg. The exposure point concentration under current conditions (Table B-1) is 4,324 mg/kg. This concentration is well above the residential soil RSL. Thus, it can be concluded that exposure to lead in surface and subsurface soil currently present at the NBG site could pose an unacceptable risk to hypothetical future residents under current conditions. USEPA Region 3 (2007a) also provided a screening level of 750 mg/kg for industrial exposure to lead in soil. Even if this concentration were used as a point of comparison, it can be concluded that site worker exposure to lead in soil under current conditions would result in an unacceptable risk.

6. Summary and Conclusions

The NBG screening-level HHRA evaluated exposure to soil under current/future industrial and future hypothetical residential land-uses. It assumed that individuals could contact both surface and subsurface soil.

Using the soil data currently found at the NBG, the potential risks for the industrial worker and resident were all within the USEPA target risk range ($1x10^{-4}$ to $1x10^{-6}$). The noncancer hazards were approximately equal to the benchmark of 1 for the site worker but were greater than 1 for the hypothetical future resident. The driver for the elevated HI was chromium. Exposure to lead was evaluated qualitatively. The exposure point concentration was compared to the residential and industrial soil screening levels of 400 mg/kg and 750 mg/kg, respectively. The exposure point concentration was well above both screening levels.

7. References

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Tables

Table B-1. Data Summary for Soil, Current Conditions
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent [a]	Frequency Detects / Total	Percent Detects	[b]	Range of Detects Minimum (mg/kg)	-	Maximum (mg/kg)	Exposure Point Concentration [c] (mg/kg)
Naphthalene	1 / 24	4 %	lo	0.0085	-	0.0085	8.50E-03 m
Phenanthrene	1 / 24	4 %	lo	0.15	-	0.15	1.50E-01 m
Pyrene	1 / 24	4 %	lo	0.5	-	0.5	5.00E-01 m
Polychlorinated Biphenyls							
Aroclor 1254	16 / 59	27 %	med	0.02	-	4.6	5.27E-01
Volatile Organic Compounds							
Acetone	2 / 37	5 %	lo	0.0030	-	0.12	1.20E-01 m
Benzene	1 / 46	2 %	lo	0.0010	-	0.0010	1.00E-03 m
2-Butanone	1 / 32	3 %	lo	0.011	-	0.011	1.10E-02 m
tert-Butylbenzene	1 / 38	3 %	lo	0.0030	-	0.0030	3.00E-03 m
Carbon Disulfide	2 / 43	5 %	lo	0.00044	-	0.00052	5.20E-04 m
Chlorobenzene	1 / 46	2 %	lo	0.0010	-	0.0010	1.00E-03 m
1,1-Dichloroethene	1 / 45	2 %	lo	0.0020	-	0.0020	2.00E-03 m
d-Limonene	1 / 17	6 %	lo	0.023	-	0.023	2.30E-02 m
Methylene Chloride	7 / 46	15 %	med	0.0020	-	0.0050	2.60E-03
Toluene	1 / 46	2 %	lo	0.0010	-	0.0010	1.00E-03 m
Trichloroethene	1 / 46	2 %	lo	0.0010	-	0.0010	1.00E-03 m
1,2,4-Trimethylbenzene	1 / 38	3 %	lo	0.0056	-	0.0056	5.60E-03 m
Semi-Volatile Organic Compounds							
Bis(2-ethylhexyl)phthalate	8 / 42	19 %	med	0.040	-	0.20	1.41E-01
Carbazole	1 / 40	3 %	lo	0.022	-	0.022	2.20E-02 m
Di-n-butylphthalate	8 / 41	20 %	med	0.040	-	0.090	9.00E-02 m
Diethylphthalate	6 / 40	15 %	lo	0.050	-	0.24	1.50E-01
Inorganics							
Aluminum	85 / 85	100 %	hi	4,670	-	59,500	2.31E+04
Antimony	44 / 83	53 %	hi	0.22	-	41.8	4.42E+00
Arsenic	84 / 85	99 %	hi	2.2	-	64.1	1.05E+01
Barium	85 / 85	100 %	hi	9.6	-	618	1.13E+02
Beryllium	72 / 85	85 %	hi	0.11	-	1.9	5.28E-01
Cadmium	45 / 84	54 %	hi	0.083	-	11.4	1.52E+00
Calcium	85 / 85	100 %	hi	27.1	-	129,000	2.55E+04
Chromium	85 / 85	100 %	hi	7.1	-	25,700	2.83E+03
Cobalt	85 / 85	100 %	hi	1.9	-	190	2.25E+01
Copper	85 / 85	100 %	hi	4.0	-	569	8.94E+01
Iron	85 / 85	100 %	hi	8,270	-	63,100	3.22E+04
Lead	85 / 85	100 %	hi	10	-	111,000	4.32E+03
Magnesium	85 / 85	100 %	hi	193	-	58,500	1.33E+04
Manganese	85 / 85	100 %	hi	19.5	-	926	2.94E+02
Mercury	65 / 83	78 %	hi	0.020	-	0.62	1.17E-01
Nickel	85 / 85	100 %	hi	3.2	-	39.6	1.32E+01
Potassium	85 / 85	100 %	hi	149	-	3,680	1.08E+03
Selenium	16 / 83	19 %	med	0.55	-	1.5	6.76E-01
Silver	10 / 83	12 %	lo	0.13	-	2.74	2.91E-01
Sodium	81 / 83	98 %	hi	7.5	-	2,020	1.83E+02
Thallium	35 / 85	41 %	med	0.10	-	1.5	3.05E-01
Vanadium	85 / 85	100 %	hi	14.9	-	127	5.96E+01
Zinc	85 / 85	100 %	hi	7.87	-	39,000	4.76E+03

[a] Detected constituents only are summarized here.

[b] The percent non-detects in each data set is indicated as low "*lo*" (15 percent or less), medium "*med*" (between 15 and 50 percent), or high "*hi*" (50 percent or more).

[c] The exposure point concentration (EPC) was set equal to the lower of the upper confidence limit on the mean (UCL) calculated by ProUCL 4.0 (USEPA 2007b) and the maximum concentration, except for lead. Where a UCL was not calculable, the maximum concentration (m) was used as the EPC. For lead, the arithmetic mean concentration was used.

[d] Data on groups of chemicals (e.g., Total HpCDDs) are not generally useful in the risk assessment process because available toxicity information used to estimate risk is most often restricted to individual compounds; therefore, "Total" constituents will not be further evaluated in this risk assessment.

mg/kg Milligrams per kilogram.

Table B-2. Selection of Constituents of Potential Concern in Soil, Current Conditions
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent		Maximum Concentration Current Conditions (mg/kg)	Screening Levels (mg/kg) [a] Residential Scenario cancer (cRSL)	noncancer (ncRSL)	Residential Scenario Screening Level [a] (mg/kg)	Background Level [b] (mg/kg)	Constituent of Potential Concern [c] Residential Scenario (Yes/no)	Rational
Dioxin/Furan Compounds								
1,2,3,4,6,7,8-HpCDD		0.0001025	0.00039	NA	0.00039	NA	no	BSL
1,2,3,4,6,7,8-HpCDF		0.00002183	0.00032	NA	0.00032	NA	no	BSL
1,2,3,4,7,8,9-HpCDF		0.00000071	0.00032	NA	0.00032	NA	no	BSL
1,2,3,4,7,8-HxCDD		0.00000118	0.000039	NA	0.000039	NA	no	BSL
1,2,3,4,7,8-HxCDF		0.00002445	0.000032	NA	0.000032	NA	no	BSL
1,2,3,6,7,8-HxCDD		0.00000237	0.000039	NA	0.000039	NA	no	BSL
1,2,3,6,7,8-HxCDF		0.0000096	0.000032	NA	0.000032	NA	no	BSL
1,2,3,7,8,9-HxCDD		0.0000030	0.000039	NA	0.000039	NA	no	BSL
1,2,3,7,8,9-HxCDF		0.00000179	0.000032	NA	0.000032	NA	no	BSL
1,2,3,7,8-PeCDD		0.00000058	0.0000039	NA	0.0000039	NA	no	BSL
1,2,3,7,8-PeCDF		0.00001225	0.00011	NA	0.00011	NA	no	BSL
2,3,4,6,7,8-HxCDF		0.00000294	0.000032	NA	0.000032	NA	no	BSL
2,3,4,7,8-PeCDF		0.0000169	0.000011	NA	0.000011	NA	**Yes**	**ASL**
2,3,7,8-TCDD		0.00000047	0.0000045	0.0000072	0.0000045	NA	no	BSL
2,3,7,8-TCDF		0.0001246	0.000032	NA	0.000032	NA	**Yes**	**ASL**
OCDD		0.01964	0.013	NA	0.013	NA	**Yes**	**ASL**
OCDF		0.00008762	0.011	NA	0.011	NA	no	BSL
Herbicides								
2,4-D		0.195	NA	69	69	NA	no	BSL
2,4-DB		0.0596	NA	49	49	NA	no	BSL
Dalapon		0.0814	NA	180	180	NA	no	BSL
Dicamba		0.00321	NA	180	180	NA	no	BSL
MCPP		3.3	NA	6.1	6.1	NA	no	BSL
2,4,5-T		0.00719	NA	61	61	NA	no	BSL
Organochlorine Pesticides								
4,4'-DDD		0.00933	2	NA	2	NA	no	BSL
4,4'-DDE		0.070	1.4	NA	1.4	NA	no	BSL
4,4'-DDT		0.24	1.7	3.6	1.7	NA	no	BSL
Dieldrin		0.00185	0.03	0.31	0.03	NA	no	BSL
Endosulfan II	[d]	0.00176	NA	37	37	NA	no	BSL
Endrin Aldehyde	[e]	0.00645	NA	1.8	1.8	NA	no	BSL
Polycyclic Aromatic Hydrocarbons								
Acenaphthene		0.0086	NA	340	340	NA	no	BSL
Acenaphthylene	[f]	0.083	NA	340	340	NA	no	BSL
Anthracene		0.032	NA	1,700	1,700	NA	no	BSL
Benzo(a)anthracene		0.49	0.15	NA	0.15	NA	**Yes**	**ASL**
Benzo(a)pyrene		0.53	0.015	NA	0.015	NA	**Yes**	**ASL**
Benzo(b)fluoranthene		0.73	0.15	NA	0.15	NA	**Yes**	**ASL**
Benzo(g,h,i)perylene	[g]	0.37	NA	170	170	NA	no	BSL
Benzo(k)fluoranthene		0.24	1.5	NA	1.5	NA	no	BSL
Chrysene		0.37	15	NA	15	NA	no	BSL
Dibenzo(a,h)anthracene		0.084	0.015	NA	0.015	NA	**Yes**	**ASL**
Fluoranthene		0.53	NA	230	230	NA	no	BSL
Fluorene		0.010	NA	230	230	NA	no	BSL
Indeno(1,2,3-cd)pyrene		0.40	0.15	NA	0.15	NA	**Yes**	**ASL**
2-Methylnaphthalene		0.0037	NA	31	31	NA	no	BSL
Naphthalene		0.0085	NA	15	15	NA	no	BSL
Phenanthrene	[h]	0.15	NA	1,700	1,700	NA	no	BSL
Pyrene		0.50	NA	170	170	NA	no	BSL
Polychlorinated Biphenyls								
Aroclor 1254		4.6	0.22	0.11	0.11	NA	**Yes**	**ASL**

Footnotes appear on last page.

Table B-2. Selection of Constituents of Potential Concern in Soil, Current Conditions
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent		Maximum Concentration Current Conditions (mg/kg)	Screening Levels (mg/kg) [a] Residential Scenario cancer (cRSL)	Residential Scenario noncancer (ncRSL)	Residential Scenario Screening Level [a] (mg/kg)	Background Level [b] (mg/kg)	Constituent of Potential Concern [c] Residential Scenario (Yes/no)	Rational
Volatile Organic Compounds								
Acetone		0.12	NA	6,100	6,100	NA	no	BSL
Benzene		0.0010	1.1	9	1.1	NA	no	BSL
2-Butanone		0.011	NA	2,800	2,800	NA	no	BSL
tert-Butylbenzene		0.0030	NA	NA	NA	NA	**Yes**	**NSL**
Carbon disulfide		0.00052	NA	67	67	NA	no	BSL
Chlorobenzene		0.0010	NA	31	31	NA	no	BSL
1,1-Dichloroethene		0.0020	NA	25	25	NA	no	BSL
d-Limonene		0.023	NA	NA	NA	NA	**Yes**	**NSL**
Methylene Chloride		0.0050	11	170	11	NA	no	BSL
Toluene		0.0010	NA	500	500	NA	no	BSL
Trichloroethene		0.0010	2.8	150	2.8	NA	no	BSL
1,2,4-Trimethylbenzene		0.0056	NA	6.7	6.7	NA	no	BSL
Semi-Volatile Organic Compounds								
Bis(2-ethylhexyl)phthalate		0.20	35	120	35	NA	no	BSL
Carbazole		0.022	24	NA	24	NA	no	BSL
Di-n-butylphthalate		0.09	NA	610	610	NA	no	BSL
Diethylphthalate		0.24	NA	4,900	4,900	NA	no	BSL
Inorganics								
Aluminum		59,500	NA	7,700	7,700	40,041	**Yes**	**ASL**
Antimony		41.8	NA	3.1	3.1	NA	**Yes**	**ASL**
Arsenic		64.1	0.39	2.2	0.39	15.8	**Yes**	**ASL**
Barium		618	NA	1,500	1,500	209	no	BSL
Beryllium		1.9	1400	16	16	1.02	no	BSL
Cadmium		11.4	1800	7	7	0.69	**Yes**	**ASL**
Calcium		129,000	NA	NA	NA	NA	no	EN
Chromium	[i]	25,700	NA	23	23	65.3	**Yes**	**ASL**
Cobalt		190	NA	NA	NA	72.3	**Yes**	**NSL**
Copper		569	NA	310	310	53.5	**Yes**	**ASL**
Iron		63,100	NA	5,500	5,500	50,962	**Yes**	**ASL**
Lead		111,000	NA	NA	400	26.8	**Yes**	**ASL**
Magnesium		58,500	NA	NA	NA	NA	no	EN
Manganese		926	NA	180	180	2,543	**Yes**	**ASL**
Mercury		0.62	NA	0.67	0.67	0.13	no	BSL
Nickel		39.6	NA	160	160	62.8	no	BSL
Potassium		3,680	NA	NA	NA	NA	no	EN
Selenium		1.5	NA	39	39	NA	no	BSL
Silver		2.74	NA	39	39	NA	no	BSL
Sodium		2,020	NA	NA	NA	NA	no	EN
Thallium		1.5	NA	0.51	0.51	2.11	**Yes**	**ASL**
Vanadium	[j]	127	NA	39	39	108	**Yes**	**ASL**
Zinc		39,000	NA	2,300	2,300	202	**Yes**	**ASL**

[a] USEPA (2008) Regional Screening Level (RSL) for residential soil based on cancer risk of 1E-06 or noncancer hazard of 0.1. The lower of the cancer and the adjusted non-cancer RSL was used as the screening level.

[b] Facility-Wide Background Point Estimate taken from Facility-Wide Background Study Report (IT Corporation 2001).

[c] Constituent with maximum concentration exceeding the screening level and those with no screening level were considered COPCs unless they were essential human nutrients.

[d] Endosulfan used as a surrogate for the RSL value.

[e] Endrin used as a surrogate for the RSL value.

[f] Acenaphthene used as a surrogate for the RSL value.

[g] Pyrene used as a surrogate for the RSL value.

[h] Anthracene used as a surrogate for the RSL value.

[i] Chromium VI particulates used as a surrogate for the RSL value.

[j] Vanadium and compounds used as a surrogate for the RSL value.

ASL Above screening level.
BSL Below screening level.
EN Essential nutrient.
mg/kg Milligrams per kilogram.
NA Not available.
NSL No screening level available.

Table B-3. Preliminary Risk and Hazard Estimates for a Site Worker Exposed to Soil, Current Conditions
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent		COPC? (Yes/no)	Exposure Point Concentration (mg/kg)	Screening Level (mg/kg) [a] cancer (cRSL)	Screening Level (mg/kg) [a] noncancer (ncRSL)	Preliminary Hazards and Risks [b] Carcinogenic Risk	Preliminary Hazards and Risks [b] Non-carcinogenic Hazard	Target Site/Critical Effect Oral	Target Site/Critical Effect Inhalation
Dioxin/Furan Compounds									
2,3,4,7,8-PeCDF		Yes	2.97E-06	3.80E-05	NA	7.82E-08 <1%	–	NA	NA
2,3,7,8-TCDF		Yes	1.99E-05	1.10E-04	NA	1.81E-07 1%	–	NA	NA
OCDD		Yes	6.90E-03	5.30E-02	NA	1.30E-07 <1%	–	NA	NA
Polycyclic Aromatic Hydrocarbons									
Benzo(a)anthracene		Yes	4.90E-01 m	2.10E+00	NA	2.33E-07 2%	–	NR	NA
Benzo(a)pyrene		Yes	5.30E-01 m	2.10E-01	NA	2.52E-06 19%	–	kidney	NA
Benzo(b)fluoranthene		Yes	7.30E-01 m	2.10E+00	NA	3.48E-07 3%	–	liver, kidney, blood	NA
Dibenzo(a,h)anthracene		Yes	8.40E-02 m	2.10E-01	NA	4.00E-07 3%	–	NA	NA
Indeno(1,2,3-cd)pyrene		Yes	4.00E-01 m	2.10E+00	NA	1.90E-07 1%	–	kidney	NA
Polychlorinated Biphenyls									
Aroclor 1254		Yes	5.27E-01	7.40E-01	1.10E+01	7.12E-07 5%	4.79E-02 3%	eye, nails, immune system	NA
Volatile Organic Compounds									
tert-Butylbenzene		Yes	3.00E-03 m	NA	NA	–	–	NA	NA
d-Limonene		Yes	2.30E-02 m	NA	NA	–	–	NA	NA
Inorganics									
Aluminum		Yes	2.31E+04	NA	7.70E+04	–	2.99E-01 21%	developmental NS	NA
Antimony		Yes	4.42E+00	NA	4.10E+02	–	1.08E-02 <1%	WB, blood	NA
Arsenic		Yes	1.05E+01	1.60E+00	2.60E+02	6.53E-06 49%	4.02E-02 3%	skin, vascular	NA
Cadmium		Yes	1.52E+00	9.30E+03	8.10E+02	1.64E-10 <1%	1.88E-03 <1%	kidney	NA
Chromium	[c]	Yes	2.83E+03	1.40E+03	3.10E+03	2.02E-06 15%	9.12E-01 65%	NR	lung
Cobalt	[d]	Yes	2.25E+01	NA	2.05E+03	–	1.10E-02 <1%	skin	NA
Copper		Yes	8.94E+01	NA	4.10E+04	–	2.18E-03 <1%	GI	NA
Iron		Yes	3.22E+04	NA	7.20E+05	–	4.47E-02 3%	blood, liver, GI	NA
Lead		Yes	4.32E+03	NA	NA	–	–	CNS	CNS
Manganese		Yes	2.94E+02	NA	2.30E+04	–	1.28E-02 <1%	CNS	CNS
Thallium		Yes	3.05E-01	NA	6.60E+01	–	4.62E-03 <1%	liver, blood, hair	NA
Vanadium		Yes	5.96E+01	NA	7.20E+03	–	8.28E-03 <1%	liver	NA
Zinc		Yes	4.76E+03	NA	3.10E+05	–	1.53E-02 1%	blood	NA
Total hazard and risk						**1E-05**	**1.4**		
Total risk minus background metals: aluminum, arsenic, cobalt, iron, manganese, thallium, and vanadium [e]						**7E-06**	**0.99**		

[a] USEPA (2008) Regional Screening Level (RSL) for an IndustrialScenario.

[b] Cancer risk = concentration x 1 x10^{-6} / cRSL; Noncancer hazard = concentration x 1 / ncRSL.

[c] Chromium VI particulates used as a surrogate for the RSL value.

[d] Cobalt screening value obtained from the Virginia Voluntary Remediation Program Tier III screening table (http://www.deq.virginia.gov/vrprisk/raguide.html).

[e] Exposure point concentrations are less than the post-wide screening level.

–	Not applicable.	COPC	Constituent of Potential Concern.	m	EPC is based on maximum concentration	NA	Not available.
CNS	Central nervous system.	GI	Gastrointestinal tract.	mg/kg	Milligrams per kilogram.	NR	None reported.

Table B-4. Preliminary Risk and Hazard Estimates for a Hypothetical Future Resident Receptor Exposed to Soil, Current Conditions
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent		COPC? (Yes/no)	Exposure Point Concentration (mg/kg)	Screening Level (mg/kg) [a] cancer (cRSL)	Screening Level (mg/kg) [a] noncancer (ncRSL)	Preliminary Hazards and Risks [b] Carcinogenic Risk		Preliminary Hazards and Risks [b] Non-carcinogenic Hazard		Target Site/Critical Effect Oral	Target Site/Critical Effect Inhalation
Dioxin/Furan Compounds											
2,3,4,7,8-PeCDF		Yes	2.97E-06	1.10E-05	NA	2.70E-07	<1%	–		NA	NA
2,3,7,8-TCDF		Yes	1.99E-05	3.20E-05	NA	6.22E-07	<1%	–		NA	NA
OCDD		Yes	6.90E-03	1.30E-02	NA	5.31E-07	<1%	–		NA	NA
Polycyclic Aromatic Hydrocarbons											
Benzo(a)anthracene		Yes	4.90E-01 m	1.50E-01	NA	3.27E-06	4%	–		NR	NA
Benzo(a)pyrene		Yes	5.30E-01 m	1.50E-02	NA	3.53E-05	38%	–		kidney	NA
Benzo(b)fluoranthene		Yes	7.30E-01 m	1.50E-01	NA	4.87E-06	5%	–		liver, kidney, blood	NA
Dibenzo(a,h)anthracene		Yes	8.40E-02 m	1.50E-02	NA	5.60E-06	6%	–		NA	NA
Indeno(1,2,3-cd)pyrene		Yes	4.00E-01 m	1.50E-01	NA	2.67E-06	3%	–		kidney	NA
Polychlorinated Biphenyls											
Aroclor 1254		Yes	5.27E-01	2.20E-01	1.10E+00	2.40E-06	3%	4.79E-01	3%	eye, nails, immune system	NA
Volatile Organic Compounds											
tert-Butylbenzene		Yes	3.00E-03 m	NA	NA	–		–		NA	NA
d-Limonene		Yes	2.30E-02 m	NA	NA	–		–		NA	NA
Inorganics											
Aluminum		Yes	2.31E+04	NA	7.70E+04	–		2.99E-01	2%	developmental NS	NA
Antimony		Yes	4.42E+00	NA	3.10E+01	–		1.43E-01	<1%	WB, blood	NA
Arsenic		Yes	1.05E+01	3.90E-01	2.20E+01	2.68E-05	29%	4.75E-01	3%	skin, vascular	NA
Cadmium		Yes	1.52E+00	1.80E+03	7.00E+01	8.46E-10	<1%	2.18E-02	<1%	kidney	NA
Chromium	[c]	Yes	2.83E+03	2.80E+02	2.30E+02	1.01E-05	11%	1.23E+01	82%	NR	lung
Cobalt	[d]	Yes	2.25E+01	NA	1.60E+02	–		1.41E-01	<1%	skin	NA
Copper		Yes	8.94E+01	NA	3.10E+03	–		2.88E-02	<1%	GI	NA
Iron		Yes	3.22E+04	NA	5.50E+04	–		5.85E-01	4%	blood, liver, GI	NA
Lead		Yes	4.32E+03	NA	NA	–		–		CNS	CNS
Manganese		Yes	2.94E+02	NA	1.80E+03	–		1.63E-01	1%	CNS	CNS
Thallium		Yes	3.05E-01	NA	5.10E+00	–		5.98E-02	<1%	liver, blood, hair	NA
Vanadium		Yes	5.96E+01	NA	5.50E+02	–		1.08E-01	<1%	liver	NA
Zinc		Yes	4.76E+03	NA	2.30E+04	–		2.07E-01	1%	blood	NA
Total hazard and risk						**9E-05**		**15**			
Total risk minus background metals [e]						**6E-05**		**13**	**		

** Risks segregated by critical/target effect:

HI (eye) =	0.5	HI (kidney) =	0.02	HI (developmental NS) =	0.3	HI (hair) =	0.06
HI (CNS) =	0.2	HI (GI) =	0.6	HI (immune system) =	0.5	HI (vascular) =	0.5
HI (blood) =	1	HI (liver) =	0.8	HI (nails) =	0.5	HI (lung) =	12
		HI (whole body) =	0.1	HI (skin) =	0.6	HI (NA, NR) =	15

Table B-4. Preliminary Risk and Hazard Estimates for a Hypothetical Future Resident Receptor Exposed to Soil, Current Conditions
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

[a] USEPA (2008) Regional Screening Level (RSL) for a Residential Scenario.
[b] Cancer risk = concentration x 1 x10^{-6} / cRSL; Noncancer hazard = concentration x 1 / ncRSL.
[c] Chromium VI particulates used as a surrogate for the RSL value.
[d] Cobalt screening value obtained from the Virginia Voluntary Remediation Program Tier 2 screening table (http://www.deq.virginia.gov/vrprisk/raguide.html).
[e] Exposure point concentrations for aluminum, arsenic, cobalt, iron, manganese, thallium, and vanadium are less than the post-wide screening level.

–	Not applicable.	GI	Gastrointestinal tract.	NA	Not available.
CNS	Central nervous system.	m	EPC is based on maximum concentration	NR	None reported.
COPC	Constituent of Potential Concern.	mg/kg	Milligrams per kilogram.	NS	Nervous system.

Table B-5. Summary of Calculated Risks and Hazards, Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

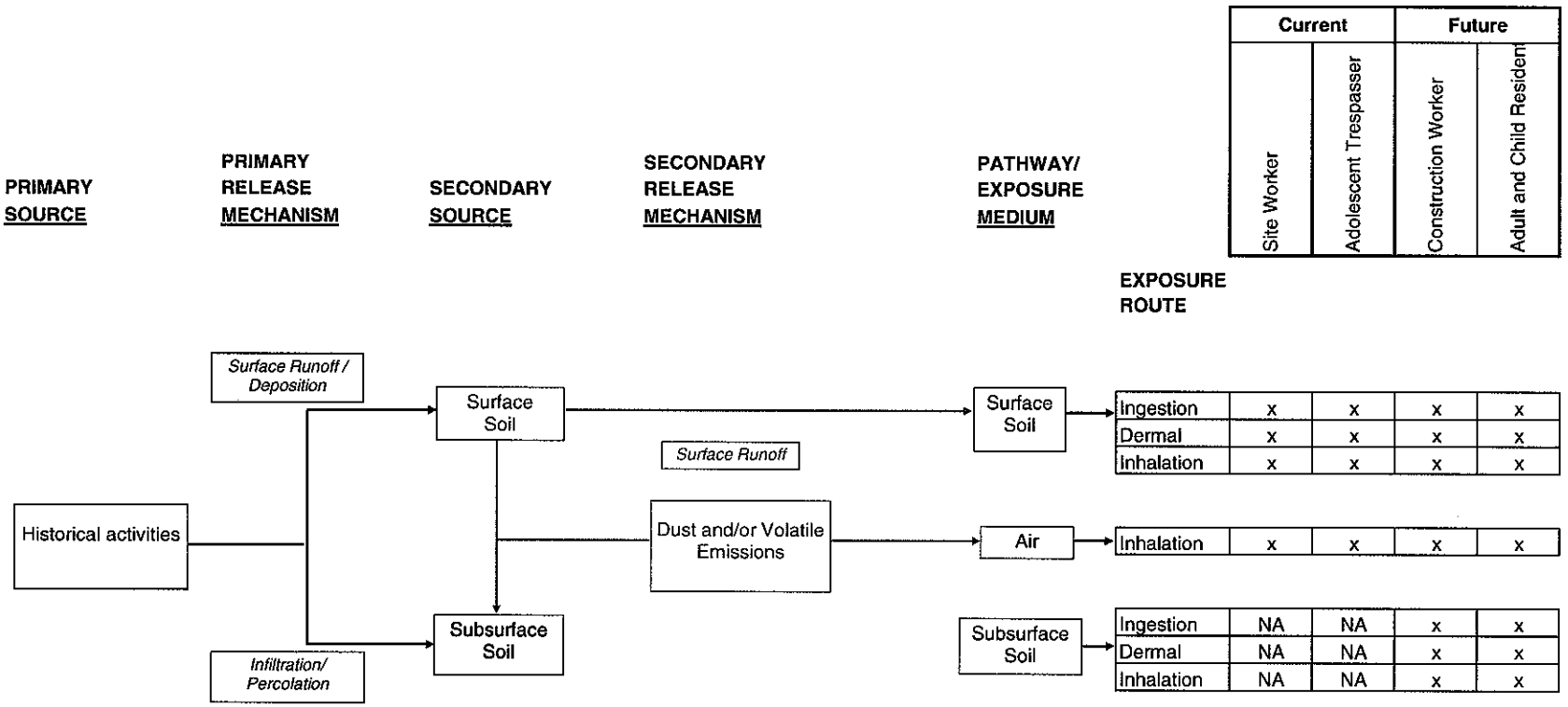
Scenario / Receptor	Calculation Table	Total Excess Lifetime Cancer Risk	Total Non-Cancer Hazard	
Current Conditions				
Site Worker	Table B-5	1E-05	1	
Risks without background metals	Table B-5	7E-06	1	
Hypothetical Future Resident	Table B-6	9E-05	15	
Risks without background metals	Table B-6	6E-05	13	**

** Risks segregated by critical/target effect:

HI (eye) =	0.5	HI (liver) =	0.8	HI (skin) =	0.6
HI (CNS) =	0.2	HI (whole body) =	0.1	HI (hair) =	0.06
HI (blood) =	1	HI (immune system) =	0.5	HI (vascular) =	0.5
HI (GI) =	0.6	HI (nails) =	0.5	HI (lung) =	12
		HI (developmental NS) =	0.0	HI (NA, NR) =	15

CNS Central nervous system.
GI Gastrointestinal tract.
HI Hazard index.
NA Not available.
NR None reported.
NS Nervous system.

Figures



NA Pathway not applicable.
x Potential pathway.

ARCADIS

Conceptual Site Model for Potential Human Health Receptors
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant
Radford, Virginia

Figure B-1

Attachment A

Exposure Point Concentrations

ATTACHMENT A: HUMAN HEALTH RISK ASSESSMENT EXPOSURE POINT CONCENTRATION CALCULATIONS FOR CURRENT CONDITIONS
NORTHERN BURNING GROUND, NEW RIVER UNIT, RADFORD ARMY AMMUNITION PLANT, RADFORD, VIRGINIA

Constituent	Distribution for UCL Selection	Total Sample Size	Percent Non-Detects	Frequency of Detect	SDp of ln Detected	Gamma K star (bias corrected)	Selected UCL Method	Selected UCL Value	Number of Detects	Number of Non Detects	Minimum Detected	Maximum Detected	Mean Detected	Standard Deviation of ln Detected	KM Mean	KM Standard Deviation	Minimum Non-Detect	Maximum Non-Detect	Goodness of Fit Test Result	Number of Potential UCLs	Potential UCL(s) to Use	Potential UCL Value
[redacted]	Gamma	23	0%	100.00%	1.25284272	0.862	Use 95% Approximate Gamma UCL	5.2E-05	23	0	0	0.000103	3.44E-05	1.281	NA		NA	NA	Data appear Gamma Distributed at 5% Significance Level	1	Use 95% Approximate Gamma UCL	5.1964E-05
[redacted]	Nonparametric	58	72.41%	27.59%	1.64698617	0.488	95% KM (t) UCL	0.527	16	42	0.02	4.6	1.112	1.701	0.321	0.907	0.03	0.048	Data Follow Appr. Gamma Distribution at 5% Significance Level	1	95% KM (t) UCL	0.527
[redacted]	Nonparametric	27	70.37%	29.63%	0.55844236	2.217	95% KM (Percentile Bootstrap) UCL	0.141	8	19	0.04	0.2	0.104	0.597	0.104	0.0568	0.36	0.47	Data appear Normal at 5% Significance Level	2 (RPD = 0.7	95% KM (t) UCL 95% KM (Percentile Bootstrap) UCL	0.14 0.141
[redacted]	Lognormal	23	0%	100.00%	0.98095335	0.981	Use 95% Chebyshev (MVUE) UCL	0.0069	23	0	0.000412	0.0196	0.00357	1.003	NA		NA	NA	Data appear Lognormal at 5% Significance Level	1	Use 95% Chebyshev (MVUE) UCL	0.0069
[redacted]	Nonparametric	23	30.43%	69.57%	1.42332138	0.515	97.5% KM (Chebyshev) UCL	3.51E-05	16	7	0	8.76E-05	1.33E-05	1.47	0	1.8971E-05	0	0	Data do not follow a Discernable Distribution (0.05)	1	97.5% KM (Chebyshev) UCL	3.5115E-05
[redacted]		23	78.26%	21.74%	2.12068687	0.306		SEE RPD	5	18	0	0.000125	3.93E-05	2.371	0	2.7677E-05	0	0	Data appear Normal at 5% Significance Level	2 (RPD = 32.	95% KM (t) UCL 95% KM (Percentile Bootstrap) UCL	0.00001991 8 0.00002765 9
[redacted]	Gamma	85	0%	100.00%	0.52389083	3.772	Use 95% Approximate Gamma UCL	23059	85	0	4670	59500	20983	0.527	NA		NA	NA	Data appear Gamma Distributed at 5% Significance Level	1	Use 95% Approximate Gamma UCL	23059
[redacted]	Gamma	85	0%	100.00%	0.48611502	4.284	Use 95% Approximate Gamma UCL	32190	85	0	8270	63100	29467	0.489	NA		NA	NA	Data Follow Appr. Gamma Distribution at 5% Significance Level	1	Use 95% Approximate Gamma UCL	32190
[redacted]	Nonparametric	85	0%	100.00%	2.32818277	0.197	Use 99% Chebyshev (Mean, Sd) UCL	22868	85	0	10	111000	4324	2.342	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	-	Arithmetic mean	4324
[redacted]	Nonparametric	85	0%	100.00%	1.49214447	0.481	Use 97.5% Chebyshev (Mean, Sd) UCL	13250	85	0	193	56500	5818	1.501	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 97.5% Chebyshev (Mean, Sd) UCL	13250
[redacted]	Lognormal	85	0%	100.00%	0.91556632	1.409	Use 95% H-UCL	293.6	85	0	19.5	926	226.6	0.921	NA		NA	NA	Data appear Lognormal at 5% Significance Level	1	Use 95% H-UCL	293.6
[redacted]	Nonparametric	83	21.69%	78.31%	0.81069103	1.405	95% KM (BCA) UCL	0.117	65	18	0.02	0.62	0.108	0.817	0.0953	0.106	0.05	0.15	Data do not follow a Discernable Distribution (0.05)	1	95% KM (BCA) UCL	0.117
[redacted]	Gamma	85	0%	100.00%	0.51394983	3.884	Use 95% Approximate Gamma UCL	13.19	85	0	3.2	39.6	12.02	0.517	NA		NA	NA	Data appear Gamma Distributed at 5% Significance Level	1	Use 95% Approximate Gamma UCL	13.19
[redacted]	Lognormal	85	0%	100.00%	0.62131265	2.607	Use 95% H-UCL	1080	85	0	149	3680	948.6	0.625	NA		NA	NA	Data appear Lognormal at 5% Significance Level	1	Use 95% H-UCL	1080
[redacted]	Nonparametric	83	87.95%	12.05%	0.8405334	1.159	95% KM (t) UCL	0.291	10	73	0.13	2.74	0.79	0.886	0.223	0.34	0.11	1.4	Data appear Gamma Distributed at 5% Significance Level	1	95% KM (t) UCL	0.291
[redacted]	Nonparametric	83	2.41%	97.59%	0.9828761	1.036	95% KM (BCA) UCL	183	81	2	7.5	2020	133.3	0.989	132.2	239.9	141	560	Data do not follow a Discernable Distribution (0.05)	1	95% KM (BCA) UCL	183
[redacted]	Nonparametric	85	58.82%	41.18%	0.7056973	1.671	95% KM (% Bootstrap) UCL	0.305	35	50	0.1	1.5	0.35	0.716	0.258	0.239	0.22	17.2	Data do not follow a Discernable Distribution (0.05)	2 (RPD = 0.3	95% KM (t) UCL 95% KM (% Bootstrap) UCL	0.304 0.305
[redacted]	Nonparametric	83	46.99%	53.01%	1.13487957	0.505	95% KM (Chebyshev) UCL	4.421	44	39	0.22	41.8	2.79	1.148	1.657	5.708	0.28	5.7	Data do not follow a Discernable Distribution (0.05)	1	95% KM (Chebyshev) UCL	4.421
[redacted]	Nonparametric	85	1.18%	98.82%	0.59741191	2.458	95% KM (BCA) UCL	10.45	84	1	2.2	64.1	8.932	0.601	8.883	7.989	6.6	6.6	Data appear Lognormal at 5% Significance Level	1	95% KM (BCA) UCL	10.45
[redacted]	Nonparametric	85	0%	100.00%	0.8360383	1.17	Use 95% Chebyshev (Mean, Sd) UCL	112.6	85	0	9.6	618	65.78	0.841	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 95% Chebyshev (Mean, Sd) UCL	112.6
[redacted]	Nonparametric	85	15.29%	84.71%	0.39820554	6.099	95% KM (BCA) UCL	0.528	72	13	0.11	1.9	0.502	0.401	0.478	0.232	0.11	0.69	Data appear Lognormal at 5% Significance Level	1	95% KM (BCA) UCL	0.528
[redacted]	Nonparametric	84	46.43%	53.57%	1.12528452	0.684	95% KM (Chebyshev) UCL	1.523	45	39	0.083	11.4	1.17	1.138	0.665	1.783	0.029	0.14	Data do not follow a Discernable Distribution (0.05)	1	95% KM (Chebyshev) UCL	1.523
[redacted]	Nonparametric	85	0%	100.00%	1.49214447	0.284	Use 97.5% Chebyshev (Mean, Sd) UCL	2827	85	0	7.1	25700	678.7	1.501	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 97.5% Chebyshev (Mean, Sd) UCL	2827
[redacted]	Nonparametric	85	0%	100.00%	0.83703241	0.991	Use 95% Chebyshev (Mean, Sd) UCL	22.48	85	0	1.9	190	11.33	0.842	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 95% Chebyshev (Mean, Sd) UCL	22.48
[redacted]	Nonparametric	85	0%	100.00%	0.99012384	0.775	Use 95% Chebyshev (Mean, Sd) UCL	89.41	85	0	4	569	43.86	0.996	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 95% Chebyshev (Mean, Sd) UCL	89.41
[redacted]	Lognormal	85	0%	100.00%	0.47120352	4.449	or 95% H-UCL	59.61	85	0	14.9	127	54.26	0.474	NA		NA	NA	Data appear Lognormal at 5% Significance Level	3 (RPD = 0.8	Use 95% Student's-t UCL or 95% Modified-t UCL or 95% H-UCL	59.1 59.16 59.61
[redacted]	Nonparametric	85	0%	100.00%	1.95638928	0.268	Use 97.5% Chebyshev (Mean, Sd) UCL	4756	85	0	7.87	39000	1346	1.968	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 97.5% Chebyshev (Mean, Sd) UCL	4756
[redacted]	Nonparametric	85	0%	100.00%	1.85101465	0.374	Use 97.5% Chebyshev (Mean, Sd) UCL	25549	85	0	27.1	129000	10550	1.862	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 97.5% Chebyshev (Mean, Sd) UCL	25549
[redacted]		31	77.42%	22.58%	0.31014973	6.105		SEE RPD	7	24	0.002	0.005	0.00314	0.335	0.00233	0.00073765	0.001	0.0067	Data appear Normal at 5% Significance Level	2 (RPD = 19	95% KM (t) UCL 95% KM (Percentile Bootstrap) UCL	0.0026 0.00317
[redacted]	Nonparametric	83	80.72%	19.28%	0.36986991	6.078	95% KM (t) UCL	0.676	16	67	0.55	1.5	0.929	0.382	0.633	0.217	0.47	1.4	Data Follow Appr. Gamma Distribution at 5% Significance Level	1	95% KM (t) UCL	0.676
[redacted]	Nonparametric	25	76.00%	24.00%	0.52855227	1.851	95% KM (Percentile Bootstrap) UCL	0.15	6	19	0.05	0.24	0.108	0.579	0.105	0.0616	0.21	0.45	Data appear Normal at 5% Significance Level	2 (RPD = 0.6	95% KM (t) UCL 95% KM (Percentile Bootstrap) UCL	0.149 0.15
[redacted]	Gamma	85	21.69%	78.31%	0.81069103	3.772	Use 95% Approximate Gamma UCL	23059	65	18	0.02	0.62	0.108	0.817	0.0953	0.106	0.05	0.15	Data appear Gamma Distributed at 5% Significance Level	1	Use 95% Approximate Gamma UCL	23059
[redacted]		23	78.26%	21.74%	1.30765255	0.515		SEE RPD	5	18	0.00009	0.00294	0.00141	1.462	0.0004	0.00076752	0.00004	0.00177	Data appear Normal at 5% Significance Level	2 (RPD = 66.	95% KM (t) UCL 95% KM (Percentile Bootstrap) UCL	0.00000071 304 0.00000142
[redacted]	Nonparametric	23	39.13%	60.87%	1.80775883	0.467	95% KM (BCA) UCL	5.01E-06	14	9	0.00012	0.0218	0.00482	1.876	0.00299	0.00526	0.00009	0.00114	Data appear Gamma Distributed at 5% Significance Level	1	95% KM (BCA) UCL	0.00000501
[redacted]	Nonparametric	23	78.26%	21.74%	1.6743677	0.357	95% KM (t) UCL	5.16E-06	5	18	0.00047	0.0245	0.0101	1.872	0.00256	0.00648	0.00003	0.00156	Data appear Gamma Distributed at 5% Significance Level	1	95% KM (t) UCL	0.00000516
[redacted]		23	78.26%	21.74%	1.76291599	0.332		SEE RPD	5	18	0.00024	0.0169	0.00565	1.971	0.00143	0.00386	0.00003	0.00116	Data appear Normal at 5% Significance Level	2 (RPD = 18.	95% KM (t) UCL 95% KM (Percentile Bootstrap) UCL	0.00000297 0.00000356
[redacted]		23	78.26%	21.74%	1.8684584	0.315		SEE RPD	5	18	0.00016	0.0123	0.00401	2.089	0.001	0.00279	0.00003	0.00111	Data appear Normal at 5% Significance Level	2 (RPD = 20.	95% KM (t) UCL 95% KM (Percentile Bootstrap) UCL	0.00000212 0.00000261
[redacted]		23	78.26%	21.74%	1.34790178	0.501		SEE RPD	5	18	0.00025	0.0096	0.00473	1.507	0.00122	0.00263	0.00003	0.00151	Data appear Normal at 5% Significance Level	2 (RPD = 52.	95% KM (t) UCL 95% KM (Percentile Bootstrap) UCL	0.00000228 0.0000039
[redacted]		23	73.91%	26.09%	0.75129277	1.074		SEE RPD	6	17	0.00028	0.003	0.00115	0.823	0.00056	0.000606	0.00006	0.00229	Data appear Normal at 5% Significance Level	2 (RPD = 23.	95% KM (t) UCL 95% KM (Percentile Bootstrap) UCL	0.00000081 679 0.00000103

Note: The distribution testing was applied to each data set and UCLs were calculated using methods presented in USEPA (2007b) ProUCL Version 4.0 User Guide.

Appendix C

Ecological Risk Assessment

Appendix C – Ecological Risk Assessment

Northern Burning Ground

Engineering Evaluation/Cost Analysis (EE/CA)

Radford Army Ammunition Plant,
Radford, Virginia

June 2009

Tables

Figures

Attachments

1. Introduction

This screening level Ecological Risk Assessment (ERA) for the Radford Army Ammunition Plant (RFAAP) Northern Burning Ground (NBG) was conducted in accordance with the United States Environmental Protection Agency (USEPA) eight-step process (USEPA 2001a; 2000a; 1997), as summarized in Figure C-1. The objective of the ERA is to evaluate whether ecological receptors may be adversely affected by exposure to site-related constituents, in support of the Engineering/Cost Analysis (EE/CA). This ERA is intended to provide input for risk management decision-making for the NBG site, while maintaining a conservative approach protective of wildlife populations and communities at the RFAAP.

In accordance with USEPA guidance, the ERA is comprised of a screening-level ERA (SLERA) and, if necessary, a baseline ERA (BERA) (USEPA 1997). The SLERA evaluates the potential risk to terrestrial ecological receptors exposed to all detected constituents in surface soil. It provides a conservative estimate of potential ecological risks and compensates for uncertainty by incorporating numerous conservative assumptions. The purpose of the SLERA is to determine whether there is a high probability that there are no ecologically significant risks; otherwise, a BERA is warranted (USEPA 2000a; 1997). If a BERA is indicated, the information developed in the SLERA is used to help focus the BERA. The BERA is more complex than the SLERA and uses more realistic and site-specific information about potential exposures and effects in order to evaluate potential ecological risks.

The approach used to assess ecological risks associated with the NBG site is based on the expanded view of the USEPA eight-step process, provided in Figure C-2. As illustrated on Figure C-2, the USEPA paradigm divides Step 3 into two pieces, Step 3a and Step 3b (USEPA 2000a). Step 3a allows for a more refined analysis of available information, while Steps 3b and beyond focus on further evaluation(s) for only those receptors, media, and constituents that are identified in previous steps. Simon (USEPA 2000a) states, "for the majority of sites, ERA activities will cease after the completion of Step 3a." The details of each step and how they relate to the NBG ERA are described in this section.

The ERA process culminates in clearly defined scientific management decision points (SMDPs). The SMDPs represent critical steps where risk management decision-making occurs. Generally, the following types of decisions are considered at the SMDPs:

1. Whether the available information is adequate to conclude that ecological risks (if any) are negligible and, therefore, there is no need for further action on the basis of ecological risk.

2. Whether the available information is inadequate to make a decision at this point and the ecological risk assessment process should continue.

3. Whether the available information indicates a potential for adverse ecological effects and a more thorough assessment or remediation is warranted.

Section 2 presents the following elements of the NBG ERA:

- Section 2.1 - Screening Level Ecological Risk Assessment
- Section 2.2 - Baseline Ecological Risk Assessment

2. Ecological Risk Assessment

2.1 Screening Level Ecological Risk Assessment

This SLERA conservatively estimates potential ecological risks to receptors, including terrestrial organisms. The SLERA compensates for uncertainty in an extremely precautionary manner, by incorporating numerous conservative assumptions. The outcome of the SLERA is the conclusion that either there is a high probability that ecologically significant risks are not posed to receptors, or further investigation in the form of a BERA is warranted. Consistent with USEPA (1997) guidance, the SLERA for the NBG site is comprised of the following steps:

- Section 2.1.1 – Step 1: Screening-Level Problem Formation
- Section 2.1.2 – Step 1: Screening Level Ecological Effects Evaluation
- Section 2.1.3 – Step 2: Screening Level Exposure Estimate and Risk Calculation
- Section 2.1.4 – Scientific Management Decision Point

2.1.1 Step 1: Screening-Level Problem Formulation

The screening-level problem formulation presents background information on site characterization, receptors, ecosystem characteristics, as well as information on the sources and effects of the stressors (UESPA 1998). This information is used to develop a conceptual site model (CSM) that illustrates the potential relationships between stressors, pathways, and receptors. The screening-level problem formation provides information used to establish the overall goals, breadth, and focus of an ERA (USEPA 1998; 1997).

The remainder of this section discusses the following components of the screening-level problem formulation for the NBG site:

Environmental Setting
Identification of Constituents Detected
Description of Constituent Fate and Transport Pathways
Description of Constituent Mechanisms of Ecotoxicity
Description of Potentially Exposed Receptors
Identification of Potentially Complete Exposure Pathways
Selection of Assessment and Measurement Endpoints

2.1.1.1 Environmental Setting

A site visit was conducted in March 2007 by an ARCADIS risk assessor, with the objective of evaluating the terrestrial habitat within the NBG site. During the visit, the NBG site was examined for signs of ecological stress (plants exhibiting stunted growth, tissue discoloration, and poor foliage growth or loss of leaf cover). While some limited foliage growth was noted where burning activities were thought to have taken place, there was no significant evidence of vegetative stress attributable to chemicals across the remainder of the site. The remainder of this section describes the terrestrial habitat included in the evaluation of the site.

Terrestrial Habitat

The site is within a forested area that is dominated by a tree cover made up of primarily pine trees, including white pine (*Pinus strobes*), shortleaf pine (*P. echinata*), and loblolly pine (*P. taeda*). The forest has a mixed herbaceous understory, without a dominant species, but typical of this forest type.

Mammals that were previously reported in the vicinity of the NBG site include red fox (*Vulpes vulpes*), white-tailed deer (*Odocoileus virginianus*), various species of shrew, and meadow vole (*Microtus pennsylvanicus*). Other species typical of this area may include gray squirrel (*Sciurus carolinensis*), white-footed mouse (*Peromyscus leucopus*), eastern cottontail (*Sylvilagus floridanus*), opossum (*Didelphis virginiana*), and raccoon (*Procyon lotor*). Avian species known to occur within the vicinity of the NBG site vary throughout the year with seasonal migration patterns. Common upland birds expected to use the NBG site include hawks, robins, dove, sparrows, warblers, and wrens. Some of the most common bird species that might be found at the NBG site include the red-tailed hawk (*Buteo jamaicensis*), mockingbird (*Mimus polyglottos*), American robin (*Turdus migratorius*), mourning dove (*Zenaida macroura*), house sparrow (*Passer domesticus*), and song sparrow (*Melospiza melodia*).

The drainage ditch at the north side of the site occasionally collects surface water runoff from the NBG site but does not hold water for more than a day or two following heavy rains. The ditch was dry at the time of the site reconnaissance; and as a result, it is unlikely that this ditch would support an aquatic community.

2.1.1.2 Data Reduction

The data were reduced and analyzed for use in the ERA as described in Section 2 in the EE/CA. The exception is that constituents detected in surface soil were included in the ecological data evaluation for that medium even if they were excluded from the human health risk assessment, because comparison with the USEPA Regional Screening Levels (RSLs) for Residential Soil is not relevant for ecological receptors.

2.1.1.3 Identification of Constituents Detected

Surface soil is the environmental media at the NBG site associated with direct contact by ecological receptors. Surface soil is defined as soil from the ground surface to a depth of one foot below ground surface (bgs). Soil samples collected from depths greater than one foot bgs are not considered because wildlife typically inhabit only the uppermost portion of the soil column (USEPA 1993a,b). The occurrence of constituents detected in surface soil is summarized in Table C-1. This table also identifies the frequency of detection, the range of detected concentrations for each compound detected, and the EPC for each detected constituent in surface soil. The EPC is defined as the lesser of the 95th upper confidence limit (UCL) on the mean and the maximum concentration. However, it should be noted that maximum detected concentrations were used to evaluate potential risks for the purpose of the SLERA. In general, the highest concentrations of most constituents were detected in soils from the center of the site, in the area where burning was likely to have occurred. Concentrations for many chemicals were much lower in other portions of the site.

2.1.1.4 Description of Constituent Fate and Transport Pathways

Knowledge about the potential constituent fate and transport pathways is vital to understanding which constituents and receptors are associated with complete exposure pathways. This is because a constituent may reach an ecological receptor in a variety of ways. In addition, the pathway and route of exposure may have a strong influence on the ecological effect of a constituent. This information is used in the development of a CSM. Constituent fate and transport pathways for the NBG site are illustrated on Figure C-3, the CSM.

2.1.1.5 Description of Constituent Mechanisms of Ecotoxicity

The mechanisms of ecotoxicity for constituents vary depending on a wide range of factors, such as constituent concentrations, the receptor species exposed, the exposure route (e.g., ingestion or direct contact), and physical factors (e.g., soil pH,

temperature, moisture content). Some of the effects that could be observed in wildlife are mortality, reduced reproductive ability, decreased fertility, decreased offspring survival, alteration of immune and behavioral function, decreased hatching success of eggs/larvae, and retarded growth (Sample et al. 1996; USEPA 2001b). The remainder of this subsection discusses mechanisms of ecotoxicity for the classes of constituents detected at the NBG site. These descriptions of constituent mechanisms of toxicity are presented without consideration of constituent concentrations, as the descriptions are intended to convey an understanding of possible effects, rather than to describe the concentrations at which these effects might occur.

Dioxin/Furan Compounds – Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are formed as by-products during the production of some herbicides, chlorophenols, and polychlorinated biphenyls (PCBs). They are also generated during the incineration of chlorinated compounds. There are 75 possible PCDD congeners and 135 possible PCDF congeners, and as with PCBs, their toxicity is dependent on the number and location of chlorine atoms. Additionally, dioxins and furans have large K_{ow} values which dictates their mobility and partitioning in environmental and biological media (Eisler 1986). Due to their high persistence and lipophilicity, dioxins and furans are accumulated in sediments, soils and sludge, bioconcentrated in aquatic organisms, and bioaccumulated in adipose tissue of aquatic and terrestrial organisms (Geyer et al. 2002).

Herbicides and Organochlorine Pesticides – While some herbicides and organochlorine pesticides may exhibit acute toxicity, the most toxicity is due to due to long-term, chronic effects. These effects may include reduced fecundity, chronic lethality, neurological effects, cessation of feeding, and bone degeneration (Nimmo and McEwen 1994; Fontenot 1999a&b). The mode of action for herbicides and organochlorine pesticides is not well understood, but they generally disrupt electrolyte balance in neurons and prevent them from conducting nerve impulses normally (Ware 1994). This manifests neurological effects such as reduced mobility, tremors, loss of equilibrium, convulsions, abnormal flexure, and lethargy or prostration. In addition, pesticides are well-known for causing eggshell thinning in birds and, thereby, reducing reproductive success (Newman 1998; Sample et al. 1996). In general, the organochlorine pesticides have very low water solubility and are considered insoluble (Nimmo 1985). However, they are soluble in polar solvents, and will preferentially move into fatty tissues. This fact, combined with the very slow breakdown rates, indicates that they will bioconcentrate into organisms in the lower levels of the food chain (such as worms) and will biomagnify into organisms in the higher levels of the food chain (such as raptors).

Polychlorinated Biphenyls– PCBs (like Aroclor 1260 and 1254) were designed for use in "closed" electrical systems like transformers, capacitors, and vacuum pumps. These compounds typically have low solubility, and low vapor pressures, and therefore tend to sorb to solid, organic material in the aquatic environment. However, PCBs can be transported in the air, and have been known to be present in measurable quantities in remote areas, far from where they were produced or used (Niimi 1994). PCBs are known to bioaccumulate and biomagnify; however, they usually do not cause acute toxic responses, and their major effects are thought to be sublethal. In addition, PCBs are currently under scrutiny for endocrine disruption, and effects on the nervous and immune systems in higher order taxa within the food web (Fontenot 1999; Niimi 1994).

Volatile Organic Compounds – VOCs tend to attenuate rapidly in surface soil due to their inherent volatility. Although the effects of VOCs on ecological receptors are not well-understood, there have been extensive inhalation studies of the effects of VOCs under laboratory conditions. Inhaled volatile organics are typically metabolized in the body (often the liver), which may cause liver damage (depending on the organism) or the release of more toxic secondary metabolites. The VOCs or their metabolites may also cause neurological damage, and many are mutagenic or carcinogenic. Additionally, some VOCs are fetotoxic and/or teratogenic (Sample et al. 1996; USEPA 2008a).

Semi-Volatile Organic Compounds – SVOCs include a wide variety of compound classes, such as phenols, organochlorine alkenes, and phthalates. SVOCs vary greatly in regard to their toxicity, mechanism of action, bioaccumulative potential, and susceptibility to being metabolized. SVOCs or their metabolites may cause neurological damage and many are mutagenic, carcinogenic, fetotoxic, and/or teratogenic (Newman 1998; Sample et al. 1996; USEPA 2008a).

Polycyclic Aromatic Hydrocarbons – PAHs, such as benzo(a)pyrene and chrysene, are often released as a result of human activities, including the incomplete combustion of fossil fuels or other organic materials. Some of these compounds are persistent and are known to be mammalian carcinogens, though the ecological effects of PAHs that are not carcinogenic are not well understood. Primary non-point sources of PAHs to the environment are aerial fallout (or rainout), road runoff (from the wear and leaching of asphalt, tire wear, vehicle exhaust, and dripping vehicle fluids), and combined storm sewer runoff (domestic sewage contains some PAHs). Most PAHs are sorbed to solid particles in the environment, which radically reduces the bioavailability and toxicity of the sorbed PAHs. PAHs may be transformed by biotic and abiotic processes in the environment. PAHs have been

shown to cause changes in liver enzymes and to perturb cell membranes but, in general, are not viewed as acutely toxic.

Metals – Trace metals (such as chromium, copper, lead, mercury, and zinc) are relatively well understood with respect to their potential adverse impacts on plants and wildlife (Newman 1998). Chromium, copper, and zinc are among the trace metals that are essential for healthy enzyme function, and some organisms cannot survive without these metals. However, these and other naturally occurring constituents may cause adverse effects when exposure occurs at concentrations that significantly exceed background concentrations. The toxicity and effects of trace metals may be greatly influenced by biotic and abiotic factors, including pH and organic carbon content of the matrix in which they occur (Leland and Kuwabara 1985). These factors affect the nature of the inorganic and organic complexes formed by the metal and its bioavailability.

Imbalances in the essential trace metals may cause a decrease in photosynthetic ability, poor spawning/hatching success, teratogenesis, susceptibility to predation and disease, reduced growth, mortality, histopathological changes, organ dysfunction of the liver or kidneys, neurological defects, changes in respiration and osmoregulation, and anemia. Some metals may bioaccumulate, but this mechanism is thought to be a less important ecological concern. Because these constituents are naturally occurring, many organisms have a limited capacity to biotransform and/or eliminate naturally occurring inorganics (Leland and Kuwabara 1985; Newman 1998).

2.1.1.6 Description of Potentially Exposed Receptors

The identification of the categories of receptors most likely to be exposed helps to focus the SLERA. Potentially exposed receptors are designated based on the available habitat associated with the site, as well as the species observed during the site reconnaissance. Section 2.1.1.1 provides a description of the habitat associated with the site as well as wildlife observed or potentially present in these habitats. As described above and presented in the CSM, potentially exposed receptors include terrestrial wildlife (including mammals, birds, reptiles, and invertebrates), and terrestrial plants.

As part of the identification of potentially exposed receptors, it is necessary to identify protected species that may be exposed to site constituents. The listing of threatened and endangered species known to occur at RFAAP is presented in Table C-2. The most recent biological survey at RFAAP was conducted in 1999 by the Virginia

Department of Game and Inland Fisheries (VDGIF). This survey identified and characterized the community types found at the site and documented any threatened or endangered species that may occur at RFAAP. As presented in this study, no threatened or endangered species were documented at the NBG site or were observed within any other pine plantation communities at RFAAP (VDGIF 1999).

However, in light of the potential presence of threatened and endangered species at RFAAP, it is appropriate to define assessment and measurement endpoints based on effects to individual organisms, as well as subpopulations and communities. The definition of assessment and measurement endpoints is further discussed in Section 2.1.1.8.

2.1.1.7 Identification of Potentially Complete Exposure Pathways

A complete exposure pathway is "one in which the chemical can be traced or expected to travel from the source to a receptor that can be affected by the chemicals" (USEPA 2001c). Therefore, a constituent, its release and migration from the source, a receptor, and the mechanisms of toxicity of that constituent must be demonstrated before a complete exposure pathway can be identified. The table below summarizes the potential exposure routes for the NBG site (also illustrated on Figure C-3).

Organism	Possible Exposure Routes
Terrestrial wildlife	Ingestion, direct contact, and food web
Terrestrial plants	Direct contact, uptake

2.1.1.8 Selection of Assessment and Measurement Endpoints

Assessment endpoints are the explicit expression of the ecological values to be protected (USEPA 1997). The selection of assessment endpoints depends on knowledge of the receiving environment, knowledge about the constituents released (including their toxicological properties and the relevant concentrations), and understanding of the values that will drive risk management decisions (Suter et al. 1995). Consistent with USEPA (1998) guidance, two elements are required to define an assessment endpoint: the specific valued ecological entity and the characteristic about the entity that is important to protect.

USEPA guidance provides that Superfund remedial actions should be designed not to protect organisms on an individual basis, but to protect local populations and communities of biota (USEPA 1999). Thus, the first management principle for conducting an ecological risk assessment is to provide a basis for selecting a response action "that will result in the recovery and/or maintenance of healthy local populations/communities of ecological receptors that are or should be present at or near the site" (USEPA 1999). The USEPA (1999) guidance also notes, as an exception to this rule, that threatened and endangered species may be evaluated on an individual basis. In concept, however, this focus is justified on the basis that, given the stressed nature of a threatened and endangered population, effects on individuals could impact the local population.

For the NBG site, assessment endpoints include the following:

- Sustainability of small mammal populations;
- Sustainability of avian populations; and
- Sustainability of terrestrial plant communities.

Because direct measurement of assessment endpoints is often difficult or infeasible, surrogate endpoints called measurement endpoints are used to provide the information necessary to evaluate whether the values associated with the assessment endpoint are being protected. A measurement endpoint is defined as a measurable ecological characteristic and/or response to a stressor (USEPA 1998). Maximum hazard quotients (HQs) serve as the measurement endpoints for the SLERA. The maximum HQ is the ratio of the maximum concentration of a given constituent to its ecotoxicity screening level (ESL). ESLs are chemical concentrations in environmental media below which there is negligible risk to receptors exposed to those media (USEPA 2000a). The ESLs used for this SLERA include the USEPA Ecological Soil Screening Levels (EcoSSLs) (USEPA 2008b), ecological screening criteria values recommended by New Jersey Department of Environmental Protection (http://www.state.nj.us/dep/srp/regs/guidance.htm), and the USEPA Region V Ecological Screening Levels (ESLs) (USEPA 2003a). In all sources, where multiple screening levels were presented, the lowest values were selected which is highly conservative as is appropriate for a SLERA (USEPA 2000b; 1998; 1997c).

ESLs are generally based on effects such as mortality and reproductive impairment, and are assumed to be widely applicable to sites around the United States for screening purposes (USEPA 1997). For most chemicals and receptors, the data

available to generate ESLs are limited and related to effects on individual organisms, rather than subpopulations or communities. Given these limitations, conservative assumptions are used to ensure that the ESLs are protective. The documents that present the ESLs caution users to recognize that such screening values do not constitute remediation goals, as they are sometimes based on highly conservative exposure assumptions and/or wildlife receptors that may not be applicable to a particular site. As such, their robustness and biological association with the assessment endpoint may be limited.

2.1.2 Step 1, continued: Screening-Level Ecological Effects Evaluation

The screening-level ecological effects evaluation involves the identification of ESLs for each detected constituent in each environmental medium at the SWMU. As described above, ESLs are based on conservative assumptions in order to ensure that the values are protective and applicable to a wide variety of sites. Regardless, ESLs provide a starting point for the SLERA as they provide an indication of the worst-case measure of the potential for adverse impacts.

As presented in Table C-4, toxicity equivalency factors (TEFs) were used to evaluate the toxicity of each dioxin compound detected at the site. TEFs are weighted quantity measures that are based on the toxicity of each member of the dioxin and dioxin-like compound relative to the most toxic members of the category. In accordance with USEPA (2007b) guidance, TEFs for the dioxin and dioxin-like compounds detected at the NBG were based on the relative toxicity with 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD.

2.1.3 Step 2: Screening-Level Exposure Estimate and Risk Calculation

The screening-level exposure assessment is comprised of the identification of exposure estimates, risk calculations, and the evaluation of uncertainties (USEPA 2003a; 1997). These form the lines of evidence necessary to support the SMDP at the conclusion of the SLERA (Section 2.1.4).

2.1.3.1 Identification of Screening-Level Exposure Estimates

Exposure estimates for the SLERA (Table C-4) are the maximum detected concentrations for each constituent (USEPA 2001a; 1997). This conservative approach (i.e., using only the maximum detected concentrations) is appropriate for a screening-level effort.

2.1.3.2 Screening-Level Risk Calculations

The screening level risk calculations provide an estimate of potential risk to ecological receptors. Risks to ecological receptors are calculated by dividing the exposure estimates (i.e., the maximum detected concentrations) by the conservative ESLs. The resulting ratio, the HQ, is a highly conservative surrogate for the assessment endpoints identified in Section 2.1.1.8. HQs equal to or less than a value of 1 (to one significant figure) indicate that adverse ecological impacts are unlikely (USEPA 1997). HQs greater than 1 indicate that further evaluation is warranted. Therefore, the constituents with HQs greater than 1 are carried forward as constituents of potential ecological concern (COPECs) into Step 3a of the BERA. Maximum HQs greater than 1 (Table C-4) are summarized below:

Summary of Maximum Hazard Quotients Greater Than 1 for Surface Soil at NBG

Constituent	Maximum HQs for Surface Soil
Herbicides	
2,4-D	7
Dioxin/Furan Compounds	
Total Dioxin/Furan Compounds	130
Herbicides	
4,4'-DDT	69
Polychlorinated Biphenyls	
Arolclor-1254	13,855
Inorganics	
Aluminum	60
Antimony	155
Arsenic	4
Barium	2
Cadmium	32
Chromium	64,250
Cobalt	1,357
Copper	105
Lead	10,099
Manganese	4
Mercury	3
Selenium	34
Thallium	19
Vanadium	61
Zinc	4,588

Screening ecotoxicity values were not available from the listed sources for the following constituents detected in soil: 2,4-DB; dalapon; dicamba; mecoprop (MCPP); 1,2,4-

trimethylbenzene; d-limonene; tert-butylbenzene; and carbazole. Therefore, these constituents are also carried forward as COPECs into Step 3a of the BERA.

2.1.3.3 Evaluation of Uncertainties

SLERAs are designed to provide estimates of the risks that may exist for ecological receptors and to incorporate uncertainty in a precautionary manner. Uncertainty is "the imperfect knowledge concerning the present or future state of the system under consideration; a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal distribution" (USEPA 1997). Uncertainties that may lead to either an overestimate or underestimate of risk are associated with each stage of risk assessment. Because the SLERA is intended to provide a precautionary approach to evaluating risks to ecological receptors, the majority of the SLERA uncertainties tend toward an overestimate of risk. Uncertainties associated with the SLERA are identified on Table C-5.

2.1.4 Scientific Management Decision Point

The SMDP represents a critical step in the ecological risk assessment process where risk management decision-making occurs (Figures C-1 and C-2). A SMDP occurs after either Step 2 or Step 3a, so that additional evaluation of risks can be conducted if needed and reporting can be streamlined into a single report (USEPA 2000a). Generally, the following types of decisions are considered at this SMDP:

- Whether the available information is adequate to conclude that ecological risks are negligible and, therefore, there is no need for remediation to mitigate ecological risks.

- Whether the available information is not adequate to make a decision at this point, and the ecological risk assessment process should continue.

- Whether the available information indicates a potential for adverse ecological effects, and a more thorough assessment or remediation is warranted.

If the SMDP indicates that either information is not adequate to make a decision or information indicates a potential for adverse ecological effects, then the ERA process should continue.

As described above, the SLERA for the NBG site indicates that 19 constituents in surface soil exceed an HQ of 1. In addition, ESLs are not available for eight other

constituents. Therefore, the possibility of adverse ecological risks should be further evaluated for ecological receptors, and the initial step of a BERA is warranted.

2.2 Baseline Ecological Risk Assessment

The BERA is designed to more realistically identify the nature and extent of ecological risks in order to support informed risk management decision-making (USEPA 2000a; 1997). This approach contrasts with the SLERA, which is designed to conservatively rule out further evaluation of chemicals and media that clearly do not pose a significant ecological risk. As indicated on Figures C-1 and C-2, the BERA process involves numerous steps. These steps are executed in a manner appropriate to the conditions at any individual site (USEPA 2000a; 1997).

The USEPA process shows that the BERA begins with Step 3, the Problem Formulation (Figure C-1). A more detailed look at the Step 3 shows that it is typically divided into Step 3a and Step 3b (Figure C-2). "Step 3a serves to introduce information to refine the risk estimates from Steps 1 and 2. For the majority of sites, ERA activities will cease after Step 3a" (USEPA 2000a). Step 3a provides a "reality check" so that "sites that do not warrant further study are not carried forward" (USEPA 2000a). Step 3b, the "additional problem formulation" is initiated only for those sites that warrant further study.

This section presents Step 3a of the BERA for the NBG site, consistent with the following guidance:

- "Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders" (USEPA 2000a)
- "ECO-Update: Role of Screening-level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments" (USEPA 2001a)
- "Ecological Risk Assessment Guidance for Superfund" (USEPA 1997)
- "Guidelines for Ecological Risk Assessment" (USEPA 1998)

Step 3a involves a refinement of the Step 2 exposure estimates and risk characterization and focuses only on COPECs that were not screened out in the

SLERA. Step 3a is followed by a SMDP that involves the reporting of results of Steps 1 through 3a. The Step 3a discussion for the NBG site is comprised of the following:

Refinement of Constituents of Potential Concern
Refinement of Risk Calculations for Direct Contact COPECs
Assessment for Bioaccumulative COPECs
Uncertainties
Risk Summary and Ecological Significance
Scientific Management Decision Point

2.2.1 Refinement of Constituents of Potential Concern

The refinement of the COPECs identified in the SLERA is necessary to help focus and streamline further risk assessment activities on the constituents that pose the greatest potential risk to ecological receptors (USEPA 2001a; 2000a; 1997). It is intended as an "incremental iteration of exposure, effects, and risk characterization" (USEPA 2001a). The outcome of this screening is that constituents are either excluded as COPECs or retained for further evaluation in the BERA process.

The process for refining the COPECs is illustrated in Figure C-4 and generally consists of two steps: 1) the comparison of maximum detected concentrations with background concentrations for each medium; and 2) the comparison of EPCs (i.e., UCLs) with established conservative SLERA ESLs. Selection of an appropriate UCL calculation method, as presented in USEPA (2007a) guidance, involves consideration of the sample size (number of data points) and the underlying data distribution for each data set. The data set for each COPC in the surface soil data set was analyzed to determine the most appropriate data distribution (normal, lognormal, or gamma) to use in the UCL calculations. UCLs for data sets which do not resemble any of these three data distributions were derived using distribution-free nonparametric statistical methods. In the BERA, EPCs are defined as the lesser of the maximum detected concentration and the 95 percent UCL of the mean. A sample size of five was set as the lower threshold for the calculation of UCLs. For chemicals with a sample size of five or more, UCLs were calculated using USEPA's (2007a) ProUCL Version 4.0 software. The ProUCL output is included in Attachment A. The maximum detected concentration was used for chemicals with a sample size of less than five.

The background screening of COPECs was based upon comparisons with ambient concentrations of metals in surface soils from RFAAP in the *Facility-Wide Background Study Report* (IT 2001). The constituents in surface soil identified as COPECs based on background comparisons are considered COPECs for direct contact exposures.

Of the constituents carried through to the BERA, the maximum concentrations of aluminum, manganese, nickel and thallium in surface soil were below the RFAAP-approved background value and thus were not evaluated further as COPECs for direct contact exposure (Table C-6). Background values were not available for dioxin/furan compounds, herbicides, pesticides, VOCs, or SVOCs.

Ecological constituents that are identified as direct contact COPECs in the BERA are also identified as COPECs for bioaccumulative exposures, if 1) they are included in the USEPA list of bioaccumulative compounds (USEPA 2000b) and 2) the maximum concentration exceeded its respective background concentration.

Eleven surface soil constituents (total dioxin/furan compounds; 4,4'-DDT; Aroclor 1254; chromium; copper; lead; mercury; nickel; selenium; and zinc) were identified as bioaccumulative; however, the maximum concentration for nickel was below the corresponding background levels therefore it was not selected as a COPEC in surface soil. Total dioxin/furan compounds; 4,4'-DDT; Aroclor 1254; cadmium; chromium; copper; lead; selenium; and zinc, however, were selected as COPECs in surface soil.

2.2.2 Refinement of Risk Calculations for Direct-Contact COPECs

The HQs were recalculated for the refined COPECs identified above for the NBG site, using the ESL and the lower of the maximum concentration and the UCL as the EPC (Table C-6).

Relevant soil screening benchmarks were not available for eight constituents (including four herbicides, three VOCs, and one SVOC). HQs greater than 1 are summarized below:

Refined Direct Contact HQs Greater than 1

Constituent	Surface Soil HQ
Dioxin/Furan Compounds	
Total Dioxin/Furan Compounds	130
Herbicides	
2,4-D	7
Organochlorine Pesticides	
4,4'-DDT	69
Polychlorinated Biphenyls	
Aroclor 1254	3,334
Inorganics	
Antimony	48
Cadmium	10
Chromium	21,358
Cobalt	3
Copper	10
Lead	4,302
Vanadium	7
Zinc	304

The ESLs used in the calculation of HQs presented above are the same conservative ESLs used in the SLERA (USEPA 2000a). Refined HQs are presented in Table C-6.

Although elevated HQs calculated using toxicity benchmarks may indicate the potential for adverse impacts to wildlife, these screening values are typically the most conservative values available. For example, the default ESL reported by Region V is the lowest value from a database of values for a particular compound (USEPA 2003b). Therefore, HQs must be considered within the context of other available information as well (e.g., basis for the ecological screening value; spatial extent of samples with elevated HQs, etc). As indicated in Table C-3, there is actually a range of benchmark values associated with most of the chemicals of concern. The range in values can be attributed to a variety of factors including differences in receptors, test conditions, endpoints measured etc. and clearly demonstrates the uncertainty associated with

predicting risks based on comparisons to screening benchmarks alone. Table C-7 presents a comparison of the site EPC to the minimum and maximum benchmark values considered in this assessment to illustrate the range of possible HQ values. Evaluation of these HQs indicates that chromium, lead and zinc are the primary risk drivers at the site, although PCBs and dioxins are also elevated.

2.2.3 Refined Uncertainties

A BERA is designed to evaluate potential risks for wildlife by incorporating iterative changes that reduce uncertainty (when possible) and provides more realistic exposure assumptions. Uncertainties associated with the BERA are summarized on Table C-5.

2.2.4 Scientific Management Decision Point

SMDPs represent critical steps in the ecological risk assessment process where risk management decision-making occurs. As was discussed previously and can be seen on Figures C-1 and C-2, the first SMDP is purposefully flexible (per the USEPA paradigm) to allow reporting to occur after either Step 2 or Step 3a, depending on the results obtained in Step 2. Step 3a of the BERA was conducted for the 26 constituents in surface soil without an ESL or whose HQ value exceeded 1. This analysis indicates that several constituents are elevated with respect to potential ecological effects at least in some portions of the site. However, there is considerable uncertainty regarding the significance of the potential risks to ecological receptors because of the range of available screening benchmarks. In addition, the elevated concentrations that are driving the risk are primarily associated with the soils from the center of the site, in the area where burning was likely to have occurred. Concentrations for many chemicals were much lower in other portions of the site. A removal action is being performed for the central portion of the site based on the presence of human health risk drivers which will also effectively reduce the site concentrations of the constituents driving the ecological risks.

3. Conclusions and Summary

Screening-level and baseline ecological risk assessments were performed for the NBG site at the RFAAP. The NBG site consists of a heavily wooded area, with the exception of a small area in the central portion of the site where burning operations are believed to have been performed. This central portion of the site has a grass and shrub groundcover and a few small trees. Little to no visible evidence of past burning activities is apparent. As such, the wooded area provides habitat for wildlife; as a result, this area is the focus of this ERA. The terrestrial habitat is comprised mainly of wooded areas with limited open canopy, dominated by species of pine. No aquatic habitat is present on the NBG site.

The SLERA and BERA focused on evaluation of constituents identified in surface soil. The SLERA represents a conservative evaluation of potential exposure and hazard. Maximum detected concentrations were compared to conservative ESLs to calculate HQs. Several constituents (total dioxin/furan compounds; 2,4-D; 4,4'-DDT; Aroclor 1254; aluminum; arsenic; barium; chromium; cobalt; copper; lead; manganese; mercury; selenium; thallium; vanadium; and zinc) were determined to have HQs greater than 1. These constituents were carried forward as COPECs into Step 3a of the BERA. Additionally, the following constituents were carried forward into the BERA because screening levels were not available: 2,4-DB dalapon; dicamba MCPP; 1,2,4-trimethylbenzene d-limonene; tert-butylbenzene and carbazole.

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Tables

Table C-1. Data Summary for Surface Soil (0 to 1 ft bgs)
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent [a]		Frequency Detects / Total			Percent Detects	[b]	Range of Detects Minimum - Maximum (mg/kg)			Exposure Point Concentration [c] (mg/kg)	
Dioxin/Furan Compounds											
1,2,3,4,6,7,8-HpCDD		10	/	18	56 %	hi	0.00001618	-	0.0001025	1.03E-04	m
1,2,3,4,6,7,8-HpCDF		7	/	18	39 %	med	0.00000244	-	0.00002183	2.18E-05	m
1,2,3,4,7,8,9-HpCDF		1	/	18	6 %	lo	0.00000041	-	0.00000041	4.10E-07	m
1,2,3,4,7,8-HxCDD		1	/	18	6 %	lo	0.00000053	-	0.00000053	5.30E-07	m
1,2,3,4,7,8-HxCDF		3	/	18	17 %	med	0.00000073	-	0.00002445	2.45E-05	m
1,2,3,6,7,8-HxCDD		1	/	18	6 %	lo	0.00000141	-	0.00000141	1.41E-06	m
1,2,3,6,7,8-HxCDF		3	/	18	17 %	med	0.00000162	-	0.0000096	9.60E-06	m
1,2,3,7,8,9-HxCDD		1	/	18	6 %	lo	0.00000142	-	0.0000014	1.42E-06	m
1,2,3,7,8,9-HxCDF		1	/	18	6 %	lo	0.00000179	-	0.00000179	1.79E-06	m
1,2,3,7,8-PeCDF		3	/	18	17 %	med	0.00000021	-	0.00001225	1.23E-05	m
2,3,4,6,7,8-HxCDF		3	/	18	17 %	med	0.000000360	-	0.00000294	2.94E-06	m
2,3,4,7,8-PeCDF		3	/	18	17 %	med	0.00000024	-	0.0000169	1.69E-05	m
2,3,7,8-TCDD		1	/	18	6 %	lo	0.00000047	-	0.00000047	4.70E-07	m
2,3,7,8-TCDF		4	/	18	22 %	med	0.00000038	-	0.0001246	1.25E-04	m
OCDD		10	/	18	56 %	hi	0.00172	-	0.01964	1.18E-02	
OCDF		5	/	18	28 %	med	0.00001394	-	0.00008762	8.76E-05	m
Total HpCDDs	[d]	10	/	18	56 %	hi	0.00002162	-	0.0002014	2.01E-04	m
Total HpCDFs	[d]	7	/	18	39 %	med	0.00000244	-	0.00007406	7.41E-05	m
Total HxCDDs	[d]	4	/	18	22 %	med	0.0000063	-	0.00001125	1.13E-05	m
Total HxCDFs	[d]	3	/	18	17 %	med	0.00000747	-	0.00006751	6.75E-05	m
Total PeCDFs	[d]	3	/	18	17 %	med	0.00000336	-	0.0001008	1.01E-04	m
Total TCDDs	[d]	2	/	18	11 %	lo	0.00000118	-	0.00000468	4.68E-06	m
Total TCDFs	[d]	4	/	18	22 %	med	0.00000151	-	0.0003194	3.19E-04	m
Herbicides											
2,4,5-T		1	/	16	6 %	lo	0.00719	-	0.00719	7.19E-03	m
2,4-D		2	/	16	13 %	lo	0.146	-	0.195	1.95E-01	m
2,4-DB		1	/	16	6 %	lo	0.0596	-	0.0596	5.96E-02	m
Dalapon		2	/	16	13 %	lo	0.0759	-	0.0814	8.14E-02	m
Dicamba		1	/	16	6 %	lo	0.00321	-	0.00321	3.21E-03	m
MCPP		1	/	16	6 %	lo	3.3	-	3.3	3.30E+00	m
Organochlorine Pesticides											
4,4'-DDD		3	/	16	19 %	med	0.00244	-	0.00933	9.33E-03	m
4,4'-DDE		3	/	16	19 %	med	0.00085	-	0.070	7.00E-02	m
4,4'-DDT		3	/	16	19 %	med	0.00421	-	0.24	2.40E-01	m
Dieldrin		1	/	16	6 %	lo	0.00185	-	0.00185	1.85E-03	m
Endosulfan II		1	/	16	6 %	lo	0.00176	-	0.00176	1.76E-03	m
Endrin Aldehyde		1	/	16	6 %	lo	0.00645	-	0.00645	6.45E-03	m
Polycyclic Aromatic Hydrocarbons											
Acenaphthene		1	/	19	5 %	lo	0.0086	-	0.0086	8.60E-03	m
Acenaphthylene		1	/	19	5 %	lo	0.083	-	0.083	8.30E-02	m
Anthracene		1	/	19	5 %	lo	0.032	-	0.032	3.20E-02	m
Benzo(a)anthracene		1	/	19	5 %	lo	0.49	-	0.49	4.90E-01	m
Benzo(a)pyrene		1	/	19	5 %	lo	0.53	-	0.53	5.30E-01	m
Benzo(b)fluoranthene		1	/	19	5 %	lo	0.73	-	0.73	7.30E-01	m
Benzo(g,h,i)perylene		2	/	19	11 %	lo	0.040	-	0.37	3.70E-01	m
Benzo(k)fluoranthene		1	/	19	5 %	lo	0.24	-	0.24	2.40E-01	m
Chrysene		1	/	19	5 %	lo	0.37	-	0.37	3.70E-01	m
Dibenzo(a,h)anthracene		1	/	19	5 %	lo	0.084	-	0.084	8.40E-02	m
Fluoranthene		1	/	19	5 %	lo	0.53	-	0.53	5.30E-01	m
Fluorene		1	/	19	5 %	lo	0.010	-	0.010	1.00E-02	m
Indeno(1,2,3-cd)pyrene		1	/	19	5 %	lo	0.40	-	0.40	4.00E-01	m
2-Methylnaphthalene		1	/	15	7 %	lo	0.0037	-	0.0037	3.70E-03	m
Naphthalene		1	/	19	5 %	lo	0.0085	-	0.0085	8.50E-03	m
Phenanthrene		1	/	19	5 %	lo	0.15	-	0.15	1.50E-01	m

Footnotes appear on last page.

Table C-1. Data Summary for Surface Soil (0 to 1 ft bgs)
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent [a]	Frequency Detects / Total	Percent Detects	[b]	Range of Detects Minimum – Maximum (mg/kg)	Exposure Point Concentration [c] (mg/kg)
Pyrene	1 / 19	5 %	lo	0.5 - 0.5	5.00E-01 m
Polychlorinated Biphenyls					
Aroclor-1254	12 / 28	43 %	med	0.068 - 4.6	1.11E+00
Volatile Organic Compounds					
1,1-Dichloroethene	1 / 26	4 %	lo	0.0020 - 0.0020	2.00E-03 m
1,2,4-Trimethylbenzene	1 / 22	5 %	lo	0.0056 - 0.0056	5.60E-03 m
2-Butanone	1 / 21	5 %	lo	0.011 - 0.011	1.10E-02 m
Acetone	2 / 24	8 %	lo	0.0030 - 0.12	1.20E-01 m
Benzene	1 / 27	4 %	lo	0.0010 - 0.0010	1.00E-03 m
Chlorobenzene	1 / 27	4 %	lo	0.0010 - 0.0010	1.00E-03 m
d-Limonene	1 / 15	7 %	lo	0.023 - 0.023	2.30E-02 m
Methylene Chloride	5 / 27	19 %	med	0.0020 - 0.0030	3.00E-03 m
tert-Butylbenzene	1 / 22	5 %	lo	0.0030 - 0.0030	3.00E-03 m
Toluene	1 / 27	4 %	lo	0.0010 - 0.0010	1.00E-03 m
Trichloroethene	1 / 27	4 %	lo	0.0010 - 0.0010	1.00E-03 m
Semi-Volatile Organic Compounds					
bis(2-Ethylhexyl)phthalate	8 / 26	31 %	med	0.040 - 0.20	1.42E-01
Carbazole	1 / 24	4 %	lo	0.022 - 0.022	2.20E-02 m
Diethylphthalate	3 / 24	13 %	lo	0.060 - 0.24	2.40E-01 m
Di-n-Butylphthalate	3 / 25	12 %	lo	0.040 - 0.090	9.00E-02 m
Inorganics					
Aluminum	40 / 40	100 %	hi	4,670 - 37,000	1.87E+04
Antimony	24 / 38	63 %	hi	0.37 - 41.8	1.29E+01
Arsenic	39 / 40	98 %	hi	2.2 - 64.1	1.63E+01
Barium	40 / 40	100 %	hi	21.4 - 618	1.99E+02
Beryllium	36 / 40	90 %	hi	0.11 - 0.8	5.21E-01
Cadmium	27 / 39	69 %	hi	0.083 - 11.4	3.73E+00
Calcium	40 / 40	100 %	hi	637 - 129,000	6.53E+04
Chromium	40 / 40	100 %	hi	7.1 - 25,700	8.54E+03
Cobalt	40 / 40	100 %	hi	3.2 - 190	4.03E+01
Copper	40 / 40	100 %	hi	4.9 - 569	2.69E+02
Iron	40 / 40	100 %	hi	8,270 - 59,800	2.66E+04
Lead	40 / 40	100 %	hi	16.5 - 111,000	4.73E+04
Magnesium	40 / 40	100 %	hi	193 - 58,500	3.11E+04
Manganese	40 / 40	100 %	hi	64.3 - 926	3.56E+02
Mercury	28 / 38	74 %	hi	0.031 - 0.27	7.43E-02
Nickel	40 / 40	100 %	hi	3.5 - 39.6	1.37E+01
Potassium	40 / 40	100 %	hi	149 - 3,680	1.34E+03
Selenium	5 / 38	13 %	lo	0.55 - 0.94	6.24E-01
Silver	4 / 38	11 %	lo	0.23 - 2.74	2.74E+00 m
Sodium	37 / 38	97 %	hi	19 - 2,020	4.41E+02
Thallium	17 / 40	43 %	med	0.14 - 1.1	3.14E-01
Vanadium	40 / 40	100 %	hi	14.9 - 121	5.10E+01
Zinc	40 / 40	100 %	hi	18.1 - 39,000	1.40E+04

[a] Detected constituents only are summarized here.
Data from two methods and data from duplicate samples were combined so that the higher detect and the lowest detection limit were used in the risk assessment dataset.

[b] The percent non-detects in each data set is indicated as low "*lo*" (15 percent or less), medium "*med*" (between 15 and 50 percent), or high "*hi*" (50 percent or more).

[c] The exposure point concentration (EPC) was set equal to the lower of the upper confidence limit on the mean (UCL) calculated by ProUCL 4.0 (USEPA 2007a) and the maximum concentration. Where a UCL was not calculable, the maximum concentration (m) was used as the EPC.

[d] Data on groups of chemicals (e.g., Total HpCDDs) are not generally useful in the risk assessment process because available toxicity information used to estimate risk is most often restricted to individual compounds; therefore, "Total" constituents will not be further evaluated in this risk assessment.

ft bgs Feet below ground surface.
mg/kg Milligrams per kilogram.

Table C-2. **Threatened and Endangered Species Potentially Occurring at Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia.**

Scientific Name Common Name	State Rank [a]	State Status [b]	Federal Status [c]	Habitat	Habitat Present at NBG, Radford, Virginia
Upland Forest					
Plants:					
Blephilia hirsuta Hairy woodmint	R	WL	NA	Upland Forest	NO
Carex hirtifolia Pubescent sedge	R	WL	NA	Upland Forest	NO
Cystopteris tennesseensis Tennessee bladderfern	ER	RL	NA	Upland Forest	NO
Hydrastis canadensis Golden-seal	R	WL	NA	Upland Forest	NO
Juglans cinerea Butternut	R	WL	NA	Upland Forest	NO
Panax quinquifolium American ginseng	C	WL	NA	Upland Forest	NO
Rhamnus lanceolata Lance-leaved buckthorn	R	WL	NA	Upland Forest	NO
Limestone Barren					
Plants:					
Carex meadii Mead's sedge	R	WL	NA	Limestone Barren	NO
Linum sulcatum Grooved yellow flax	R	WL	NA	Limestone Barren	NO
Calcareous Cliff					
Plants:					
Clematis coactilis Virginia White-haired leatherflower	VR/R	RL	NA	Calcareous Cliff	NO
Pellaea glabella Smooth cliff-brake	PR	WL	NA	Calcareous Cliff	NO
Calcareous Fen					
Plants:					
Carex interior Inland sedge	ER	RL	NA	Calcareous Fen	NO
Carex schweinitzii Schweinitz's sedge	ER	RL	NA	Calcareous Fen	NO
Carex suberecta Prairie straw sedge	R	WL	NA	Calcareous Fen	NO
Carex tetanica Rigid sedge	R	WL	NA	Calcareous Fen	NO
Juncus brachycephalus Small-headed rush	VR	RL	NA	Calcareous Fen	NO
Piedmont/Mountain Bottomland Forest					
Plants:					
Carex cherokeensis Cherokee sedge	NA	NL	NA	Piedmont/Mountain Bottomland Forest	NO

Footnotes appear on last page.

Table C-2. **Threatened and Endangered Species Potentially Occurring at Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia.**

	Scientific Name Common Name	State Rank [a]	State Status [b]	Federal Status [c]	Habitat	Habitat Present at NBG, Radford, Virginia
	Carex conjuncta Soft fox sedge	R	WL	NA	Piedmont/Mountain Bottomland Forest	NO
	Hasteola suaveolens Sweet-scented Indian plantain	VR	RL	NA	Piedmont/Mountain Bottomland Forest	NO
Sand/Grave/Mud Bar and Shore						
	Plants:					
	Sagittaria rigida Sessile-fruited arrowhead	ER	RL	NA	Sand/Grave/Mud Bar and Shore	NO
	Eleocharis intermedia Matted spikerush	ER	RL	NA	Sand/Grave/Mud Bar and Shore	NO
Grassland						
	Plants:					
	Carex mesochorea Midland sedge	C	WL	NA	Grassland	NO
	Onosmodium hispidissimum Shaggy False Gromwell	C	WL	NA	Grassland	NO
	Invertebrates:					
	Speyeria idalia Regal Fritillary	ER	ST	NA	Grassland	NO
	Birds:					
	Ammodramus henslowii Henslow's Sparrow	ER	ST	NA	Grassland	NO
	Lanius ludovicianus Loggerhead Shrike	VR	ST	NA	Grassland	NO
Wet Meadow/Marsh and Ponds						
	Plants:					
	Carex suberecta Praire straw sedge	R	WL	NA	Wet Meadow/Marsh and Ponds	NO
	Juncus brachycephalus Small-headed rush	VR	RL	NA	Wet Meadow/Marsh and Ponds	NO
	Liparis loeselii Bog Twayblade	VR	RL	NA	Wet Meadow/Marsh and Ponds	NO
	Spiranthes lucida Shining ladies'-tresses	ER	RL	NA	Wet Meadow/Marsh and Ponds	NO
	Sporobolus asper Tall Dropseed	NL	NL	NA	Wet Meadow/Marsh and Ponds	NO

Notes:

Notes:

[a] PR=Possibly Rare; R=Rare; VR=Very Rare; ER=Extremely Rare; C=Common and secure; NL=Not listed.

[b] WL=Watchlist; RL=Rarelist; ST=State Threatened; NL=Not listed.

[c] FE=Federal Endangered; FT=Federal Threatened; FC=Federal Candidate; SOC=Federal Species of Concern (not a legal status; list maintained by USFWS Virginia Field Office); NL=Not listed.

NBG - Northern Burning Ground
RFAAP - Radford Army Ammunition Plant

** Source: Virginia Department of Game and Inland Fisheries (1999).

Table C-3. Summary of Soil Benchmark Values Considered
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Toxic Substance	Soil (mg/kg)					
	Wildlife PRGs (flora and fauna)	Terrestrial Plant Tox Benchmarks	EcoSSLs[7]			
			Plants	Soil Invertebrates	Avian	Mammalian
Acenaphthene	20[2] 682[1]					
Acenaphthylene	682[1]					
Acetone	2.5[1]					
Aluminum	600[9]	50				
Anthracene	1,480[1]					
Antimony	5[2]	5		78		0.27
Arsenic	9.9[2,3]	10	18		43	46
Barium	283[4]	500		330		2,000
Benz(a)anthracene	5.21[1]					
Benzene	0.255[1]					
3,4-Benzofluoranthene (Benzo(b)fluoranthene)	59.8[1]					
Benzo(k)fluoranthene	148[1]					
Benzo(g,h,i)perylene	119[1]					
Benzo(a)pyrene (BaP)	1.52[1]					
Beryllium	10[2]	10		40		21
Bis(2-ethylhexyl) phthalate	0.925[1]					
2-Butanone	89.6[1]					
Cadmium	4[2,4]	4	32	140	0.77	0.36
Chlorobenzene	40[5] 13.1[1]					
Chromium	0.4[1,5]	1				
Chromium+3					26	34
Chromium+6						130
Chrysene	4.73[1]					
Cobalt	20[2] 0.14[1]	20	13		120	230
Copper	60[5] 5.4[1]	100	70	80	28	49
2,4,5-T	0.596[1]					
2,4-D	0.0272[1]					
4,4'-DDD (p,p'-TDE)	0.758[1]					
4,4'-DDE	0.596[1]					
4,4'-DDT	0.0035[1]					
DDT (Total)					0.093[8]	0.021[8]
Dibenz(a,h)anthracene	18.4[1]					
Di-n-butyl phthalate	200[2] 0.15[1]					
1,1-Dichloroethylene	8.28[1]					
Dieldrin	0.00238[1]				0.022	0.0049
Diethyl phthalate	100[2] 24.8[1]					
Endosulfans (alpha and beta)	0.119[1]					
Endosulfan sulfate	0.0358[1]					
Endrin	0.0101[1]					

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Table C-3. Summary of Soil Benchmark Values Considered
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Toxic Substance	Soil (mg/kg)					
	Wildlife PRGs (flora and fauna)	Terrestrial Plant Tox Benchmarks	EcoSSLs[7]			
			Plants	Soil Invertebrates	Avian	Mammalian
Endrin aldehyde	0.0105[1]					
Fluoranthene	122[1]					
Fluorene	122[1]					
Indeno(1,2,3-cd)pyrene	109[1]					
Lead	40.5[4] 0.0537[1]	50	120	1,700	11	56
Manganese		500	220	450	4,300	4,000
Mercury	0.00051[4] 0.1[1]	0.3				
Methylene chloride	4.05[1]					
2-Methylnaphthalene	3.24[1]					
Naphthalene	0.0994[1]					
Nickel	30[2] 13.6[1]	30	38	280	210	130
Phenanthrene	45.7[1]					
Polychlorinated biphenyls (PCBs)	0.371[3] 0.000332[1]	40				
Pyrene	78.5[1]					
Selenium	0.21[6] 0.0276[1]	1	0.52	4.1	1.2	0.63
Silver	2[2] 4.04[1]	2	560		4.2	14
2,3,7,8-Tetrachlorodibenzo-p-dioxin	0.00000315[3] 0.000000199[1]					
Thallium	1[2] 0.0569[1]	1				
Toluene	200[2] 5.45[1]	200				
Trichloroethylene	12.4[1]					
Vanadium	2[1]	2			7.8	280
Zinc	8.5[4] 6.62[1]	50	160	120	46	79

1. USEPA Region 5, RCRA Ecological Screening Levels (ESLs) represent a protective benchmark (e.g., water quality criteria, sediment quality guidelines/ criteria, and chronic no adverse effect levels) for 223 contaminants and are not intended to serve as cleanup levels, but are intended to function as screening levels. http://www.epa.gov/reg5rcra/ca/ESL.pdf

2. Wildlife Preliminary Remediation Goal based on plant study as reported by NJDEP
http://www.state.nj.us/dep/srp/guidance/ecoscreening/
3. Wildlife Preliminary Remediation Goal based on shrew study as reported by NJDEP
http://www.state.nj.us/dep/srp/guidance/ecoscreening/
4. Wildlife Preliminary Remediation Goal based on woodcock study as reported by NJDEP
http://www.state.nj.us/dep/srp/guidance/ecoscreening/

5. Wildlife Preliminary Remediation Goal based on earthworm study as reported by NJDEP
http://www.state.nj.us/dep/srp/guidance/ecoscreening/

6. Wildlife Preliminary Remediation Goal based on mouse study as reported by NJDEP
http://www.state.nj.us/dep/srp/guidance/ecoscreening/

7. Guidance for Developing Ecological Soil Screening Levels, OSWER Directive 9285.7-55, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, 1200 Pennsylvania Avenue, N.W., Washington, DC 20460, November 2003, Revised February 2005, http://www.epa.gov/ecotox/ecossl/pdf/ecossl_guidance_chapters.pdf

8. Value applies to DDT and metabolites.

9. Suter et al., 1997

Table C-4. Selection of Constituents of Potential Ecological Concern in Surface Soil (0 to 1 ft bgs)
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent	Maximum Concentration (mg/kg)	TEF [a]	Ecological Screening Levels (mg/kg) Value	Maximum HQ [b] (unitless)	Constituent of Potential Ecological Concern? [c] (Yes/no)	Rational
Dioxin/Furan Compounds						
1,2,3,4,6,7,8-HpCDD	0.0001025	0.01	NA	NA	—	—
1,2,3,4,6,7,8-HpCDF	0.00002183	0.01	NA	NA	—	—
1,2,3,4,7,8,9-HpCDF	0.00000041	0.01	NA	NA	—	—
1,2,3,4,7,8-HxCDD	0.00000053	0.1	NA	NA	—	—
1,2,3,4,7,8-HxCDF	0.00002445	0.1	NA	NA	—	—
1,2,3,6,7,8-HxCDD	0.00000141	0.1	NA	NA	—	—
1,2,3,6,7,8-HxCDF	0.0000096	0.1	NA	NA	—	—
1,2,3,7,8,9-HxCDD	0.0000014	0.1	NA	NA	—	—
1,2,3,7,8,9-HxCDF	0.00000179	0.1	NA	NA	—	—
1,2,3,7,8-PeCDF	0.00001225	0.03	NA	NA	—	—
2,3,4,6,7,8-HxCDF	0.00000294	0.1	NA	NA	—	—
2,3,4,7,8-PeCDF	0.0000169	0.3	NA	NA	—	—
2,3,7,8-TCDD	0.00000047	1	NA	NA	—	—
2,3,7,8-TCDF	0.0001246	0.1	NA	NA	—	—
OCDD	0.01964	0.0001	NA	NA	—	—
OCDF	0.00008762	0.0001	NA	NA	—	—
Total Dioxin/Furan Compounds [d]	0.0000258		0.000000199	130	**Yes**	**HQ > 1**
Herbicides						
2,4,5-T	0.00719	—	0.596	0.01	no	HQ ≤ 1
2,4-D	0.195	—	0.0272	7	**Yes**	**HQ > 1**
2,4-DB	0.0596	—	NA	NA	**Yes**	**NSL**
Dalapon	0.0814	—	NA	NA	**Yes**	**NSL**
Dicamba	0.00321	—	NA	NA	**Yes**	**NSL**
MCPP	3.3	—	NA	NA	**Yes**	**NSL**
Organochlorine Pesticides						
4,4'-DDD	0.00933	—	0.758	0.01	no	HQ ≤ 1
4,4'-DDE	0.070	—	0.596	0.12	no	HQ ≤ 1
4,4'-DDT	0.24	—	0.0035	69	**Yes**	**HQ > 1**
Dieldrin	0.00185	—	0.00238	0.78	no	HQ ≤ 1
Endosulfan II	0.00176	—	0.0358	0.05	no	HQ ≤ 1
Endrin Aldehyde	0.00645	—	0.0105	0.61	no	HQ ≤ 1
Polycyclic Aromatic Hydrocarbons						
Acenaphthene	0.0086	—	20	0.00043	no	HQ ≤ 1
Acenaphthylene	0.083	—	682	0.0001	no	HQ ≤ 1
Anthracene	0.032	—	1480	2E-05	no	HQ ≤ 1

Footnotes appear on last page.

Table C-4. Selection of Constituents of Potential Ecological Concern in Surface Soil (0 to 1 ft bgs)
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent		Maximum Concentration (mg/kg)	TEF [a]	Ecological Screening Levels (mg/kg) Value	Maximum HQ [b] (unitless)	Constituent of Potential Ecological Concern? [c] (Yes/no)	Rational
Benzo(a)anthracene		0.49	—	5.21	0.1	no	HQ ≤ 1
Benzo(a)pyrene		0.53	—	1.52	0.3	no	HQ ≤ 1
Benzo(b)fluoranthene		0.73	—	59.8	0.01	no	HQ ≤ 1
Benzo(g,h,i)perylene		0.37	—	119	0.003	no	HQ ≤ 1
Benzo(k)fluoranthene		0.24	—	148	0.002	no	HQ ≤ 1
Chrysene		0.37	—	4.73	0.08	no	HQ ≤ 1
Dibenzo(a,h)anthracene		0.084	—	18.4	0.005	no	HQ ≤ 1
Fluoranthene		0.53	—	122	0.004	no	HQ ≤ 1
Fluorene		0.010	—	122	8E-05	no	HQ ≤ 1
Indeno(1,2,3-cd)pyrene		0.40	—	109	0.004	no	HQ ≤ 1
2-Methylnaphthalene		0.0037	—	3.24	0.001	no	HQ ≤ 1
Naphthalene		0.0085	—	0.0994	0.09	no	HQ ≤ 1
Phenanthrene		0.15	—	45.7	0.003	no	HQ ≤ 1
Pyrene		0.50	—	78.5	0.006	no	HQ ≤ 1
Polychlorinated Biphenyls							
Aroclor-1254	[e]	4.6	—	0.000332	13855	**Yes**	**HQ > 1**
Volatile Organic Compounds							
1,1-Dichloroethene		0.0020	—	8.28	0.0002	no	HQ ≤ 1
1,2,4-Trimethylbenzene		0.0056	—	NA	NA	**Yes**	**NSL**
2-Butanone		0.011	—	89.6	0.0001	no	HQ ≤ 1
Acetone		0.12	—	2.5	0.048	no	HQ ≤ 1
Benzene		0.0010	—	0.255	0.004	no	HQ ≤ 1
Chlorobenzene		0.0010	—	13.1	8E-05	no	HQ ≤ 1
d-Limonene		0.023	—	NA	NA	**Yes**	**NSL**
Methylene Chloride		0.0030	—	4.05	0.0007	no	HQ ≤ 1
tert-Butylbenzene		0.0030	—	NA	NA	**Yes**	**NSL**
Toluene		0.0010	—	5.45	0.0002	no	HQ ≤ 1
Trichloroethene		0.0010	—	12.4	8E-05	no	HQ ≤ 1
Semi-Volatile Organic Compounds							
bis(2-Ethylhexyl)phthalate		0.20	—	0.925	0.22	no	HQ ≤ 1
Carbazole		0.022	—	NA	NA	**Yes**	**NSL**
Diethylphthalate		0.24	—	24.8	0.01	no	HQ ≤ 1
Di-n-Butylphthalate		0.09	—	0.15	0.6	no	HQ ≤ 1
Inorganics							
Aluminum		37,000	—	50	740	**Yes**	**HQ > 1**
Antimony		41.8	—	0.27	155	**Yes**	**HQ > 1**

Footnotes appear on last page.

Table C-4. Selection of Constituents of Potential Ecological Concern in Surface Soil (0 to 1 ft bgs)
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent	Maximum Concentration (mg/kg)	Ecological Screening Levels (mg/kg) TEF [a]	Ecological Screening Levels (mg/kg) Value	Maximum HQ [b] (unitless)	Constituent of Potential Ecological Concern? [c] (Yes/no)	Constituent of Potential Ecological Concern? [c] Rational
Arsenic	64.1	—	18	4	Yes	HQ > 1
Barium	618	—	330	2	Yes	HQ > 1
Beryllium	0.8	—	10	0.08	no	HQ ≤ 1
Cadmium	11.4	—	0.36	32	Yes	HQ > 1
Calcium	129,000	—	NA	NA	no	NT
Chromium	25,700	—	0.4	64250	Yes	HQ > 1
Cobalt	190	—	0.14	1357	Yes	HQ > 1
Copper	569	—	5.4	105	Yes	HQ > 1
Iron	59,800	—	NA	NA	no	NT
Lead	111,000	—	11	10091	Yes	HQ > 1
Magnesium	58,500	—	NA	NA	no	NT
Manganese	926	—	220	4	Yes	HQ > 1
Mercury	0.27	—	0.1	3	Yes	HQ > 1
Nickel	39.6	—	13.6	3	Yes	HQ > 1
Potassium	3,680	—	NA	NA	no	NT
Selenium	0.94	—	0.0276	34	Yes	HQ > 1
Silver	2.74	—	2	1	Yes	HQ > 1
Sodium	2,020	—	NA	NA	no	NT
Thallium	1.1	—	0.0569	19	Yes	HQ > 1
Vanadium	121	—	2	61	Yes	HQ > 1
Zinc	39,000	—	8.5	4588	Yes	HQ > 1

[a] Toxicity Equivalency Factor (TEF); Federal Register Vol. 72, No. 90 (USEPA 2007b).
[b] The maximum hazard quotient (HQ) is the ratio of the maximum constituent concentration to the surface soil screening level.
[c] Constituent with maximum concentration exceeding the screening level or without a screening level were considered COPECs unless they were considered non-toxic.
[d] Sum of individual dioxin/furan compounds multiplied by their individual TEFs.
[e] Aroclor (total) used as a surrogate for the ESL.

— Not applicable.
COPEC Constituent of potential ecological concern.
ft bgs Feet below ground surface.
mg/kg Milligrams per kilogram.
NA Not available.
NSL No screening level available.
NT Non-toxic.

Source:

Table C-5. Uncertainties in the SLERA and BERA, Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia.

Assumptions	Description And Discussion Related To Uncertainties in ERA	Uncertainty in SLERA	Uncertainty in BERA
Analytical Sampling and Data Analysis			
Limited number of samples	Frequently, there are only a limited number of samples used in ERAs, and very often they are collected in a biased manner (i.e., targeting "hot spots"). This type of sampling often lacks statistical power and does not likely represent the concentrations in the environment in which wildlife exposure occurs. Similarly, limited data used to estimate uptake into organisms may overestimate exposure via the food web.	Overestimate of exposure and risk	Overestimate of exposure and risk
Use of maximum concentrations	Maximum concentrations are used to represent the upper estimate exposures. This practice compensates for uncertainty contributed by limited numbers of samples, but overestimates exposure and risk.	Overestimate of exposure and risk	Overestimate of exposure and risk
Detection limits	Detection limits may exceed ESVs (e.g., PAHs) or thresholds for adverse impacts are well below the analytical methods used in ERA (e.g., compounds that are known or suspected to cause endocrine effects).	May underestimate risk or effect on risk estimate unknown	May underestimate risk or effect on risk unknown
Degradation of chemicals not considered	ERAs are almost exclusively based on concentrations of target compounds, and little if any attention is given to degradation compounds that could be more toxic than the original chemical. Conversely, chemical concentrations may decrease over time due to natural physical processes.	Effect on risk estimate unknown	Effect on risk estimate unknown
Selection of COPCs			
Background concentrations	Chemicals may be identified as COPCs despite the fact that the detected concentrations are less than background concentrations. This occurs because the ERA process does not permit use of background until Step 3a of the BERA (USEPA 2001a; 2000).	Overestimate of risk	Not Applicable
Toxicology and ESVs			
Toxicity and exposure data for a limited number of species	Uncertainties exist in many aspects of the toxicology relied upon for conducting ERAs (Newman 1998; Lovett Doust et al. 1993). Toxicity and wildlife exposure data are only available for a limited number of species (most of them laboratory test species) under a strictly defined set of test conditions that deviate from natural conditions (Sample et al. 1996; Suter 1996; Sample et al. 1997).	Effect on risk estimate unknown	Effect on risk estimate unknown
Laboratory testing	In current practice, more than 95 percent of the resources in toxicology are focused toward the study of single chemicals (Cassee et al. 1998), while wildlife exposures rarely occur on a chemical-specific basis. Simplistic extrapolations from laboratory species to wildlife species and testing conditions to field conditions are not likely accurate, and are rarely, if ever, validated against natural conditions (Power 1996; Tannenbaum 2003).	Effect on risk estimate unknown	Effect on risk estimate unknown
Adaptation and tolerance	There is little consistency and no quantitative methodology for the consideration of the diminished bioavailability (and, thereby, diminished toxicity) even though this process is well documented (e.g., Alexander and Alexander 1999; Alexander 2000). Similarly, tolerance and adaptation are not considered directly (Millward and Klerks 2002; Grant 2002). Furthermore, the white rat often used in toxicological testing is bred to minimize differences between lab animals, thereby diminishing the genetic variability that gives wildlife some capability for adaptation and tolerance (Tannenbaum 2003).	Overestimate of risk	Overestimate of risk
Predator-prey interactions	There are relatively few studies that actually evaluate the effects of toxicity on predator-prey interactions, or on competition for scarce resources (Atchison et al. 1996), the very conditions within which all wildlife exists (Kapustka and Landis 1998).	Effect on risk estimate unknown	Effect on risk estimate unknown

Footnotes appear on last page.

Table C-5. Uncertainties in the SLERA and BERA, Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia.

Assumptions	Description And Discussion Related To Uncertainties in ERA	Uncertainty in SLERA	Uncertainty in BERA
HQs			
HQs based on maximum	The SLERA HQ is based on the maximum detected concentrations and the most conservative ESVs available (USEPA 1997; 2000). HQs in the BERA are based on the exposure point concentration (minimum of the 95% upper confidence limit on the mean and the maximum concentration).	Overestimate of risk	Overestimate of risk
Elevated HQs for background concentrations	HQs may exceed a value of 1 for background concentrations of naturally occurring metals (Tannenbaum 2003). This is due to many of the toxicology and ESV uncertainties already discussed.	Overestimate of risk	Overestimate of risk
Interpretation of HQs	An HQ less than or equal to a value of 1 indicates that adverse impacts to wildlife are considered unlikely (USEPA 2001c). However, there is no clear guidance for interpreting the HQs that exceed a value of 1, except that this point of departure indicates that adverse effects of some kind may have occurred or may occur in the future.	Effect on risk estimate unknown	Effect on risk estimate unknown
HQs for individual used to evaluate risks to populations	HQs are based on the types of impacts that could occur to individuals (i.e., those individuals exposed to maximum concentrations) and they completely fail to address ecological exposure and risk at spatial scale of populations (Tannenbaum 2003; Durda and Preziosi 1999).	Overestimate of risk to wildlife populations	Overestimate of risk to wildlife populations
HQs with unrealistic magnitudes	HQs are seen at magnitudes that suggest that every animal should die upon acute exposure (i.e., in the hundreds or thousands) (Tannenbaum et al. 2003). Often, physical conditions at a site demonstrate that this is not the case.	Overestimate of risk	Overestimate of risk
No evaluation of dermal or inhalation pathways	The dermal and inhalation exposure pathways are generally considered "insignificant" due to protective fur and feathers. Under certain conditions, these exposure pathways may occur, but adequate information is rarely available by which to evaluate them.	Not Applicable	Potentially an underestimate of risk

BERA	Baseline Ecological Risk Assessment.
COPC	Constituent of potential concern.
ERA	Ecological risk assessment.
ESV	Ecological screening value.
HQ	Hazard quotient.
PAH	Polynuclear aromatic hydrocarbon.
RTV	Reference toxicity value.
SLERA	Screening level ecological risk assessment.

Table C-6. Refinement of Constituents of Potential Ecological Concern in Surface Soil (0 to 1 ft bgs)
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

Constituent	Maximum Concentration (mg/kg)	Background Screening Value (mg/kg)	Exposure Point Concentration [a] (mg/kg)		Ecological Screening Levels (mg/kg)	COPEC? [b] (Yes/no)	Bioaccumulative ? [c] (Yes/no)	Rational
Dioxin/Furan Compounds								
Total Dioxin/Furan Compounds [d]	0.0000258	NA	0.00003	m	0.000000199	YES	YES	EPC > ESL
Herbicides								
2,4-D	0.195	NA	0.2	m	0.0272	YES	no	EPC > ESL
2,4-DB	0.0596	NA	0.06	m	NA	YES	NA	NSL
Dalapon	0.0814	NA	0.0814	m	NA	YES	NA	NSL
Dicamba	0.00321	NA	0.00321	m	NA	YES	no	NSL
MCPP	3.3	NA	3.3	m	NA	YES	no	NSL
Organochlorine Pesticides								
4,4'-DDT	0.24	NA	0.24	m	0.0035	YES	YES	EPC > ESL
Polychlorinated Biphenyls								
Aroclor-1254 [e]	4.6	NA	1.107		0.000332	YES	YES	EPC > ESL
Volatile Organic Compounds								
1,2,4-Trimethylbenzene	0.0056	NA	0.0056	m	NA	YES	no	NSL
d-Limonene	0.023	NA	0.023	m	NA	YES	NA	NSL
tert-Butylbenzene	0.0030	NA	0.003	m	NA	YES	no	NSL
Semi-Volatile Organic Compounds								
Carbazole	0.022	NA	0.022	m	NA	YES	no	NSL
Inorganics								
Aluminum	37,000	40,041	18721		50	no	no	Max ≤ BKG
Antimony	41.8	NA	12.86		0.27	YES	no	EPC > ESL
Arsenic	64.1	15.8	16.34		18	no	no	EPC < ESL
Barium	618	209	198.9		330	no	no	EPC < ESL
Cadmium	11.4	0.69	3.73		0.36	YES	YES	EPC > ESL
Chromium	25,700	65.3	8543		0.4	YES	YES	EPC > ESL
Cobalt	190	72.3	40.31		13	YES	no	EPC > ESL
Copper	569	53.5	269.40		28	YES	YES	EPC > ESL
Lead	111,000	26.8	47324		11	YES	YES	EPC > ESL
Manganese	926	50,962	356		220	no	no	Max ≤ BKG
Mercury	0.27	0.13	0.0743		0.1	no	YES	EPC < ESL
Nickel	39.6	62.8	13.65		38	no	YES	Max ≤ BKG
Selenium	0.94	NA	0.62		0.52	YES	YES	EPC > ESL
Thallium	1.1	2.11	0.31		0.0569	no	no	Max ≤ BKG
Vanadium	121	108	51		7.8	YES	no	EPC > ESL
Zinc	39,000	202	13974		46	YES	YES	EPC > ESL

Footnotes appear on last page.

Table C-6. Refinement of Constituents of Potential Ecological Concern in Surface Soil (0 to 1 ft bgs)
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

[a] Exposure point concentration; minimum of the 95% upper confidence limit on the mean and the maximum concentration.
[b] Constituents with maximum concentration exceeding the background concentration and with an EPC exceeding the screening level (or without a screening level) were considered COPECs.
[c] Designated as a bioaccumulative constituent as described in the text (see Section 2.2.1).
[d] Sum of individual dioxin/furan compounds multiplied by their individual TEFs.
[e] Aroclor (total) used as a surrogate for the ESL.

BKG Background screening value.
COPEC Constituent of potential ecological concern.
EPC Exposure point concentration; minimum of the 95% upper confidence limit on the mean and the maximum concentration.
ESL Ecological Screening Level.
ft bgs Feet below ground surface.
Max Maximum concentration.
mg/kg Milligrams per kilogram.
NSL No screening level available.

Table C-7. Risk and Hazard Estimates for Terrestrial Ecological Receptor Exposed to Surface Soil (0 to 1 ft bgs)
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant, Radford, Virginia

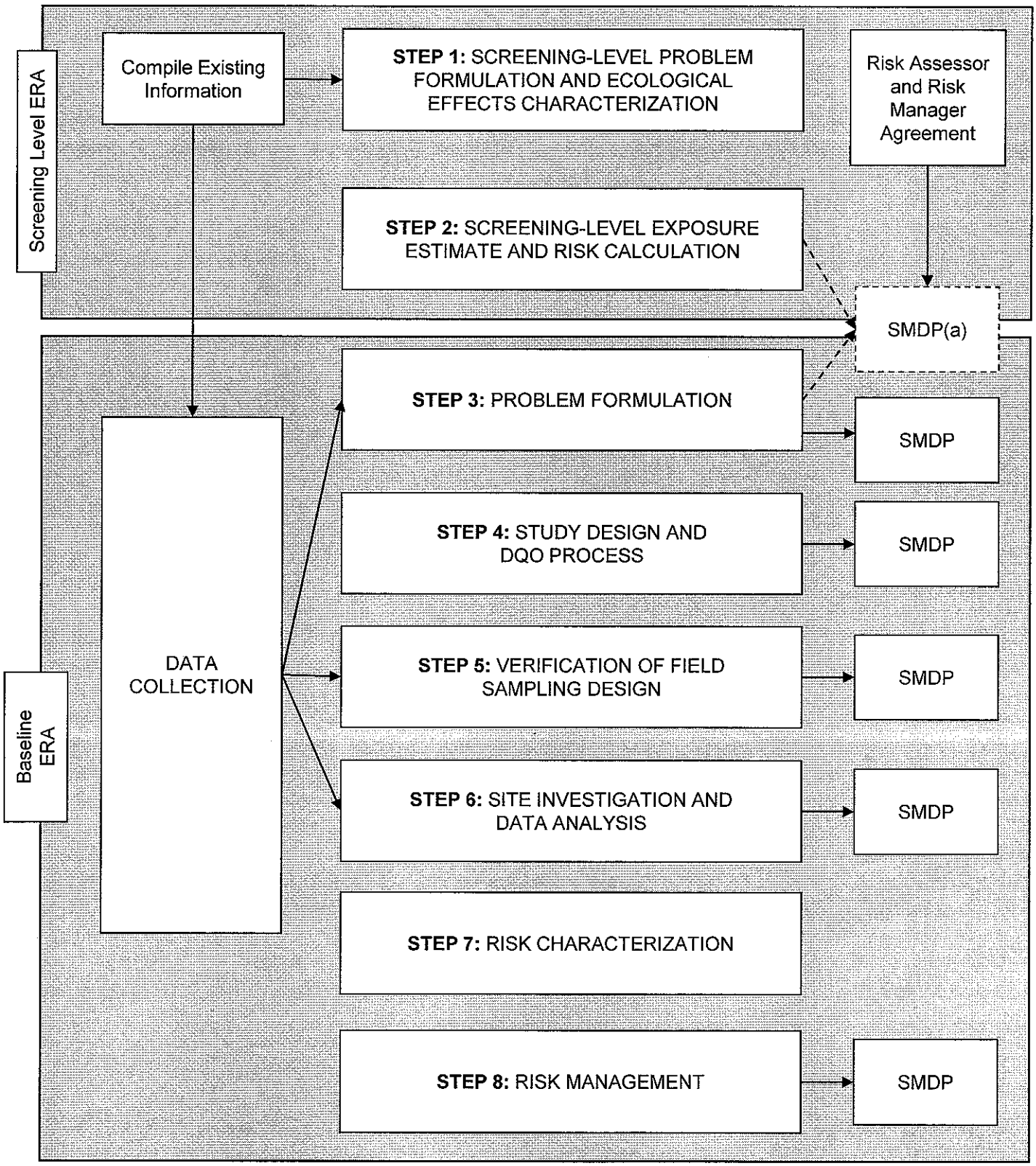
Constituent	Exposure Point Concentration mg/kg	Range of Ecological Screening Levels (mg/kg) Minimum	Maximum	Range of HQs (unitless) Minimum	Maximum
Dioxin/Furan Compounds					
Total Dioxin/Furan Compounds [b]	0.0000258 m	0.000000199	3.15E-06	130	8.19
Herbicides					
2,4-D	0.2 m	0.0272		7	
2,4-DB	0.06 m	NA		–	
Dalapon	0.081 m	NA		–	
Dicamba	0.00321 m	NA		–	
MCPP	3.3 m	NA		–	
Organochlorine Pesticides					
4,4'-DDT	0.24 m	0.0035	9.30E-02	69	2.58
Polychlorinated Biphenyls					
Aroclor-1254	1.11	0.000332	40	3,334	0.03
Volatile Organic Compounds					
1,2,4-Trimethylbenzene	0.0056 m	NA		–	
d-Limonene	0.023 m	NA		–	
tert-Butylbenzene	0.003 m	NA		–	
Semi-Volatile Organic Compounds					
Carbazole	0.022 m	NA		–	
Inorganics					
Antimony	12.86	0.27	78	48	0.16
Cadmium	3.73	0.36	140	10	0.03
Chromium	8543	0.4	130	21358	65.72
Cobalt	40.31	13	230	3	0.18
Copper	269	28	100	10	2.69
Lead	47324	11	1700	4302	27.84
Selenium	0.62	0.52	4	1	0.15
Vanadium	51	7.8	280	7	0.18
Zinc	13974	46	160	304	87.34

[a] The hazard quotient (HQ) is the ratio of the EPC to the surface soil screening criteria.
[b] Sum of individual dioxin/furan compounds multiplied by their individual toxicity equvalency factors (TEFs).

– Not applicable.
COPEC Constituent of Potential Ecological Concern.
EPC Exposure point concentration; minimum of the 95% upper confidence limit on the mean and the maximum concentration.
ft bgs Feet below ground surface.
m EPC is based on maximum concentration
mg/kg Milligrams per kilogram.
NA Not available.

Figures

Figure C-1
Eight-Step Ecological Risk Assessment



Notes:

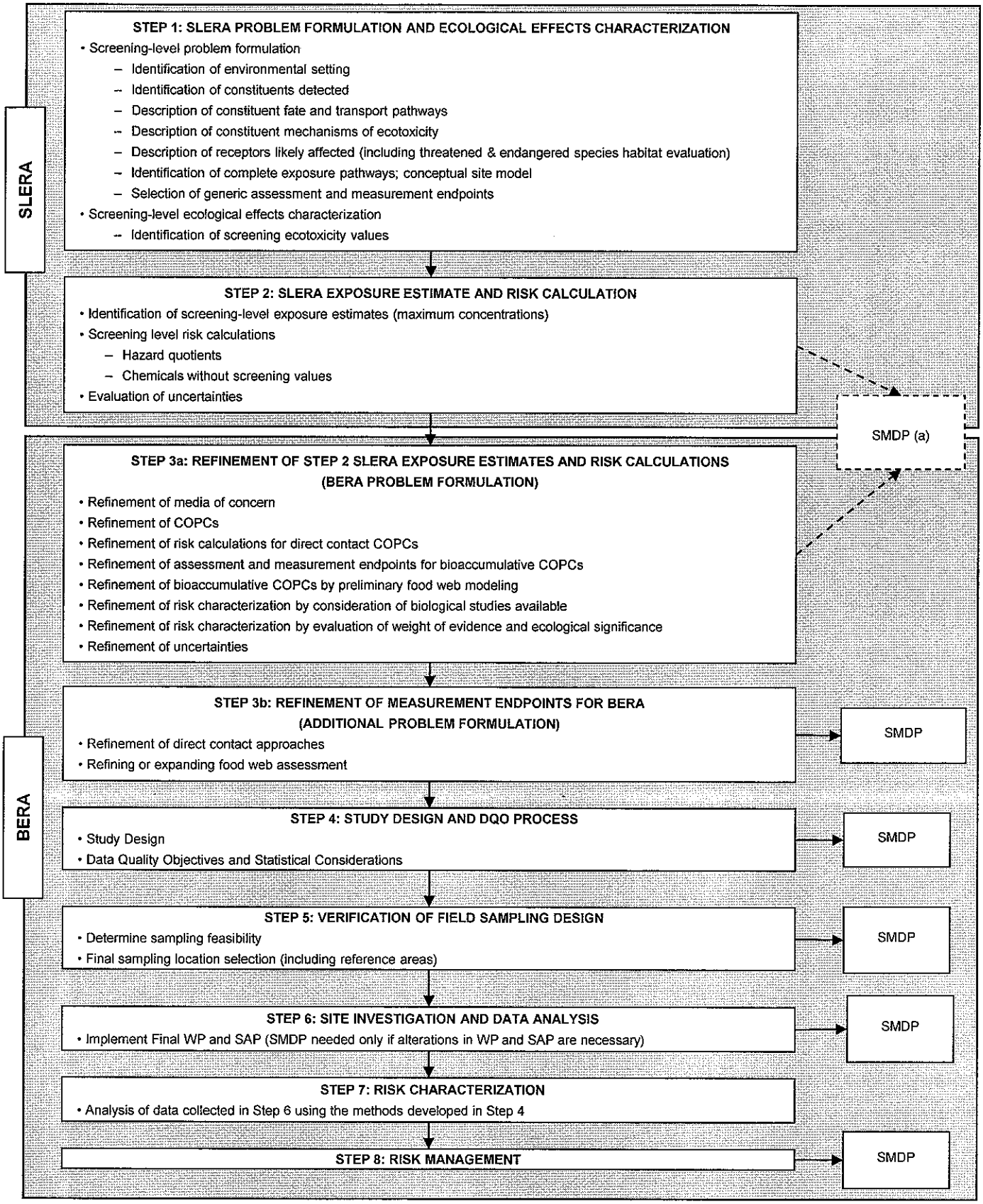
(a) SMDP occurs EITHER after Step 2 or after Step 3a

ERA Ecological Risk Assessment

SMDP Scientific Management Decision Point

Source Adapted from USEPA 2000a

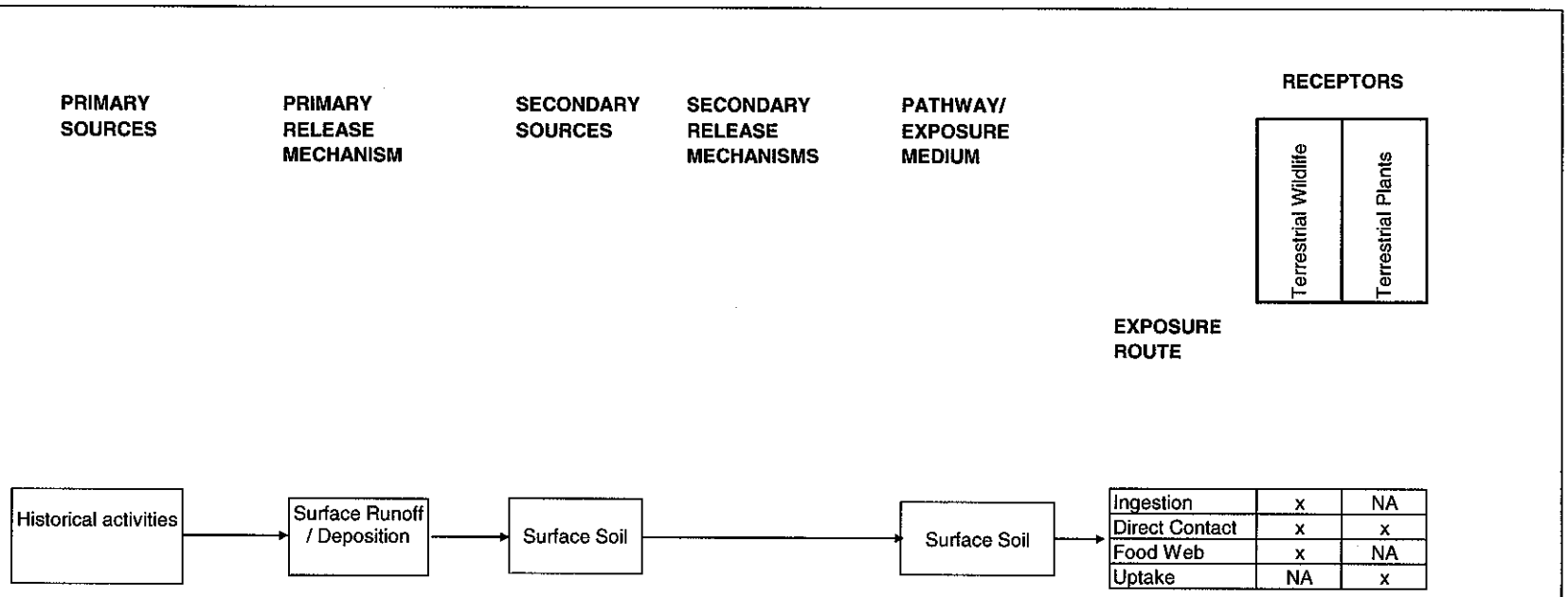
Figure C-2
Expanded Eight-Step Ecological Risk Assessment Process



Notes:

(a)	SMDP occurs EITHER after Step 2 or after Step 3a	SMDP	Scientific Management Decision Point
COPCs	Constituents of Potential Concern	WP	Work Plan
DQO	Data Quality Objectives	BERA	Baseline ERA
GW	Groundwater	SLERA	Screening-level ERA
SAP	Sampling and Analysis Plan		

Source: Adapted from USEPA 1997 and 2000a



NA Pathway not applicable.
x Potential pathway.

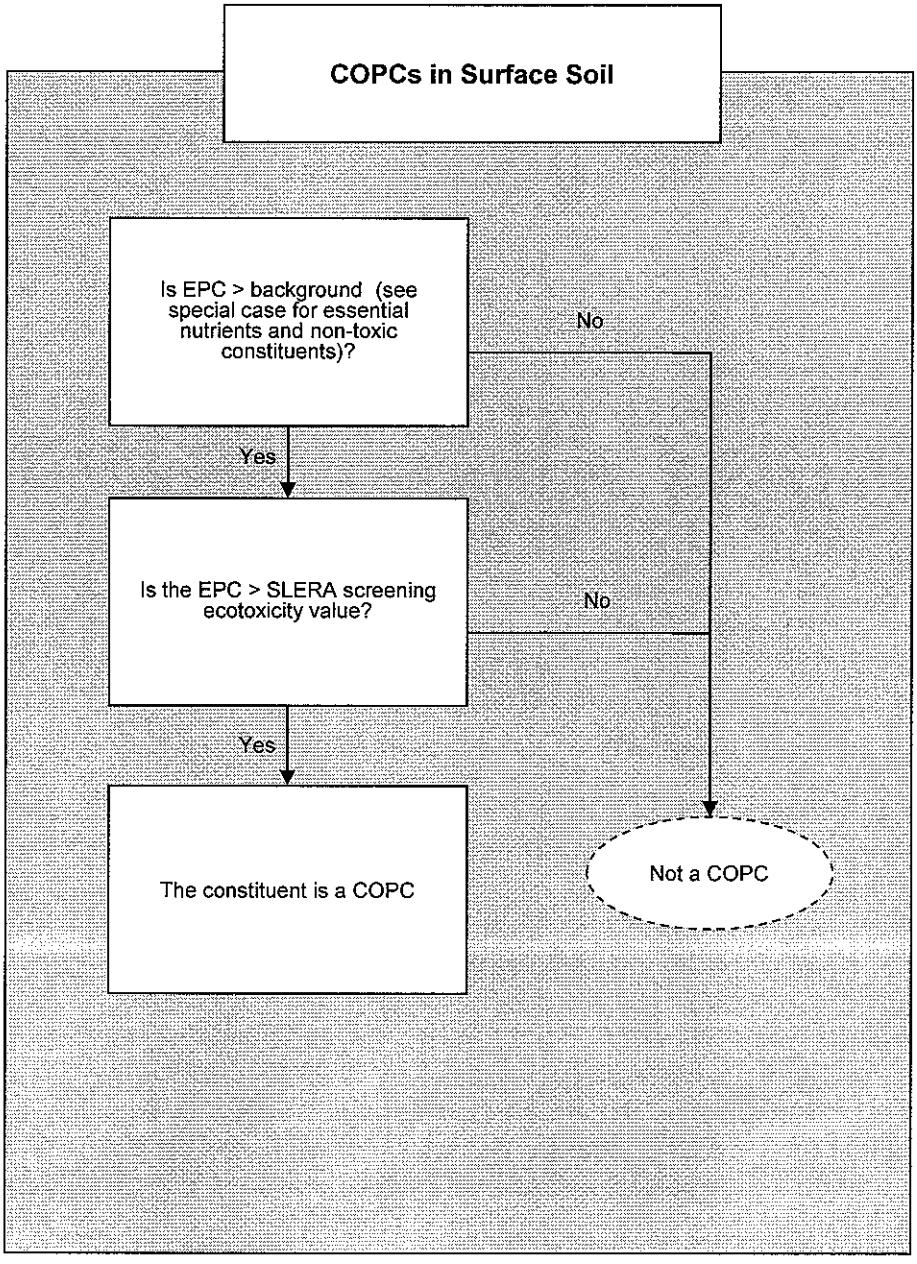
ARCADIS

Conceptual Site Model for Potential Ecological Receptors
Northern Burning Ground, New River Unit, Radford Army Ammunition Plant
Radford, Virginia

Figure C-3

Figure C-4

Step 3a – Refinement of Ecological COPCs



Notes:

COPC Constituent of potential concern

EPC Exposure point concentration

SLERA Screening level risk assessment

Source Adapted from USEPA, 1997 and 2001a

Attachment A

Exposure Point Concentration for
Current Conditions

ATTACHMENT A: ECOLOGICAL RISK ASSESSMENT EXPOSURE POINT CONCENTRATION CALCULATIONS FOR CURRENT CONDITIONS
NORTHERN BURNING GROUND, NEW RIVER UNIT, RADFORD ARMY AMMUNITION PLANT, RADFORD, VIRGINIA

Constituent	Distribution for UCL Selection	Total Sample Size	Percent Non-Detects	Frequency of Detect	SDp of ln Detected	Gamma K star (bias corrected)	Selected UCL Method	Selected UCL Value	Number of Detects	Number of Non Detects	Minimum Detected	Maximum Detected	Mean Detected	Standard Deviation of ln Detected	KM Mean	KM Standard Deviation	Minimum Non-Detect	Maximum Non-Detect	Goodness of Fit Test Result	Number of Potential UCLs	Potential UCL(s) to Use	Potential UCL Value
[redacted]	Normal	10	0.00%	100.00%	0.5682613	2.51	Use 95% Student's-t UCL	7.011E-05	10	0	1.618E-05	0.0001025	5.313E-05	0.599	NA		NA	NA	Data appear Normal at 5% Significance Level	1	Use 95% Student's-t UCL	7.0107E-05
[redacted]	Nonparametric	27	56%	44.44%	1.4380555	0.6	95% KM (t) UCL	1.107	12	15	0.068	4.6	1.455	1.502	0.684	1.233	0.03	0.044	Data appear Gamma Distributed at 5% Significance Level	1	95% KM (t) UCL	1.107
[redacted]	Nonparametric	13	38%	61.54%	0.5584424	2.217	95% KM (t) UCL	0.142	8	5	0.04	0.2	0.104	0.597	0.104	0.0568	0.37	0.39	Data appear Normal at 5% Significance Level	2 (RPD = 2.8	95% KM (t) UCL□95% KM (Percentile Bo	0.142□0.138
[redacted]	Nonparametric	10	30%	70.00%	0.7323237	1.21	95% KM (t) UCL	1.035E-05	7	3	0	2.183E-05	0	0.791	0	0	0	0	Data appear Normal at 5% Significance Level	2 (RPD = 1.3	95% KM (t) UCL□95% KM (Percentile Bo	0.000010347 0.000010208
[redacted]	Nonparametric	10	0%	100.00%	0.6545915	1.245	Use 95% Chebyshev (Mean, Sd) UCL	0.0118	10	0	0.00172	0.0196	0.00432	0.69	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 95% Chebyshev (Mean, Sd) UCL	0.0118
[redacted]		10	50%	50.00%	0.626099	1.134		SEE RPD	5	5	1.394E-05	8.762E-05	3.681E-05	0.7	2.537E-05	2.189E-05	0	0	Data appear Normal at 5% Significance Level	2 (RPD = 5.6	95% KM (t) UCL□95% KM (Percentile Bo	0.00003956 0.000041872
[redacted]	Normal	40	0.00%	100.00%	0.4423646	5.196	Use 95% Student's-t UCL	18721	40	0	4670	37000	16802	0.448	NA		NA	NA	Data appear Normal at 5% Significance Level	1	Use 95% Student's-t UCL	18721
[redacted]	Gamma	40	0%	100.00%	0.4127419	5.412	Use 95% Approximate Gamma UCL	26646	40	0	8270	59800	23739	0.418	NA		NA	NA	Data appear Gamma Distributed at 5% Significance Level	1	Use 95% Approximate Gamma UCL	26646
[redacted]	Nonparametric	40	0%	100.00%	2.6374012	0.224	Use 99% Chebyshev (Mean, Sd) UCL	47324	40	0	16.5	111000	9023	2.671	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 99% Chebyshev (Mean, Sd) UCL	47324
[redacted]	Lognormal	40	0%	100.00%	1.5591376	0.584	Use 95% Chebyshev (MVUE) UCL	31141	40	0	193	58500	10695	1.579	NA		NA	NA	Data appear Lognormal at 5% Significance Level	1	Use 95% Chebyshev (MVUE) UCL	31141
[redacted]	Gamma	40	0.00%	100.00%	0.5855406	2.847	Use 95% Approximate Gamma UCL	356.1	40	0	64.3	926	303	0.593	NA		NA	NA	Data appear Gamma Distributed at 5% Significance Level	1	Use 95% Approximate Gamma UCL	356.1
[redacted]	Nonparametric	38	26.32%	73.68%	0.5145578	2.799	95% KM (BCA) UCL	0.0743	28	10	0.031	0.27	0.0653	0.524	0.061	0.0446	0.05	0.12	Data do not follow a Discernable Distribution (0.05)	1	95% KM (BCA) UCL	0.0743
[redacted]	Gamma	40	0%	100.00%	0.4828488	4.262	Use 95% Approximate Gamma UCL	13.65	40	0	3.5	39.6	11.98	0.489	NA		NA	NA	Data appear Gamma Distributed at 5% Significance Level	1	Use 95% Approximate Gamma UCL	13.65
[redacted]	Gamma	40	0%	100.00%	0.6872449	2.186	Use 95% Approximate Gamma UCL	1337	40	0	149	3680	1110	0.696	NA		NA	NA	Data appear Gamma Distributed at 5% Significance Level	1	Use 95% Approximate Gamma UCL	1337
[redacted]	Nonparametric	38	2.63%	97.37%	0.8680267	1.026	95% KM (Chebyshev) UCL	441.4	37	1	19	2020	200.8	0.88	198.9	338	560	560	Data do not follow a Discernable Distribution (0.05)	1	95% KM (Chebyshev) UCL	441.4
[redacted]	Nonparametric	34	50.00%	50.00%	0.5461902	2.381	95% KM (% Bootstrap) UCL	0.314	17	17	0.14	1.1	0.304	0.563	0.255	0.183	0.32	17.2	Data do not follow a Discernable Distribution (0.05)	2 (RPD = 0.3	95% KM (t) UCL□95% KM (% Bootstrap)	0.313 0.314
[redacted]	Nonparametric	34	29%	70.59%	1.3274494	0.47	97.5% KM (Chebyshev) UCL	12.86	24	10	0.37	41.8	4.679	1.356	3.438	8.61	0.54	5.7	Data do not follow a Discernable Distribution (0.05)	1	97.5% KM (Chebyshev) UCL	12.86
[redacted]	Nonparametric	40	3%	97.50%	0.6823416	1.69	95% KM (Chebyshev) UCL	16.34	39	1	2.2	64.1	8.997	0.671	8.889	10.66	6.6	6.6	Data do not follow a Discernable Distribution (0.05)	1	95% KM (Chebyshev) UCL	16.34
[redacted]	Nonparametric	40	0%	100.00%	0.8077103	1.284	Use 95% Chebyshev (Mean, Sd) UCL	198.9	40	0	21.4	618	108.1	0.818	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 95% Chebyshev (Mean, Sd) UCL	198.9
[redacted]	Nonparametric	40	10%	90.00%	0.3796151	8.042	95% KM (Percentile Bootstrap) UCL	0.521	36	4	0.11	0.8	0.498	0.385	0.475	0.165	0.11	0.59	Data appear Normal at 5% Significance Level	2 (RPD = 0.1	95% KM (t) UCL□95% KM (Percentile Bo	0.52 0.521
[redacted]	Nonparametric	39	31%	69.23%	1.3385024	0.567	97.5% KM (Chebyshev) UCL	3.727	27	12	0.083	11.4	1.646	1.364	1.165	2.514	0.03	0.13	Data appear Lognormal at 5% Significance Level	1	97.5% KM (Chebyshev) UCL	3.727
[redacted]	Nonparametric	40	0.00%	100.00%	1.9708921	0.262	Use 99% Chebyshev (Mean, Sd) UCL	8543	40	0	7.1	25700	1387	1.996	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 99% Chebyshev (Mean, Sd) UCL	8543
[redacted]	Nonparametric	40	0%	100.00%	0.9074396	0.87	Use 95% Chebyshev (Mean, Sd) UCL	40.31	40	0	3.2	190	17.54	0.919	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 95% Chebyshev (Mean, Sd) UCL	40.31
[redacted]	Nonparametric	40	0%	100.00%	1.1059114	0.674	Use 99% Chebyshev (Mean, Sd) UCL	269.4	40	0	4.9	569	65.64	1.12	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 99% Chebyshev (Mean, Sd) UCL	269.4
[redacted]	Gamma	40	0%	100.00%	0.4137293	5.391	Use 95% Approximate Gamma UCL	50.99	40	0	14.9	121	45.41	0.419	NA		NA	NA	Data appear Gamma Distributed at 5% Significance Level	1	Use 95% Approximate Gamma UCL	50.99
[redacted]	Nonparametric	40	0%	100.00%	2.0538354	0.322	Use 99% Chebyshev (Mean, Sd) UCL	13974	40	0	18.1	39000	2790	2.08	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 99% Chebyshev (Mean, Sd) UCL	13974
[redacted]	Nonparametric	40	0%	100.00%	1.5640747	0.563	Use 99% Chebyshev (Mean, Sd) UCL	65302	40	0	637	129000	20517	1.584	NA		NA	NA	Data do not follow a Discernable Distribution (0.05)	1	Use 99% Chebyshev (Mean, Sd) UCL	65302
[redacted]		11	55%	45.45%	0.1985628	10.68		SEE RPD	5	6	0.002	0.003	0.0026	0.222	0.00243	0.0004949	0.001	0.0064	Data do not follow a Discernable Distribution (0.05)	2 (RPD = 6.8	95% KM (t) UCL□95% KM (% Bootstrap)	0.00281 0.003
[redacted]	Nonparametric	28	82.14%	17.86%	0.2271845	7.764	95% KM (Percentile Bootstrap) UCL	0.624	5	23	0.55	0.94	0.694	0.254	0.576	0.0883	0.47	0.71	Data appear Normal at 5% Significance Level	2 (RPD = 2.6	95% KM (t) UCL 95% KM (Percentile Bootstrap) UCL	0.608 0.624

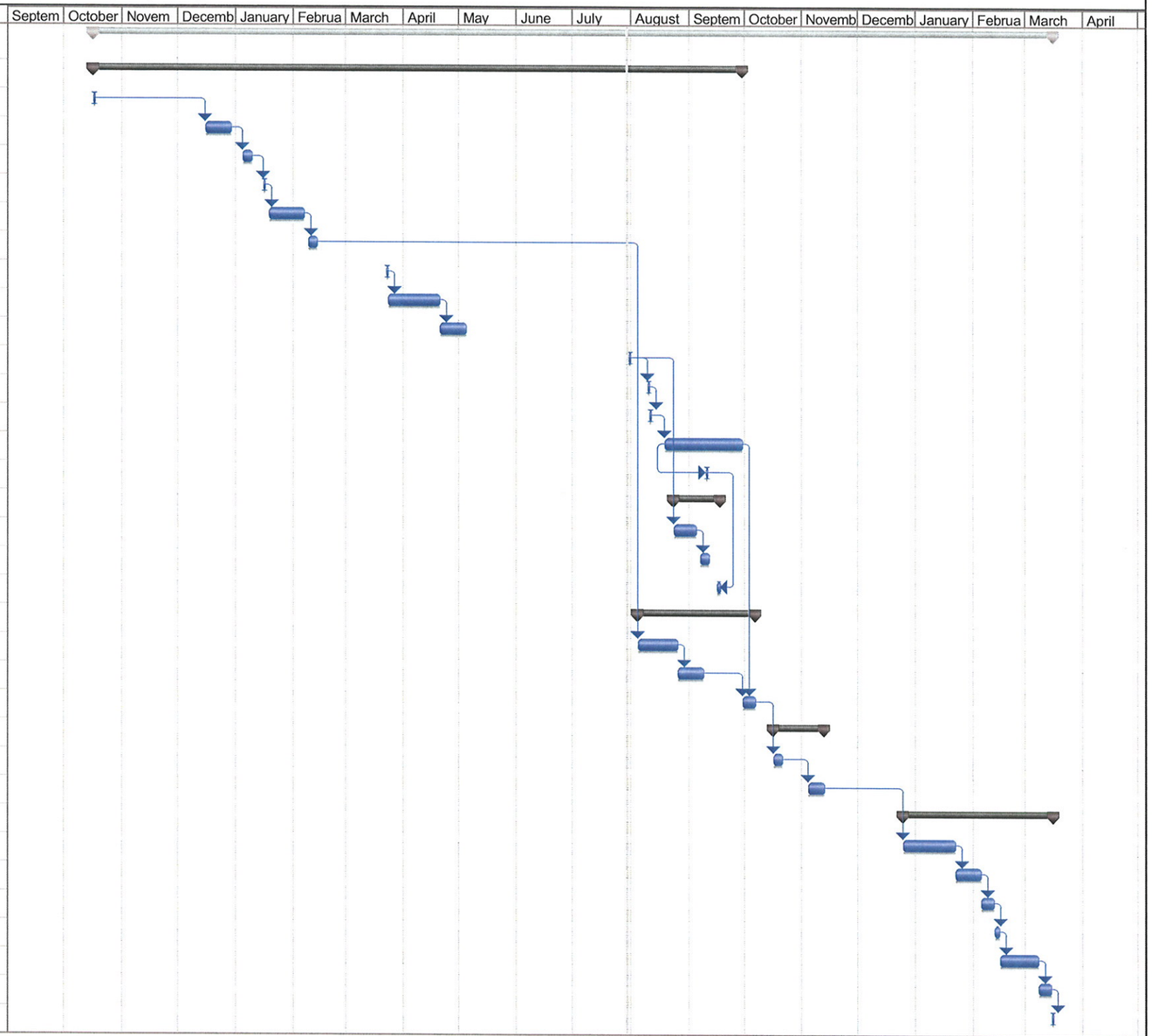
Note: The distribution testing was applied to each data set and UCLs were calculated using methods presented in USEPA (2007b) ProUCL Version 4.0 User Guide.

Appendix D

Schedule for Removal Action

Project Schedule for Northern Burning Ground Removal Action

ID	Task Name	Duration	Start	Finish	Predecessors
0	**NBG Removal Action**	**367.5 days**	**Fri 10/17/08**	**Tue 3/16/10**	
1	**EE/CA for Removal Action**	**248 days**	**Fri 10/17/08**	**Tue 9/29/09**	
2	Submit Internal Draft EE/CA	1 day	Fri 10/17/08	Fri 10/17/08	
3	Army Review	2 wks	Tue 12/16/08	Mon 12/29/08	2
4	Response to Comments	5 days	Mon 1/5/09	Fri 1/9/09	3
5	Submit Draft EE/CA to VDEQ	1 day	Fri 1/16/09	Fri 1/16/09	4FS+1 day
6	VDEQ Review	3 wks	Mon 1/19/09	Fri 2/6/09	5
7	RTC	5 days	Mon 2/9/09	Fri 2/13/09	6
8	Submit Revised Draft EE/CA to VDEQ	1 day	Mon 3/23/09	Mon 3/23/09	
9	VDEQ Review	1 mon	Tue 3/24/09	Mon 4/20/09	8
10	RTC	10 days	Tue 4/21/09	Mon 5/4/09	9
11	Submit Final EE/CA to VDEQ	1 day	Fri 7/31/09	Fri 7/31/09	
12	VDEQ Approves EE/CA	1 day	Mon 8/10/09	Mon 8/10/09	11FS+5 days
13	Publish Notice of Availability for EE/CA	1 day	Tue 8/11/09	Tue 8/11/09	12
14	Public Comment Period	30 days	Wed 8/19/09	Tue 9/29/09	13FS+5 days
15	Public Meeting	1 day	Thu 9/10/09	Thu 9/10/09	14SS+16 days
16	**Action Memo for Removal Action**	**19 days**	**Mon 8/24/09**	**Thu 9/17/09**	
17	ARCADIS Prepares Draft Action Memo for VDEQ	2 wks	Mon 8/24/09	Fri 9/4/09	11FS+3 wks
18	Army Approval of Action Memo	5 days	Mon 9/7/09	Fri 9/11/09	17
19	Submit Final Action Memo	2 days	Wed 9/16/09	Thu 9/17/09	15FF+1 wk
20	**Removal Action Work Plan**	**45 days**	**Wed 8/5/09**	**Tue 10/6/09**	
21	Prepare Internal Draft Work Plan	3 wks	Wed 8/5/09	Tue 8/25/09	7
22	Army Review	2 wks	Wed 8/26/09	Tue 9/8/09	21
23	Finalize Work Plan	1 wk	Wed 9/30/09	Tue 10/6/09	14,22
24	**Conduct Removal Actiion**	**20 days**	**Fri 10/16/09**	**Fri 11/13/09**	
25	Survey Excavation Area	3 days	Fri 10/16/09	Wed 10/21/09	23FS+1.5 wks
26	Perform Removal Action	7 days	Wed 11/4/09	Fri 11/13/09	25FS+2 wks
27	**Removal Action Completion Report**	**57 days**	**Fri 12/25/09**	**Tue 3/16/10**	
28	Prepare Internal Draft Completion of Completion Report	4 wks	Fri 12/25/09	Fri 1/22/10	26FS+30 days
29	Army Review	2 wks	Fri 1/22/10	Fri 2/5/10	28
30	Response to Comments	5 days	Fri 2/5/10	Fri 2/12/10	29
31	Submit Draft Report to VDEQ	1 day	Fri 2/12/10	Mon 2/15/10	30
32	VDEQ Review	3 wks	Mon 2/15/10	Mon 3/8/10	31
33	Response to Comments	5 days	Mon 3/8/10	Mon 3/15/10	32
34	Finalize Completion Report	1 day	Mon 3/15/10	Tue 3/16/10	33



Project: NBG Removal Action
Date: Thu 7/30/09

Task — Progress — Summary — External Tasks — Deadline
Split — Milestone — Project Summary — External Milestone